Advanced Aquaculture Technology
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Lecture 57
Impact of Climate Change on Aquaculture (Contd.)

Hello everyone, welcome to the second lecture of the module 12 on the environmental conservation of aquaculture. So, my name is Professor Gaurav Dhar Bhowmick. I am from the Agriculture and Food Engineering department of IIT Kharagpur.

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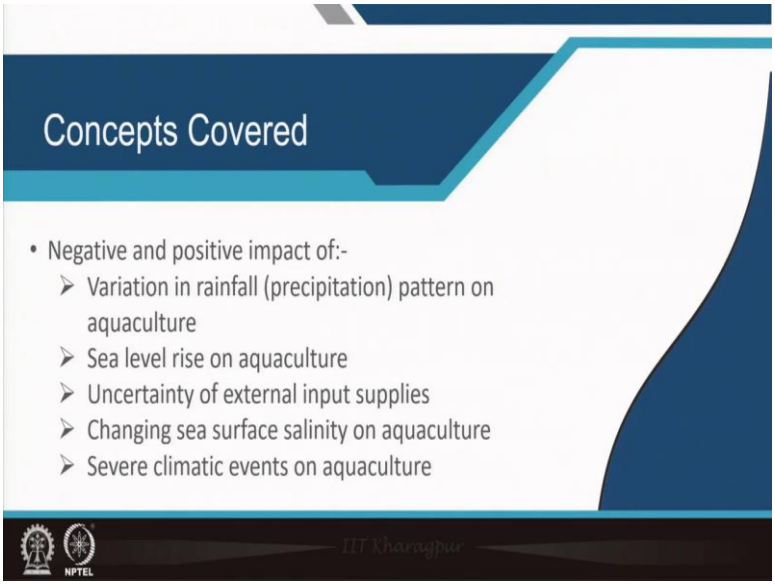

The concepts that I will be covering in this particular lecture material are the negative and the positive impact of different climatic, the effects of different climate change conditions like variation in the rainfall or the precipitation pattern on aquaculture. Sea level rise and impacts of it in aquaculture uncertainty on of different external inputs supplies, changing sea surface salinity on aquaculture and also severe climatic events on aquaculture and all okay.

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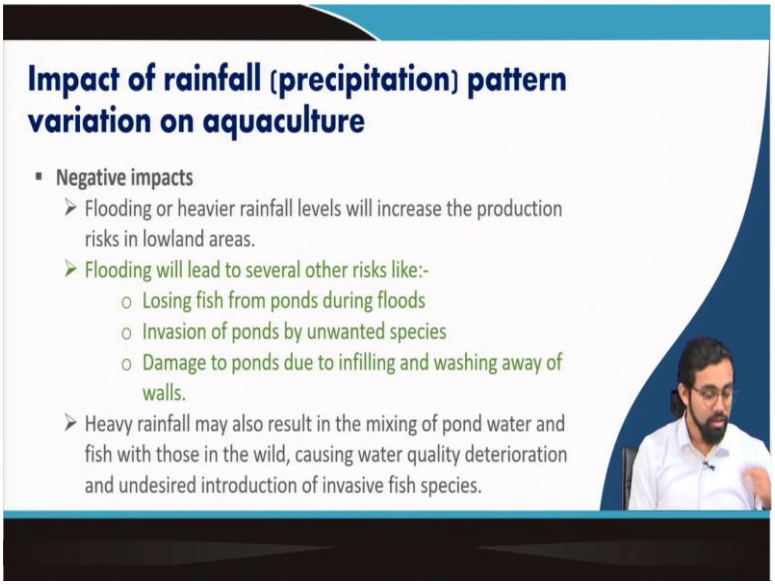

So, in general to start with you know, the rainfall on the precipitation pattern is changing like anything nowadays, the places where it is supposed to be having you know like the flood in certain amount certain period of time a certain period of season, there is like drought on the other way around in different places. In India, most of the places are like, they can normally witness 6 different seasons precisely even like 10 years back also.

But now, you can hardly see like three you can hardly understand the changes in the season time to time it is like it is very rare, sometimes it is drastic, sometimes it is the changes are not even much more visible. So, it can either seasonal change is dropped down to select three or four only nowadays instead of six very find differences find changes for the variations and it also impact you this is only just one example of how the climate change is affecting the overall seasonal variation weather pattern. And the climatic condition in general.

It also affects the rainfall pattern, there are certain places in the world which started getting very high amount of rainfall, nowadays, especially if you talk about the world scenario India and China is facing huge amount of rainfall nowadays, whether whereas, there are certain places in the certain places in the US is experiencing high drought like situations nowadays.

So, this changes was not expected these changes are very certain and I mean like it was there for like very small amount of time, the changes should have cannot be this fast and it is only happening because of the changes in the climate change in a very faster way because of the anthropogenic activities.

What are the negative effects of the precipitation on aquaculture and how it affects the aquaculture? In general suppose, you have a flooding or the heavier rainfall, it will increase the production risk in the lowland areas because your catch may you know, fly away like it will because of the flood and flood situation your production you can lose the your production in general.

It can lead to several other risks like the losing fish from the pond during the flood. Invasion of pond by unwanted species and which can cause them to have some disease or say like they can be the predator of those cultural species. Damage of pond due to the infilling and washing away of walls. Also, this heavy rainfall it can affect the mixing of pond water with the fish that is there in the wild causing water quality deterioration and an undesired introduction to the invasive fish species.

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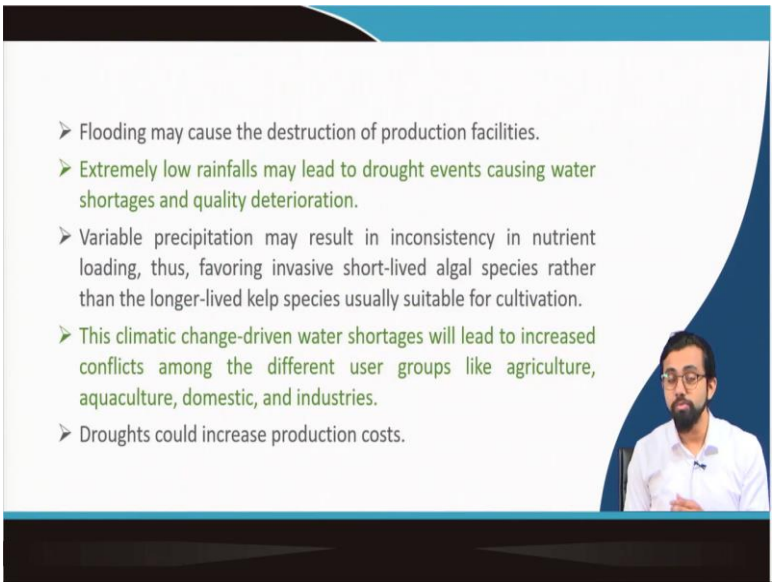

Flooding may cause the destruction of the production facilities extremely low rainfall also can lead to the drought events and which cause drastic changes in the shortages in the water availability and also the ~~world~~ overall quality deterioration and that will definitely have a major impact in your aquaculture.

Variable precipitation in may also result in inconsistency in a nutrient loading, thus favoring the most of the invasive short-lived algal species rather than longer lived kelp species usually suitable for cultivation. And this shortage is because of the climate change driven water shortages lead to the increasing conflict of different user groups like agriculture, aquaculture, domestic and industries.

Someone will say like no, the water should be directed towards the agriculture because that will give us the more produce and that will that is the one of the survival strategies. But the policymakers are sometimes they cannot do anything because the limited in water supply, they will be forced to reduce the amount of agricultural demand they post to reduce the amount of industrial activity or aquaculture practices and all.

In general, that will give a very huge amount of conflict in conflict of interest between the in the policymakers in different zones of practices and all okay. It can also increase the production cost the droughts and all because you have to supply the water from far away and it will definitely cost you much more money than it requires in general.

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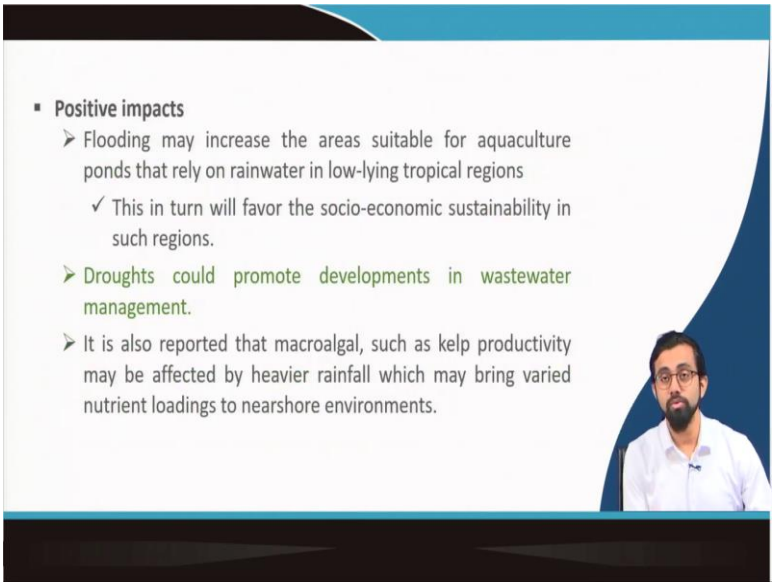

What are the positive effects? Sometimes the flooding it in cases the areas of suitable aquaculture pond in the low-lying tropical regions, like desert and the plateau regions where normally it experiences less water. But all of a sudden, they started experiencing the rainfall and all and it helps them to grow their aquaculture in general. It also in turn favors the local socio-economic sustainability.

Droughts can sometimes promote the development of very standard wastewater management practices. And in a way it actually helps the scientific community to thrive you know for going for much how to say faster production of different ideas and new novel technologies. It is also reported that microalgal such as like kelp productivity, it can affect it can be it may be affected by heavier rainfall, which may bring varied nutrient loadings to the nearshore environments.

Do you understand the point if you have a high amount of rainfall in the near coastal region, it will just simply take away and let you know that because of the washed away products from the nutrient from this zone will be coming in contact with this near shore water body it will take all the nutrient load along with them. Because of that this nearshore environment will be very high in different nutrient concentration.

This is a perfect area for this sea grasses and different scalps production. So, that can also the sea weeds, sea grasses can also grow in this region. So, it somehow has some positive effect also. But majorly then negative effects are more drastic okay.

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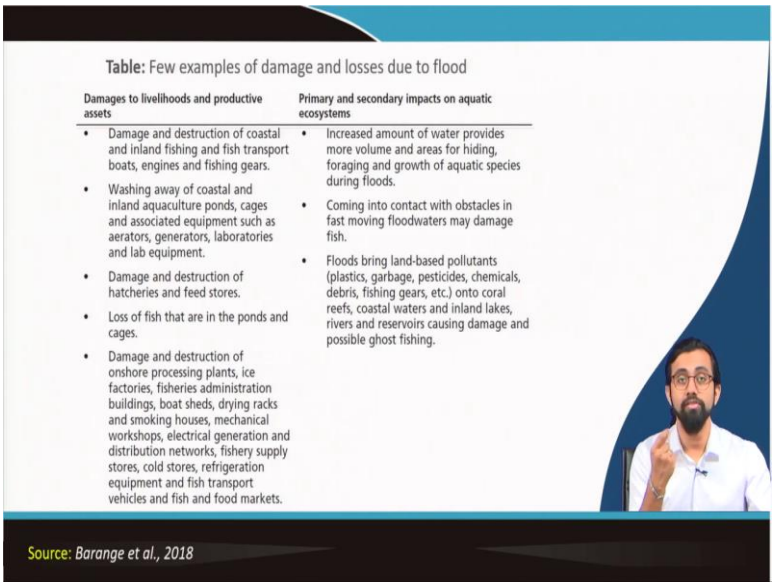

There are some few examples of the damage and losses due to the flood in general the damages to the livelihood and the productive assets. It can damage the other destruct the coastal and inland fishing and the fish transport boat engine gear. It can wash over the coastal or inland aquaculture pond.

It can damage the hatcheries and the feed store it can lose the fish from your pond it can damage the onshore processing plant like ice factories, administration buildings, boats sheds, drying racks. Primary and secondary impacts on aquatic ecosystem it increases the amount of water provides more volume and area for hiding foraging and growth of aquatic species during the flood.

It comes in contact with the obstacle in fast moving floodwaters may damage the fish and also floods bring land-based pollutants plastics, garbage, pesticides, chemicals, debris and

fishing gears and all into the coral reefs and also because of that they can there is a chance of huge amount of damage and possible ghost fishing and all okay.

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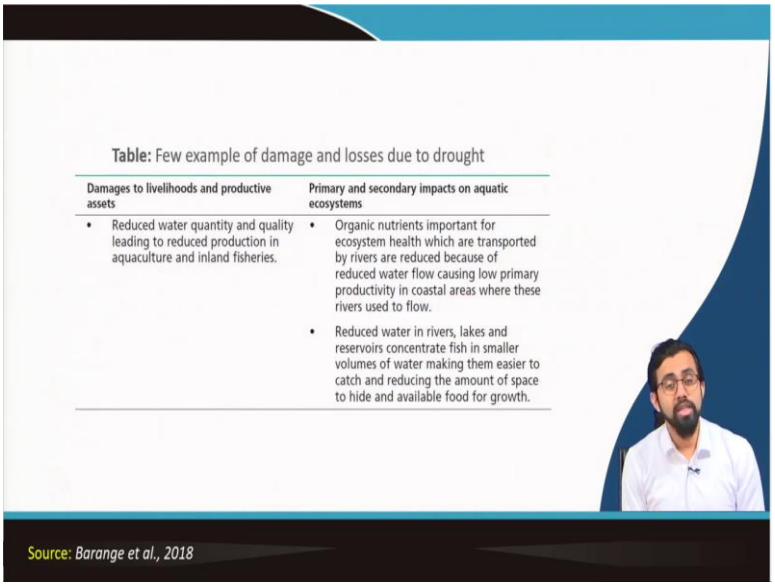

Few more example of damage and losses due to drought rather than the flood. What will happen? It will damage the livelihood like it will reduce the water quantity and the quality leading to the reduced production of aquaculture and inland fisheries. How it will affect the primary and the secondary impact on how it has the primary and secondary impacts on aquatic ecosystem?

The organic nutrients which are important for this ecosystem health which are transported by the rivers are reduced because of the reduced water flow. Causing the low primary productivity in coastal areas where these rivers used to flow and because of that overall ecosystem will also be in danger in this near shore area okay.

Also, this reduced water in the rivers, lakes and reservoirs it concentrates the fish in smaller volumes of water making them easier to catch and reduce the amount of space to hide and available food for growth and all.

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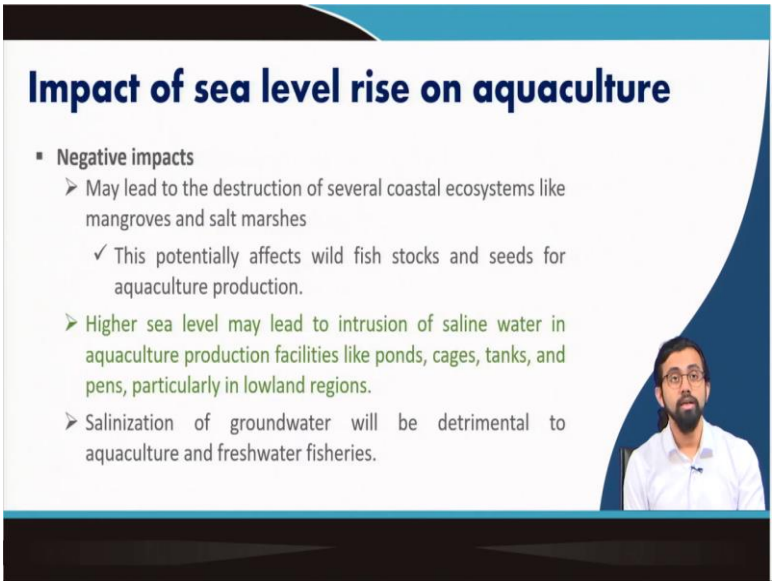

What is the impact of the sea level rise on the aquaculture? I hope you know the reason of sea level rise? I will discuss with you about it in coming slides in general just think about it what can be the negative impact of sea level rise on aquaculture? It may lead to the destruction of the several coastal ecosystems like mangrove and the salt marshes.

If you go to the Sundarbans area world largest delta in the West Bengal and Bangladesh border and India Bangladesh border. In this largest delta region southern part of it is a very rich mangrove forest is there. One type of plant which is very famous the Sundar plant and because of that it is called Sundarban. So, this forest is mangrove area is drastically affected by the sea level rise nowadays. This is also reduced this is also causing changes in the ecosystem in general, it can drastically affect the fish stocks and the seeds for aquaculture production.

Higher sea level may lead to the intrusion of saline water in the aquaculture production facilities like pond, cages, tanks, pens, particularly in the lowland areas and what will happen? Because suppose the species that you are targeting is very much susceptible to changes in the salinity. Once the sea level intrusion, sea water intrusion will happen, because of that salinity will go up and your production will be hampered. Other than that, the salination of groundwater will be detrimental to aquaculture and the freshwater fisheries as well okay.

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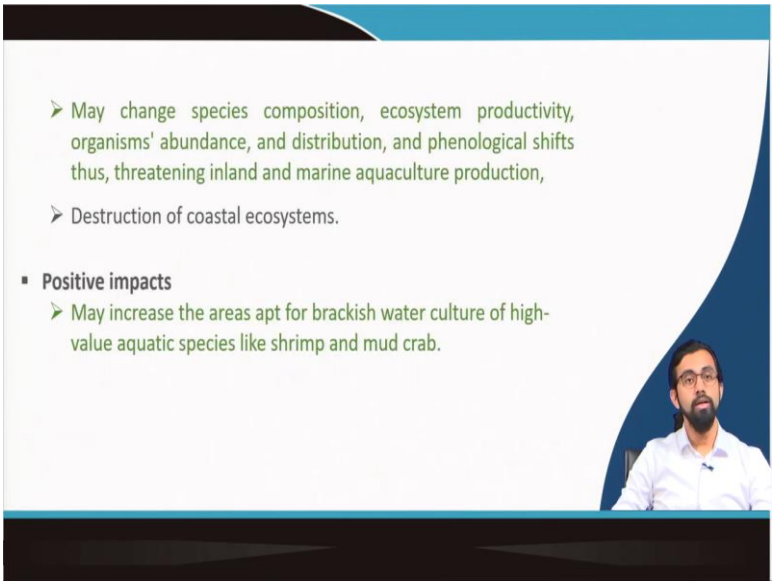

It may also change the species composition, ecosystem productivity and organisms abundance and distribution and also phenological shift thus, threatening the inland and marine aquaculture production in general. It can drastically it can completely disrupt the coastal ecosystem. However, it has as I told you, there is always if there is negative part of it there is definitely somewhere there is some positive impact of it as well.

Sea level rise it actually increase the area's apt for the brackish water culture in high value aquatic species like shrimp and mud crab. Most of the cases we design a ~~tight fit~~ tide fed farm and in the tide fed farm, we try to go ahead with the production of the shrimp and mud crabs.

Because of the sea level rise the amount of this the conveyance lines and all these systems pumping and all these things started becoming this requirement is much lesser than its actual one. Because of that, like I mean like the previous stages, because of that, the production level is increased and with reduced economic application and all okay. So, that is possible in case of sea water rise.

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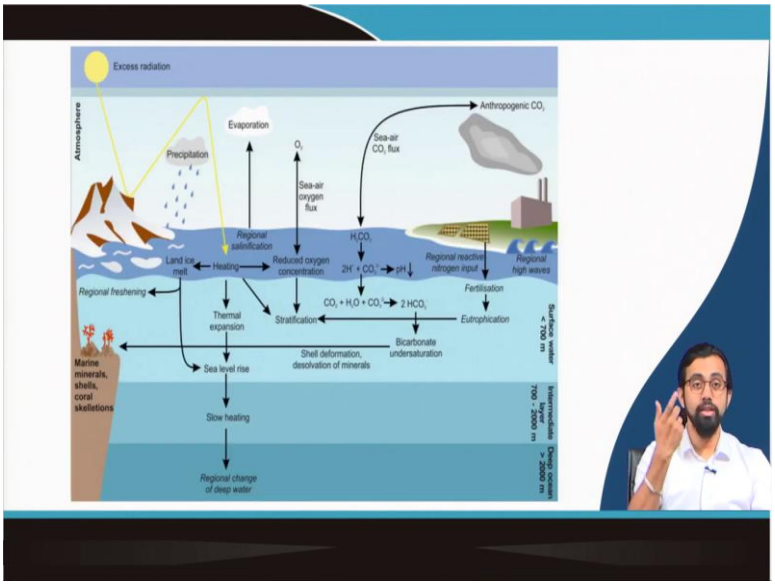

And if you see this picture, you can get an overall idea of how the sea level rise is happening and what are the effects of it okay? See, the excess radiation that is happening and it is bounced back from the cloud and come to the because of the presence of greenhouse gases it increases it heats the oceanic surfaces.

Because of that there is a thermal expansion because of heat the land ice started melting and because of that, there is a chances of reduced oxygen concentration and this reduced oxygen concentration because of heating and land ice melt and because of this regional salinification what will happen? The sea level will keep on rising.

And this thermal expansion will and also this overall heating in general what will happen? It will affect the sea level rise; it will be having a very slow process like which is called like slow heating. The original change in the deep water because what is this slow heating it will slowly heat and a different stratum of your aquatic body. The carbon dioxide because of the anthropogenic carbon dioxide the sea air carbon dioxide flux is increased.

And it will come and increase the bicarbonate concentration which will definitely cause this bicarbonate under saturations and also it will cause the cell deformation and dissolution of different minerals which will cause the reduction in the marine minerals, shells, coral skeletons and all these things.

In general, it will also cause the high regional high waves in the you know your near coastal region. So, all together this is drastically affecting the whole ecosystem, the sea level rise because of different activities because of global warming.

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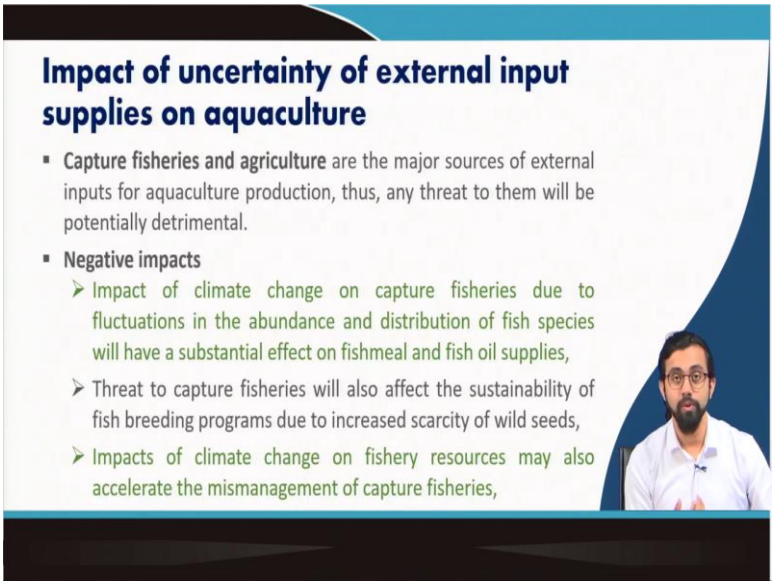

What are the impact of uncertainty in the external input supply in aquaculture on aquaculture? First of all, what do I mean by the external input? First is capture fisheries second is agriculture. These two are the major external input because capture fisheries will give you the fish which can be used as fish meal or fish oil to produce the culture fisheries to produce as for feed or to produce the feed for the culture fisheries right.

Also, different agricultural activities also help the providing the ample amount of nutrient for the aquatic species to survive. What will happen if the capture fisheries will go down or the agriculture will go down, the production of agriculture production will go down? Because of the changes in the climate capture fisheries are getting you know potentially it has a high impact and because of these fluctuations in the abundance and the distribution of fish species it has a substantial effect on fish meal and fish oil supplies in general.

It threats the capture fisheries and which will go which will also affect the sustainability of the fish breeding program due to the increased scarcity of the wild seeds. If you remember we need the brooder species, instead brooder which we normally used to do capture the wild breeders and all them or we can simply catch the wild seeds and we can supply it for our aquaculture production that is not possible because of the changes in the climate. It has the different fishery resources you know may also accelerate like the mismanagement which can also accelerate the mismanagement of the capture fisheries.

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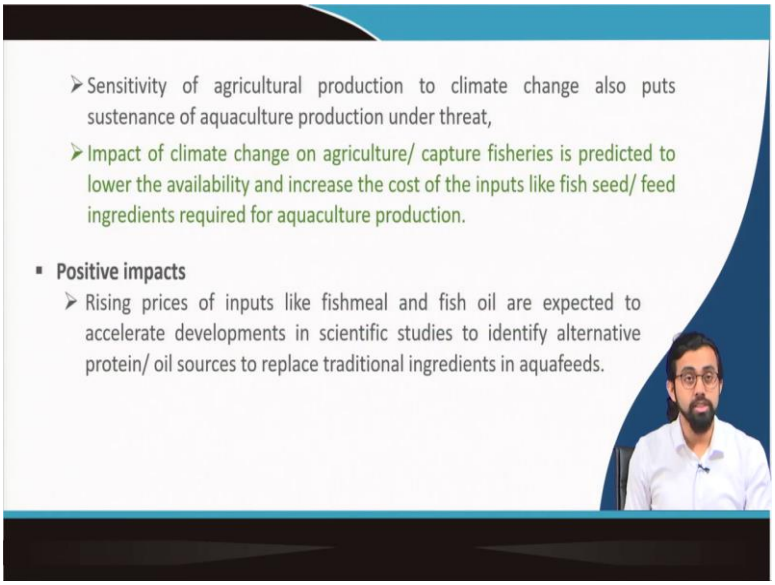

It is not only have an impact on how to say the capture fisheries, but also it will impact on the agricultural production as well the climate change. Because the crop production this getting hampered if I tell you one story about it one example of it. You know the carbon dioxide level is rising in the atmosphere right? because of that some types of crops are actually for them it is not a sustainable situation is not a how to say appropriate environment to surviving.

For them the when the carbon dioxide is getting carbon dioxide level is getting increased in the atmosphere, it is in a stress key to a situation. Once it is in the stress situation, it will definitely affect the overall agricultural crops and production and all. Also, this impact is predicted to lower the availability and increase the cost of inputs like fish seed and fish ingredients which is required for the aquaculture production in general.

What is the positive impact of it? Rising prices of inputs like fish meal and fish oil are expected to accelerate the development of scientific studies to identify the alternate protein and oil sources to replace the traditional ingredients in a aquafeed. If you remember in our sixth module, I think we discussed about different aquafeed and what is the standards, what is the noble aquafeed technologies are people are trying to find out and which way which can replace the fish meal or fish oil in general?

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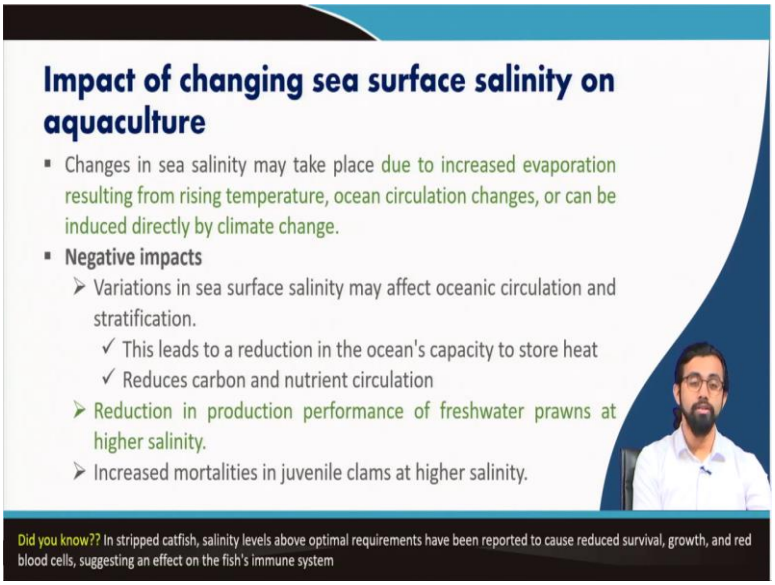

Impact on the changing in the sea surface salinity on the aquaculture, changes in the sea salinity may take place due to the increased evaporation resulting in the rising temperature just try to understand. Once if you remember that pay figure that we discussed in our earlier slide the temperature sea surface temperatures getting increased.

Because of that the evaporation will also be increased, evaporation it will increase one's the temperature will increase. The evaporation once the evaporation will increase what will happen? Suppose you have a water you have a cup of water which is 10 ppm, which has 10 ppm. So just like 10 ppm saline water is there in a cup of water.

Once the water will evaporate what will happen? From say like x a liter it will come down to x by 2 liters. What will happen to its salinity level? It will increase like anything right? because water will evaporate but not the salt ions, not the ions, ions cannot evaporate and because of that the salt concentration will increase.

This is what was happening in the sea surface salinity level as well. The sea surface salinity is also getting increased with time because of the increased evaporation rate because of the rising temperature and also ocean circulation changes okay. What are the negative effects of it? Sea surface salinity may affect the overall oceanic circulation and the stratification it can change the course of wave pattern and all like anything okay.

It leads to the reduction in the oceanic capacity to store the heat okay, it reduces the carbon and the nutrients circulation and also it reduces the production performance of freshwater prawns and the higher salinity. And also, it can increase the mortality in the juvenile clams, in

at the higher salinity and all. In general, higher salinity is not expected because of that your production your aquaculture produce can also be drastically hampered.

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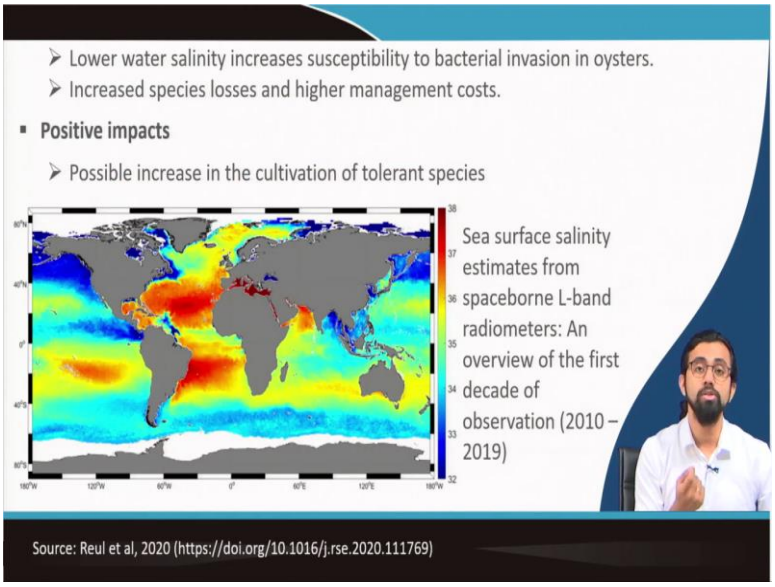

Lower water salinity in the other ways also increase the susceptibility of the bacterial invasion in oysters which is also not good. So you know, I am not talking about only salinity rises a salary lower is also possible and a lower like, reducing the salinity level is also possible because of the climate change and that can have a have an impact on the bacterial invasion in the oyster species.

It can also increase the species loss and the higher management costs and all. And what is the positive impact? Definitely it can increase the cultivation of the tolerant species which can tolerate much higher range of salinity level in the dwelling water bodies and all. If you see this figure sea surface salinity estimates from this space borne L band radiometers and an overview of this first decade like 2010 to 2019 this observation is taken from the source Reul et al 2020.

There if you see the temperature rate sciences like you know 37, 30 this is the salinity level okay, it is PPT parts per 1000, 38 PPT, 37 PPT, 36, 35, 34, 33, 32 something like that. So, the more the reading nature it means the salinity level is very high if you see this Atlantic zone and Atlantic Ocean salinity level is much high the Arabic Ocean is in this place, it is the this in the Mediterranean in this area, Red Sea this is having very high salinity level than the other part of the ocean.

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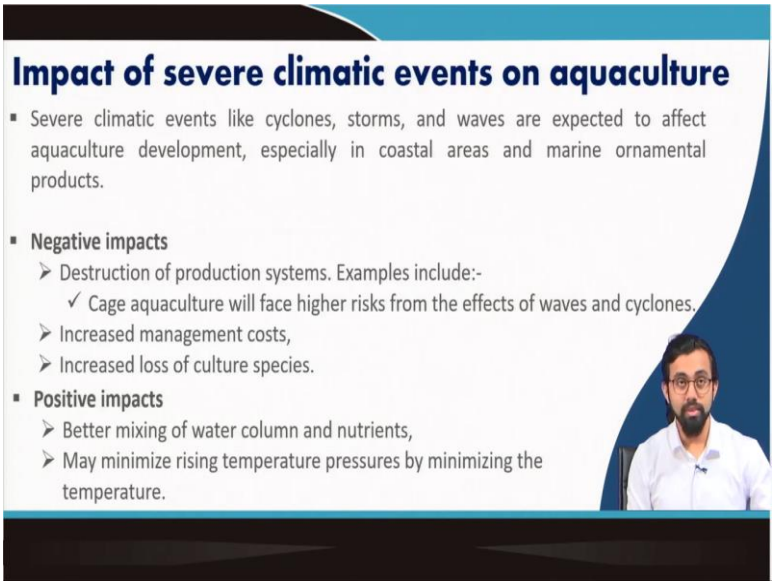

What are the impact of the different severe climatic events on aquaculture? Different climatic events like cyclones, storms and waves high waves are happening okay. Because of the changes in the salinity changes in the water sea, sea water temperatures. And which can drastically affect the aquaculture developments especially in the coastal areas and also the marine ornamental products and all.

What are the negative impact of it there in the ecosystem in the oceanic environment? First, it can drastically reduce the production systems examples like cage aquaculture systems will face very high risk because of the effect of wave and cyclones suppose you have your cage culture in your pain culture in a near shore or say like high sea region.

What will happen because of these high waves and because of the cyclonic activities? Your production will get hampered because not only get hampered right? there is a chance that it will completely destroy your structures. This aquaculture structures that you are culturing that you are having in your in this high sea region or even the coastal regions.

It can increase the management cost it can you can lose the cultures species as well because of these different factors and all. What is the positive impact? It can have a better mixing of water column and nutrients and also it will minimize the rising temperature pressure by minimizing the temperature in general because of this proper water mixing of the water different water stratum and all.

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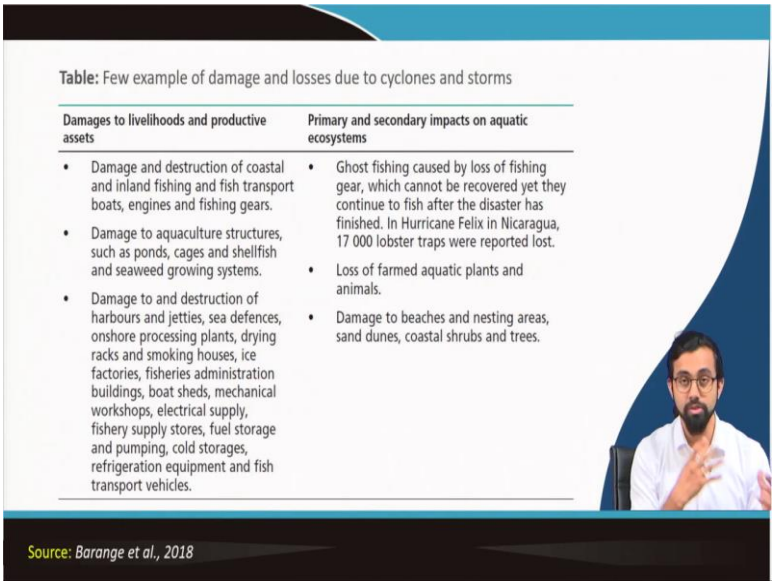

There are some few examples of damage and losses due to the cyclones and storms. Because of the cyclones and storms in general the livelihood like if you talk about the livelihood and the productive assets, it will definitely destruct completely it can destroy the coastal and inland fishing under fish transport boats, engines and fishing gears. It can damage the aquaculture structures as we discussed pond, cages, or seaweed growing systems.

It can damage and destroy the harbors and the jetties and the sea defense systems and the onshore processing plants, the drying racks on the smoking houses and all. It can, how it will impact in the primary and the secondary like its impacts on the aquatic ecosystems. The ghost fishing caused by the loss of fishing gears which cannot be recovered yet they continue to fish after the disaster has finished in like in Hurricane Felix in Nicaragua it happens.

Because of that 17,000 lobster crabs were reported to be lost during this event. And this is called the ghost fishing because of these Nets and all they are still there in that most still they are in oceanic bodies they are capturing a lot of fishes and all they are doing completely disrupting the nearby ecosystem and the ecosystem in general.

Which can lose a huge amount of formed aquatic products and not only that, you can lose a lot of wild aquatic products as well because of that. It will damage the beaches and the nesting areas and sand dunes and the coastal shrubs and trees in general.

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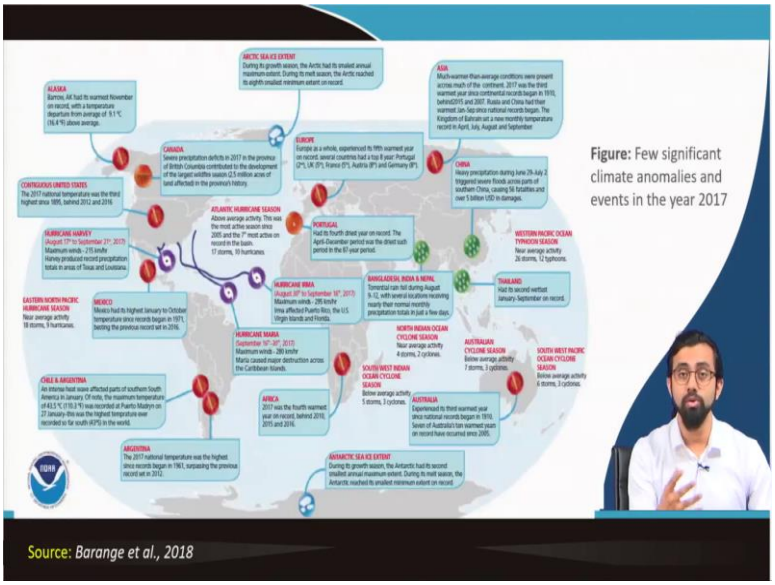

In this figure, if you can find it in Barange et al, 2018. So, they have mentioned few significant climatic anomalies and the events that happened in the year 2017 that you can identify that you can easily understand how much this climate change is happening it is like how much it is how real it is and how it is affecting all the other parts of all the different places in the in the earth definitely in a very drastic way.

Some part is getting benefited in that but the that examples are very few, just to give you a couple of examples in the Alaskan region, if you go to the Alaska regions, they are the it has a in 2017 the November, they have the temper average temperature of almost 9.1 degrees Celsius higher than the average.

If you go to the Canada region, Canada and we will go to the Arctic Sea ice extent and all in the top, if you see the Arctic Sea area, so it reaches its eighth smallest minimum extent in record, and in this during the 2017 growth season, the Arctic had the smallest annual maximum extent, what do you mean by annual maximum extent?

It means the area at which the Arctic this ice sheets are actually extended it is called the maximum extent annual maximum extent. In 2017, it reached its minimum value the smallest value, same way the Atlantic Sea extent also the same. In Atlantic also in the during the growth season in 2017. It also had the second smallest annual maximum extent, which is something to really worry about.

And this is the discussion that we had this is the data that we have it from 2017, in 2021, it reaches further below and it is very something that is to be, people should be very much

worry about okay. And it is not about something only climate change and it does not have it is does not have any influence in your life, you can say okay, this is something to be, only the scientists can think about it, they will be policymakers.

It is it comes from the individuals okay it is not any particular policymakers cannot do drastic changes in it, they can do some stuff, but definitely, your contribution will make a major change in it as well. In general, if you see the oceanic activities in the Southwest Pacific Ocean, if you go to the Western Pacific Ocean go to the Australian cyclone season and all.

They receive around below average or near average amount of oceanic activity, Typhoon activity. They received in general, if I give you an example, in the in North Indian Ocean cyclone season, they received near average activity four storms and two cyclones in 2017.

If you go to the South West Pacific Ocean, they recieves below average activity, only six storms and three cyclonic activity. Now, if you go to the Atlantic region, if you go to the Atlantic hurricane season, there receives much higher than the average activity. There was a most active season since 2005, and seven most active season in record in that region, with 17 storms and 10 hurricanes.

Same way it is like Hurricane, I think you remember the Hurricane Harvey, Irma and Maria, they drastically affect this Atlantic belt. And it changes this, the course of the costs a trillion of amount of like damages. I mean, like the valuation of damages in this region. So, in general, in the European situation if you see the Portugal, if you go in general, they been Portugal, it was the fourth driest year on record in 2017.

And in Bangladesh, India, Nepal they receive the huge amount of this torrential rainfall during the August of 2017. In general, what I mean to say these are only some anomalies that is affecting if you see these are only couple of dots that you are seeing right now, there are thousands of them. Thousands of changes are happening because of the changes in the climate change.

And it is definitely from your basic idea, you can identify that it will definitely impact the human life as well as all the activities that we are doing all the production related activities that we are doing in general. So, it will it will affect the aquaculture it can affect the agriculture and if it will affect this aquaculture capture fisheries, culture fisheries and all.

It will definitely affect the human food behavior and food consumption nature and all. It will increase the amount I mean like the rate of production of food and definitely it will be very hard and the you know how to say the cost of leaving will be will have a very drastic impact because of that okay.

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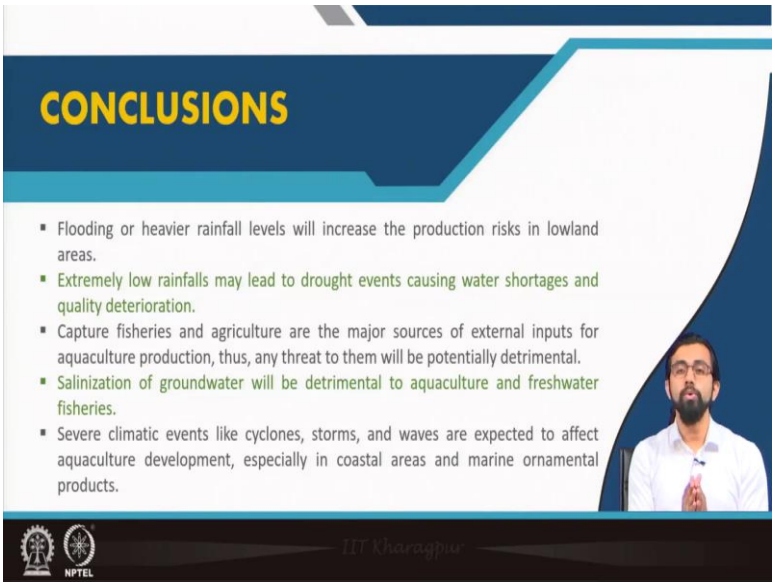

I hope you have some basic ideas some good amount of information about the effect of climatic changes on aquaculture in general. So in conclusion, we can say we discuss about the flooding, how flooding or the heavier rainfall increases the production risks in the lowland areas, we discussed about the extremely low rainfall, also may lead to the drought events and causing the water shortage and the quality deterioration for your aquaculture.

Capture fisheries and agriculture are one of the major sources of external input for aquaculture production, thus, any threat to them will be potentially detrimental for your aquaculture production. Salinization of groundwater will be detrimental for aquaculture and freshwater not only groundwater, but also for which we can talk about the sea water as well. Severe climatic events like cyclones, storms, waves are expected to affect the aquaculture development especially in the coastal areas and the marine ornamental products.

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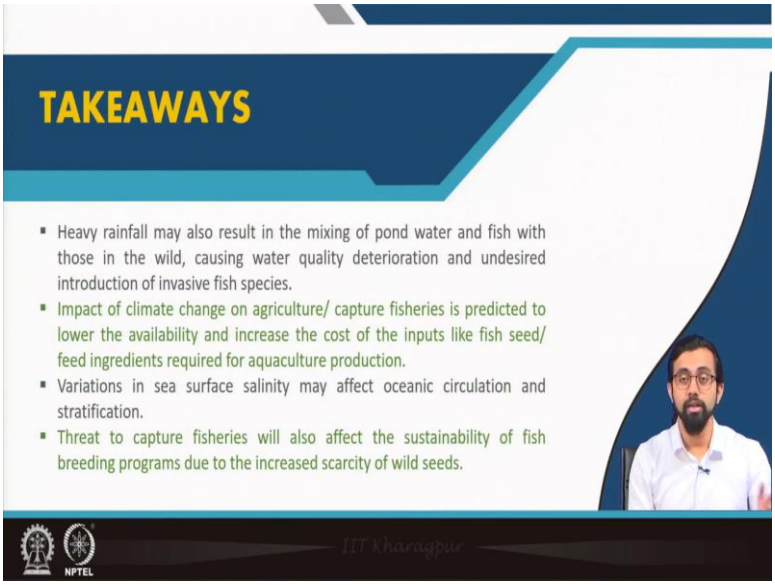

The major takeaways from this lecture matter and I would say the we discuss about the how heavy rainfall effects and changes in the rainfall can affect the aquaculture production. Impact of climatic change on agriculture and capture fisheries, how it can you know interrelated to the production of aquaculture. Variation of sea surface salinity and how it can affect the ocean circulation and stratification.

Also, we discuss about the threat to the capture fisheries, which can have an effect have an effect on the sustainability of the fish breeding program due to the increased scarcity of wild seeds. And in at the end, we discussed about different climatic event different climatic anomalies that we are experiencing in different parts of the world nowadays. And definitely it has a very huge impact on the aquaculture in general.

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So, these are the references that you can follow to get more information about climate change, impact on aquaculture. I hope you get to know some very good amount of information about the impact of climate change on aquaculture and I am very happy that to help you out in future as well okay. So, we will see you in the next lecture. Thank you so much.