Course Name: I Think Biology

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W11L55_Biology and Climate Change - Part 1

Hello and welcome to this lecture in the I Think Biology NPTEL course. This week we are discussing biology and climate change. This first lecture will be an introduction to climate change. But first let's think about the fact as to why are we talking about climate change in a course on biology. And there are two reasons for that. The first is a general reason.

Climate change is a crisis that will affect every human being on earth. So whether you are a student or teacher, whether you are a farmer or a factory worker or homemaker or a businessman, our lives are going to be changed by climate change and sometimes in very drastic ways. So we need to know about this crisis and what can be done about it. So that's at the general level.

On a particular level as biologists, climate change is going to alter the biology of the earth in very drastic ways. So we need to understand the effects of climate change on the earth's ecosystems and organisms. And so with that reasoning in mind, we have included this topic in our course. In this lecture, I will provide you with a general framework to think about climate change. And the reason is we know that there are many crises which are affecting the earth.

And it's very difficult to think about all of them in a systematic fashion. So we thought we could make use of certain frameworks to look at all the different issues that affect the earth and then think about ways in which we can try and tackle them. So in this lecture, I will give you two such frameworks to look at these issues. So the first framework is that of planetary boundaries. And the planetary boundaries were formulated in 2009 by Johan Rockstrom and his group, the Stockholm Resilience Institute.

And they said that we need to think about the earth as a system which is dynamic, but which is held in equilibrium by nine processes which make sure that life on earth can

thrive. And these nine processes are, if we look at it in an anti-clockwise way, starting with climate change. Then you have the biosphere integrity or biodiversity. Then you have land system change, or basically the change of land for different activities. You have freshwater use.

You have biogeochemical flows where we primarily look at nitrogen and phosphorus. You have ocean acidification. You have aerosol loading or particulate matter in the atmosphere. Then you have ozone depletion. And finally you have novel entities which we can think of as chemicals in the environment.

And so if you look at the image, you will see that there is a green zone, there is an orange zone, and then there is a red zone. So if the values of these nine processes, which were quantified by this group, remain in the green zone, then life on earth can thrive. But as you start to go beyond a particular boundary for any of these processes, then you enter a zone of uncertainty. And then even beyond that zone of uncertainty, if that boundary is exceeded, then you are entering a zone of high risk. So when this framework was first given in 2009, three of the boundaries had already been transgressed and those were that of the biosphere integrity, or we can think of it as biodiversity, and the boundary for nitrogen and phosphorus.

They've already been crossed. And so the way to think about this is, in the words of Rockström and his group, if we remain within the boundary limits for these nine processes, then humanity can continue to develop and thrive for generations to come. So we can understand the multiple crises affecting the earth by just looking at this one image and trying to understand what these nine processes are. So let's look at them in a little bit of detail. And here I have used the same categorization provided by Rockström and his group.

So in the first category are what they call three big ones. So these are planetary boundaries on a global scale and those are that of climate change, ocean acidification, and the ozone layer. So basically things to do with the earth's atmosphere or the earth's waters. The second category is what they call under the hood, or processes that keep life on earth going and thriving. And here we have the planetary boundaries of biodiversity, freshwater use, land system change, and flows of nitrogen and phosphorus.

And finally we have chemical loading. So basically how much chemical matter are we putting out into the atmosphere or on the land or in the water. And there are two categories here that are aerosols or particulate matter and novel entities which are man-made chemicals in the environment. So now let's look at these boundaries in a bit of detail. Shown in this table is the boundary, particular boundary, then what are the

parameters used to measure it, what is the proposed boundary level, what is its current status, and what was the value in the pre-industrial era.

So for instance if you look at climate change the parameter is carbon dioxide concentration in the atmosphere and that's measured in parts per million by volume. The proposed boundary is 350 ppm and the current status is 417, which means we have crossed the safe boundary for this planetary process. Then you have ocean acidification which is measured by the global mean saturation state of aragonite which is a kind of carbonate. The safe value for this is thought to be around three. So currently we are at the boundary and we need to be extremely careful that we do not cross it in the future.

The ozone layer is a planetary boundary which is near the safe level and this is an example of global cooperation which happened because we started to realize that chemicals that were being used were depleting ozone and this then led to a global cooperation treaty which was called the Montreal Protocol which led to the banning of these chemicals and which finally led to the repair of the ozone layer. So the ozone layer is a good example of a boundary which was transgressed in the past but now is coming back to the safe zone. Then you have the planetary boundaries related to life on earth. So you have biodiversity which is measured. There are different measures of biodiversity.

I've just given one here which is that of the extinction rate. So number of species per million years per year that are going extinct and that number exceeds a hundred currently and its pre-industrial value was 0.1 to 1. So definitely species do go extinct via natural processes but this current number is much above that value and which is a very disturbing thing to think about. Then you have global freshwater use which is the consumption of fresh water by humans.

This is measured in kilometer cube per year and the current status is below the proposed boundary but freshwater use is growing exponentially almost every year and it needs to be kept in careful watch. Then you have land system change which is now measured as the area of forested land as the percentage of original forest cover. So the pre-industrial value is taken as a hundred and it is compared to the current value. So the current value is at 60 which means we have diverted almost 40 percent of pre-industrial era forest to some kind of human activity. So whether it's farming or mining or plantations or industries or urbanization, things of that kind.

And the proposed boundary is that at 75 which means that we need to grow back our forests. This boundary of land system change is intricately tied to many other boundaries and that's a point I will come back to again. Then you have the planetary boundaries of flows which are of nitrogen and phosphorus. If we just look at the nitrogen boundary

which is the amount of N2 removed from the atmosphere for human use which is in million tonnes per year and the value which it is at currently which is 121 million tonnes per year is much above the proposed safe boundary for this. And nitrogen is obviously used as fertilizer in chemical agriculture and a lot of it flows via water into our lakes and ponds and seas and then disturbs the equilibrium of particular ecosystems there.

Similarly for phosphorus. Finally we have the planetary boundaries related to chemicals. The first one is that of aerosols. We generate aerosols by a variety of processes that are burning of fossil fuels or by construction or by transport and there is no particular value that it can be ascribed because obviously it will change on a regional basis. So no boundary has been proposed for this particular process. The other one we have is novel entities.

So these are man-made chemicals such as POPs, persistent organic pollutants. We have plastics or then we have endocrine disruptors which are used in the making of plastics. We have heavy metals and we have nuclear waste in the environment. So again this could have different values but currently this boundary is assumed to be transgressed because of the effects we can see of these chemicals on human and other organisms in the earth. So looking at all these boundaries allows us to determine what is the current state of the earth.

So Rockstrom's group has done that and they have published reports periodically and as you can see here the progression from 2009 to 2023 it does not paint a pretty picture where currently six of these boundaries have been crossed. So we could say that the earth system is in a zone of high risk and the reason this becomes important is that because it's a dynamic system any of these boundaries could nudge it out of its present equilibrium and then it could go into a new state where the equilibrium may not be conducive for life on earth to thrive. So that is something which we need to be aware of and take extremely seriously. The other thing people have tried to do is say that the planetary boundaries are not just talking about natural processes but they are intricately linked to human society and human development and so the Rockstrom group has tried to define in a variation safe and just earth system boundaries. So basically can we organize human society and human development in such a way that it is a just process so that the benefits of our societal activities accrue to the largest number in that society and yet we try and maintain all these nine processes within their safe boundaries and obviously there are a lot of challenges related to this.

But the point they are trying to make is that the stability and resilience of the earth system and human well-being are inseparably linked. Finally let me give you another framework to think about all this and that is one of the SDGs or Sustainable

Development Codes. So these were defined by the UN and they have been ratified by many countries. India is also a signatory to the SDGs and there are 17 SDGs but here they have been demarcated into different categories and the foundation of the SDGs are thought to be these four SDGs which relate to life on earth or the integrity of the biosphere.

So we need to make sure that we meet all these SDGs first because they are related to life on earth and really are the basis for making sure that human society can thrive. After that you have goals linked to society so there's things like an end to hunger, free education, no poverty, peace on earth and gender equality. So these are goals which are built on top of the ones which relate to the biosphere or life on earth and then after that you have goals linked to the environment. So this is not the way we are normally taught to think about things where usually we think about development only in economic realm but we don't look at its effects on the planet and so here this way of looking at the SDGs where we foreground the SDGs related to the biosphere or the earth's integrity makes sure that we keep this goal front and center and then build on top of it. So I urge you to look up the SDGs and find out what they are.

You can look at them on the UN website for your benefit. So this ends the first part of this introduction to climate change. In the second part of the lecture I will be looking specifically at the planetary boundary of climate change. So I will see you then. Thank you.