Advanced Aquaculture Technology
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Lecture-13
Mariculture

Hello, welcome everyone. My name is Professor Gourav Dhar Bhowmick; I am from the agricultural food engineering, department of IIT Kharagpur. Welcome to the course advanced aquaculture technology. Today, this is the third lecture of module three farming systems; and today I will mainly be discussing about the mariculture.

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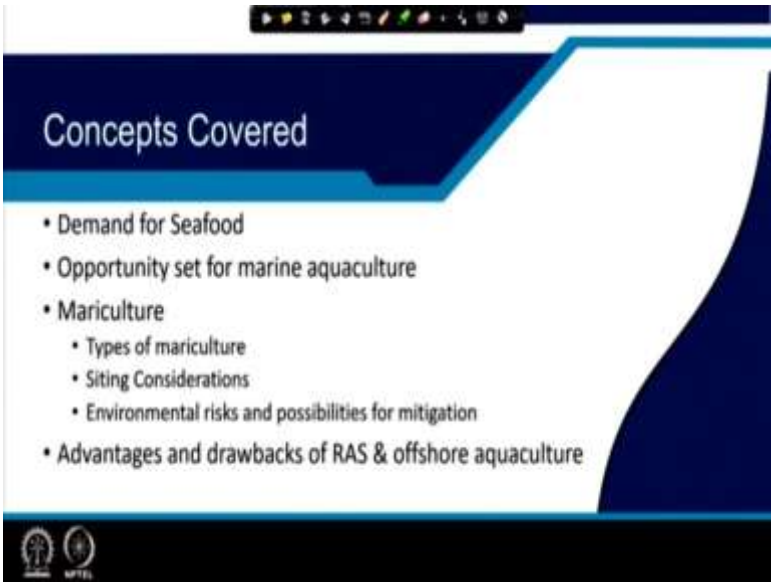

So, the concepts that I will be covering today in this particular lecture is the demand for seafood, opportunity set for the marine aquaculture, the types of mariculture, the siting consideration, environmental risks and the possibilities for mitigation techniques; and advantages and drawbacks of RAS that is recirculating aquaculture system and offshore aquaculture.

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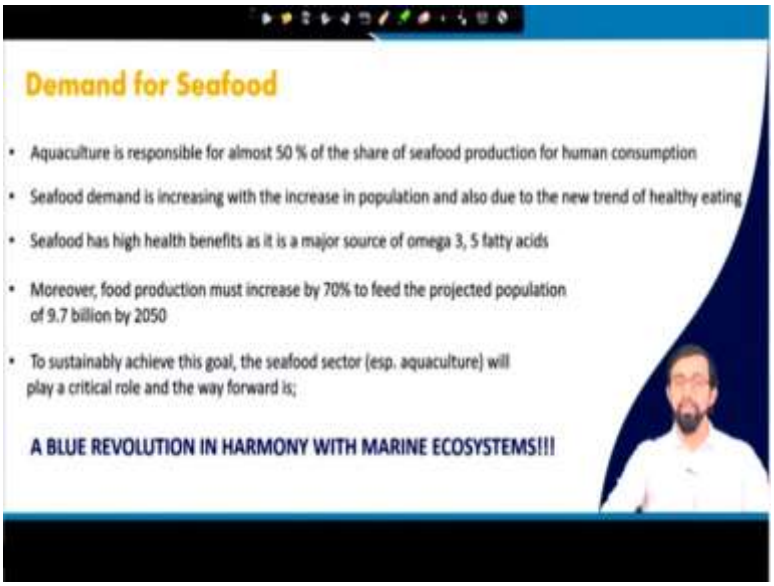

So, in general we know that aquaculture which is responsible for almost 50 percent of the share of the seafood production for human consumption. More like it is it is very recent study actually, but previously, it was much less than that. Even 10 years back also it was not more than 20 percent of the total seafood production; but now it almost equals to the capture fisheries which is like 50 percent of the rest of the seafood production; and which I have discussed in the very first module. The seafood demand it is increasing with increase in population definitely and definitely for this new trend of healthy eating that we are having.

So because of that, we try to be more prone of prone to eating seafood based products and all. And it has actually a very high health benefits because of the major source of omega 3 and 5 fatty acids. Moreover, the food production must increase by at least 70 percent to what it is right now to feed the projected population of around 9.7 billion; and to what right now it is I think 7.4 billion people in 2022. And it will it can increase up almost around 10 billion by by the end of 2050. To sustainably achieve this goal, the seafood sectors especially the aquaculture it, it has to play a very crucial role.

And the main way forward is the blue revolution in harmony with the marine ecosystem. So, the blue revolution is the one that we are right now in in this era and the Government of India is also putting a lot of effort for this blue revolution. We have different technologies related to the blue

revolutions and all and also its harmony with the marine ecosystem; not disrupting the existing ecosystem or not disrupting the environment in general in a general.

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So, in case of like, based on the growth in population, based on the increase in the middle class income and the consumers, they are mainly prone to eating the seafoods and the predictability definitely the desire for consistent quality product year-around; and also the increase in the quality, volatility and the scarcity of the wild product. People are more prone to go for aquaculture based sea products; so, and also the taste and preferences as we already discussed and the food safety definitely.

It is there is a major concern regarding the frequency and the severity of food safety incidents all over the world, and people are more prone to go for the natural products; so natural seafood are becoming a very high demand right now, all over the globe. So, based on all these criteria's and all, I can we can definitely say that the (defini) the demand for the seafood is increasing; it is in a very rising trend right now.

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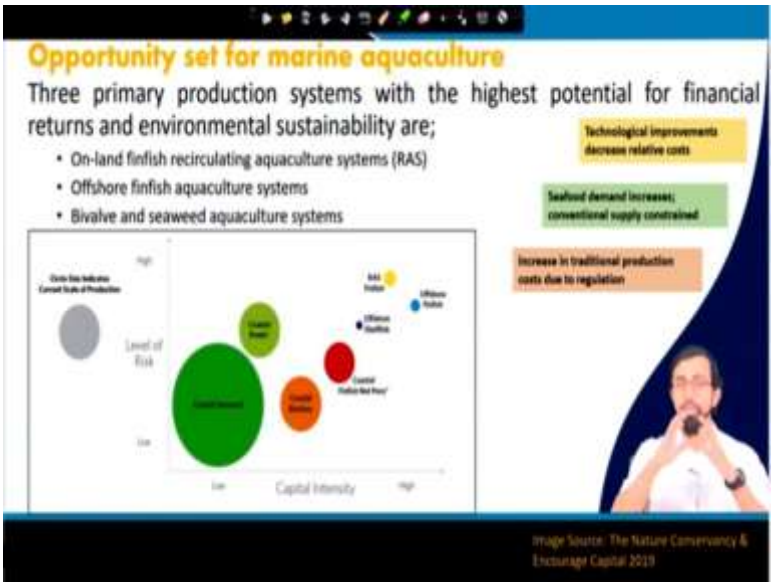

And there are different opportunities which are lies with which lies with this particular sector and which there is a possible especially in terms of Indian scenario, like the coastal region that we have almost 7500 kilometer of coastal coastal link that we have. And if I talk about the area including the exclusive economic zone, it is I think, more than 2 million square kilometer. So, which is like huge and there are possibility of exploring a huge amount of entrepreneurship as well as like you know like the job and all, it is available in this particular sector.

So, Government of India is also putting a lot of effort; so maybe it is better to in next decade or so; this sector will bloom like anything and hold. I really request all the the young generation people right now watching this video to look at look into this matter and try to find out some opportunity. Try to grab the opportunity which lies especially in sub sub Indian subcontinent continental scenario in this aquaculture sector specifically. So, there are 3 primary production systems with the highest potential for the financial returns and environmental sustainability in case of aquaculture systems are first the on-land finfish recirculating aquaculture systems.

Second is offshore finfish aquaculture systems and third is bivalve and the seaweed aquaculture systems; out of all the aquaculture methods aqua aquaculture methods and they the the processes that is available, systems that is available. According to the FAO's recent discussion and all like and also based on the based on the very like, based on the discussions by the resource person all over the world. It was found out that these three particular these production systems, this

aquaculture systems has a very high potential to become a major supplier of the seafood, major supplier of the protein based aquatic species in a very near in the near future.

RAS system you already know already know what is recirculating recirculating aquaculture systems and how it works. So, will know will be discussing about it in details more in later slides, later slides as well as in later lectures in details with the design and all. The offshore finfish aquaculture systems you know the what is offshore is. In this offshore regions when we go for cage on a cage cultures and all. So, there we call it offshore finfish culture systems, bivalves, oysters and all like the seaweeds; the different kinds of seaweeds we know the brown, green, red seaweeds and all.

So, this has a huge potential; I will discuss in details like what is the what are the potentials that lies with this kind of production systems. So, if you see this particular graph in that is particular figure that it shows the abscissa versus coordinate, if you see the level of risk versus capital intensity. The coastal seaweed has a very low capital intensity required at the very beginning stage of its production; also the level of risks is also very less. Moreover, it can also give us a huge amount of environmental benefits and all. Whereas, the coastal ponds, the coastal bivalves, coastal finfish has almost moderate level of risk, and moderate level of capital intensity.

And this this circle size actually showing us the current scale of production. You can see the coastal seaweed production is very high all over the world. But in Indian scenario, it is not yet properly explored. So, there is a high chance of going to this particular sector for there is a there will be a huge bloom in near future in this particular sector. If you go for the offshore finfish and all, the capital intensity is very high and the level of risk is very high. However, you will get a huge amount of benefits economic return also, if you can do it proper sustainable way, proper scientific way.

So, this is also a very high economic return production systems, but it comes with the certain level of risk; and also the capital involvement is also very high at the beginning. So, the technological improvement in decrease the relative cost as I discussed. And also seafood, the more the seafood demand increase the conversion supply will constraint. So, this these are the problems that are associated with this kind of sectors as well. The increase in the traditional production costs due to the regulations and all that also a major issue that we need to address

based on the. We have to convince the policymakers and all to go ahead, so providing us with this kind of solutions.

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If you see, in general, what is mariculture? It is a branch of aquaculture which involves the cultivation of marine organisms in seawater; either it is practiced in offshore, inshore, onshore based system. Offshore mariculture means the enclosed section in the open sea. The what is the inshore? The fish farms build in the littoral waters. And the artificial tanks, ponds and raceways are called normally that we culture in the near to the shore; it is onshore mariculture. If you see this particular figure, if you see this is the this is the this is the surfing zone; if you see the terrace, the burns and the cliffs.

So, this is the call the breakers and after this littoral zone or the benthic zone if you see up to the almost the moment, the depth of seawater becomes more than 60 meter around 200 feet. So, up to that part is called the littoral zone. So, there is you will find a cliff, this is the different very standard nomenclature that you need to remember. The coast area the what is the beach? What is the call the beach? What is the coastal area? What is offshore area? What is near shore? And this is the shoreline you can see.

This is the terrace, this is the surfing zone; this is the high tide and low tide area. That means the in low tide tide low tide region, this is the low tide region and this is the high tide regions; it can go cover the almost the pool of the burns. So, this is this is how it looks like and this is the

standard nomenclature for these kind of aquaculture systems and especially in mariculture systems that you need to remember. So, so other than that the products from the mariculture that have a wide variety of uses like pharmaceuticals, cosmetics, nutraceuticals, food additives, jewelry, et-cetera et-cetera. The major and the minor species found around the worlds coastline is the seaweed, mollusk, shrimp, marine fishes; and the minor is like sea cucumber and sea horses.

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So, what are the types of mariculture? In general, we have this mollusc culture, crustaceans and marine plant, finfish et-cetera. So, will discuss about all these four in details a little bit details. So, in what is mollusc culture? Actually, the if you know the bivalves, especially the bivalve mollusc; so they are how in all the discussions I have covered it in two different by bifurcated into two different subsections. First one is the brood stock or the seed supply availability. Second is the grow out pond or the grow water is necessaries and necessities and all. In the brood stock and all the seed supply if you consider for the mollusc culture, the bivalve mollusc larva are collected from the natural rock in general, using the material to which is normally adhere to.

Then, or either it is produced in the hatcheries using the artificial propagation methods or artificial populations methods. So, these are the two methods by which the seeds are being collected and seeds are been mollusc larva has been collected, larva collected or the seeds are being grown there or collected. And the grow out in general the larva are grown in the hanging cultures, either it is like a suspended from a floating raft or the long lines. We call it is like long

rope and where there would be strings and trays and stacks or the mesh bags will be hanged with it.

So, in general, these mollusc are normally grown in these kind of structures, vertical or rack structure or either I mean like it is a stick like structure, if it will be called vertical if it is like a platform like structure, it is a wrap. The bottom culture the shells, stones, rocks or the cement slab added to the ground, where also they can grow or in the land based systems.

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So, second is the crustacean culture, mainly the shrimps. So, mainly the seed supply for the streams are actually mainly. Previously, it was majorly we are actually majorly relied on this wild caught larva's and all. And but nowadays this in case of hatcheries we are where we are mainly that new trend is like we go for this artificial propagation methods by which we use the varied females; or the egg carried females and then we do the proper brood-stock management and all, we get the larva out of it.

So, the grow-out points where grow-out ponds, the grow-out takes place. In general, the earthen ponds or the concrete raceways or tanks in case of crustacean this kind of shrimps. So, will more discuss about in details and then later lecture about the culture of shrimps and about the culture of this crustaceans, and how to the management of hatcheries. So, marine plant cultures, it also either macro or micro, microalgae or macroalgae, and also the sea grasses. So, major sources of brood-stock is the wild collection definitely.

But, most culture is now dependent on the hatchery collection also, hatchery production in the early life stages also, in different stages of the world. So, they are like people are working on it, scientists are working on it on this particular broodstock management of marine plant cultures also. So, in case of growout, the young plants are cultured in three different method; either in suspended, either in long line or rafting methods, either bottom culture in the sea and the benthic regions where the large rocks or artificial shapes of concrete on the seabed, or the inland tank culture.

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The third, another thing is the finfish culture where the broodstock or the seed supply is mainly from the mix of domesticated and the wild animals. Most of the species are grown from larva or fry produced in the hatcheries though nowadays. The growout, it can happen in the cage culture, it can happen in the pen culture; because mainly we are talking about marine eco mariculture. So, where is the cage culture which is it can be inshore, offshore cages fixed; it can be fixed, it can be floating or it can be submerged.

So, inshore cages are located in protected over shallow areas with the less water circulation; whereas, the offshore cages where they are located in the more than 30 meter of at least the water depth; and where they will be having at least this like deep water and the open areas which less protection from storms but with a better water exchange. So, there is a chance, it has a very high turbulence area. There is chance that it can be in high turbulence area, but we try to protect it as

much as possible; we try to put it in such a way, we try to find a way, find a place in the offshore area where there is a less affected by the sea storms and this high turbulence waves and all. Next the pen culture, the nets or the fish pens are located in the shallow water and their edges are anchored to the bottom.

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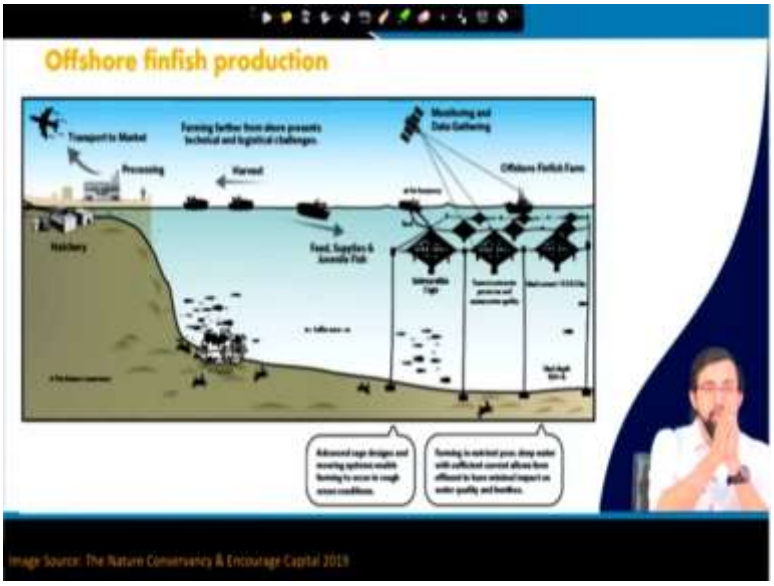

In case of in this picture, if you see this it it shows exactly how it looks like the offshore finfish production. If you see this is the this is only the inshore areas, where this is the offshore area, where either the submersible cages are installed with the offshore. This is the offshore finfish farm where there are different kinds of sensors; nowadays people are putting like the industries, the business entrepreneurs who are working there. So, they put the different kinds of sensors to get a real time data about the existing structure, and about how it can be that all the parameters can be well monitored throughout the throughout the (lifestyle) throughout the harvesting cycle.

And this data is directly connect connected through the satellite to the to the to the inland offices and all; they collect the data and they try to monitor that whether they meet their needs. They need some some kind of human super intervention is needed or not. Or there are some troubleshooting measures which are already installed there; so, these kind of troubleshooting measures automatically starts acting on it. Suppose there is a very lack of additional foods or additional feed. And also there are artificial feeders which are installed there in case of feed deficiency and all. So, they will they can easily operate from the inland office offshore.

So, they can control room, they can control the system and they this automatic feeder starts working; and then they can feed it is like emergency measure, kind of emergency. This is just an example of how the emergency measure look like in this kinds of offshore aquaculture system, finfish farms and all. And after the see feed supply feed supplies and the juvenile fishes are being provided from the land; and they were provided there. And after a while, after it comes to the maturation stage, it is harvested and go to the processing plant; and from there it goes to the market.

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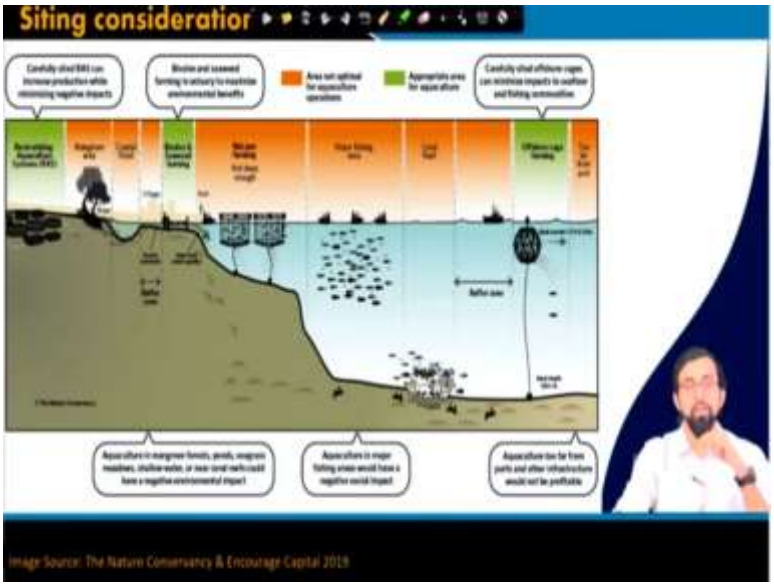

And so this is the, if you see further about what this mariculture looks like in general in terms of the siting considerations. So, if you see this green thing is, green thing is the place where actually we should go ahead and go for aquaculture practices. This this other color this this orange colors are the one where we should not go. These are the ones which are which should be free from any our anthropogenic activities. Especially, anthropogenic activities they mean like you should not go for at least the major aquaculture practices. So, if you see this first first green region is the aqua recirculatory aquaculture systems which you can do in the inland areas in near coastal areas, even in the coastal areas also with artificial island in island.

So, that is a separate thing. RAS, you can do mangrove areas, you should not interfere with the environment; we should not interfere with the this especially the mangrove areas. Mangrove areas are a huge source of carbon sink for us; they consume a huge amount of carbon dioxide,

they sequestered that carbon. And not only that, they helps us to get rid of the all the (unwanted) like all the this in the high tidal situation; or not only high tide, any storm and all, they protect the land from this this storm this is is sees from activities and all.

So, these mangrove areas are the one which we should not dislikes, somehow we should not make any changes to the land, land and all. Also we should not cut the mangrove areas for the sake of aquaculture. That is the worst possible scenario that we can do for the harm that we can do to the environment. Then, the coastal ponds, coastal ponds are very high source of these different kind of mangrove grasses, the sea grasses and all and which are actually very good. They are also naturally there are different kind of different type of fishes, different kind of aquatic species can be made available, which can fed the local villagers and the local entrepreneurs.

So, that is a complete different issues that people can work on it. So, we should not put that thing also in at risk. So, the aquaculture practices should not be followed in this coastal ponds on the village areas definitely. Then, there comes the shallow water regions. In the shallow water regions, where the side of the coastal area; there you can easily culture the bivalves and seaweed. It is a perfect corporate dwelling space for the culturing of the seaweeds and the bivalves; so, we should go ahead with this. It will not only help to give you economic benefit, but also it will give you the environmental benefit as well because these seaweeds and bivalves.

Bivalves, they are actually call the these filter feeders; they I think they they can consume a huge amount of particulate matter from the system. And they can utilize it and they can reduce the pollutant load of the collected that that wastewater that water. And also not only that the seaweed, it can consume a huge amount of carbon dioxide, and it can provide the ample amount of oxygen. So, it somehow it it helps, it is a huge sector now people are working on all over the world in seaweed and by seaweeds.

So, to utilize it as a source of carbon dioxide storage and utilization process, carbon dioxide sequestration process. And then there come the ports and all where major economic activities are taking place; so you should not disrupt their that ecosystem, disrupt their that that that particular systems that. Then the net pen forming and all not deep enough, so we should not go for this pen farming, it is. We we should go for this pen farming which is not very deep and all. We can have

an enclosed space, we can have this enclosed space, we can supply our seeds or we can naturally collect the wild seeds, and we can supply there; and we can have the have our production there.

So, it is not good enough for offshore farmings and all, offshore farming or bivalve. So, this is this is possible; human intervention is it is it is it is done; actually they are in the in the pen net pen farming. But, it is somehow has a lot of environmental how to say the disadvantageous; it causes it has a lot of disadvantages including the environmental disruptions and all. So, normally it is not kind of suggested by the by different by a lot of scientists all over the world.

So, then there comes a major fishing area where actually natural; naturally there are a lot of fishes, lot of aquatic species are available. So, you do not want to disrupt their; you can go there and you can you can collect the, you can just capture the fishes from there. Then, there comes the coral reefs and all; coral reefs definitely it is a very major eco ecosystem. It normally dwell there, so we do not want to disrupt those kinds of systems as well; it is a marine ecosystem. Then, this buffer zone where you normally do not find anything; then there comes the offshore offshore cage farming.

You can go ahead with this theory, you can put the put your cages in multiple cages, and go for a proper farming there. It involves with some capital investment, but it gives you a huge return. And also you do not have to worry about the any kind of. In most of the inputs are actually being somehow suppressed. There like you do not have to supply with the water, you do not have to go for fresh water exchange; you do not have to provide it with the feed. So, it is like you are you are culturing your production, your farm, actually in a very natural situations.

So, you are actually mimicking the natural situation; not only mimicking, actually you are using your farming in a natural environment. But, your production can be very high based on your, you are going to want to go for intensive or semi-intensive aquaculture. And after that, you do not want to go for aquaculture because it is too far from the port; it is economically not viable.

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So, what are the environmental risks and impacts that associated with the mariculture? The first of all, nutrient pollution and the eutrophication; so, that is one of the major reason. I remember, I told you in the last slide that the pen culture is sometimes considered as not a very good idea to go for mariculture process. This is not a good practice actually in general. So, there are people, there are ways of actually recovering those cons by recovering the disadvantages. But, in general, it causes the eutrophication. What is the eutrophication? It because of the because it is it is near to the coastal pens, near to the coastal pens and coastal the banks and all.

What happened? There are like it and it normally we go for the intensive aquaculture. In case of intensive aquaculture, intensive pen culture, they produce a huge amount of this fish faeces and all; and all any aquatic species that were culturing. So because of that, it causes a huge harm to the surrounding ecosystem. Not only that, it is a major, it is a huge source of nitrogen species are being developed here. Because of that, what happened? There are there is a chances of algal bloom. And if it started algal blooming and it this far if they find it very suitable environment for them to grow, they will keep on producing very fast.

At one point of time, they will just completely cover the surface and it will cause the eutrophication. It will cause the sunlight to not to enter to the system to the that particular water body; and that is that is a major that can cause a major harm. So, that is the eutrophication of the nutrient pollution. Harmful algal blooms as I already discussed, there is a chance like harmful

algal blooms can happen and which causes this eutrophication. Spreading of parasites and diseases is very there is a chance of because it is in the wild situation. You do not have any control with the environment any control with your catch; with your I mean with your farming products, so that is a major issue.

The escapes, there is a chance they can they get escape somehow somehow natural because of some natural calamity or natural erosion process. So, they may get this net can get eroded like they can be somehow there is there is a small hole or something; so all the fishes all your farming products will escape that is a major problem. Aliens the same way not only escapes, but alien species alien aquatic species can come in inside the system; and which can also disrupt the whole ecosystem like anything.

Genetical issues, because there is a chance of interbreeding and all, because there is a chances of. This is actually I mean there are possibilities of the mixed culture; this mix culture and like. What do you mean by mixed culture? Here like when there is any alien species are coming inside your system inside your farm. And it because of their the the in the offspring, there is a there is chances of having very weak offspring, which actually causes a very different kinds of genetical problems and all in this kind of.

So, farming up and in the fishing down the food chain, what does that mean? Sometimes there is a chance like we go for farming outside of the food chain or maybe we fishing down the food chain or the food, or the different tropical level. And because of that, the whole ecosystem, this ecosystem that we have this in case of food chain, that can disrupt. Catching the brood-stock from the wild is actually not a good idea all the time. Because in the wild, they may reduce the, the actual number of; because we are when we are catching, we are not catching in one or two; we are catching numbers, so in huge number.

So because of that, it can cause serious consequences in the surrounding ecosystem. The habitat degradation and the modification we are actually kind of playing with the nature here. And we because of that, there is a chances of habitat degradation for the existing dwelling species there. And the acoustic disturbance is definitely there. Acoustic disturbances like nearby places if there is like in a port or something; so they can also cause the environmental disruption to these systems to this kind of our mariculture.

Possibilities for mitigation obviously, first is like IMTA process as we have already discussed integrated multi-trophic aquaculture, that can minimize this kind of problems. Use of the enclosed recirculating systems for shrimp and finfish; definitely you go for enclosed in the inshore this shrimp and finfish culture. Reduce the disease outbreak and transmission by use of medication and different hormonal strategy or the hormonal injection. Feeding management to reduce the waste and to improve the food security. Reduction of the eutrophication impacts by properly supplying or by somehow arranging the system pen in such a way in such a place, where there is a certain amount of water flow.

And because of that it can get rid of the all the obnoxious particles or the pollutants along with it. So, somehow we can have a reduced in eutrophication impact. Proper site selection is very important as I already discussed; the use of hydraulic devices to get rid of the water in the gravity through gravity, or the through proper way. So, through conduit systems and all, removal of the harmful algae; so we need to think about it. We need to really worry about the harmful, so not to have the harmful algae in our system.

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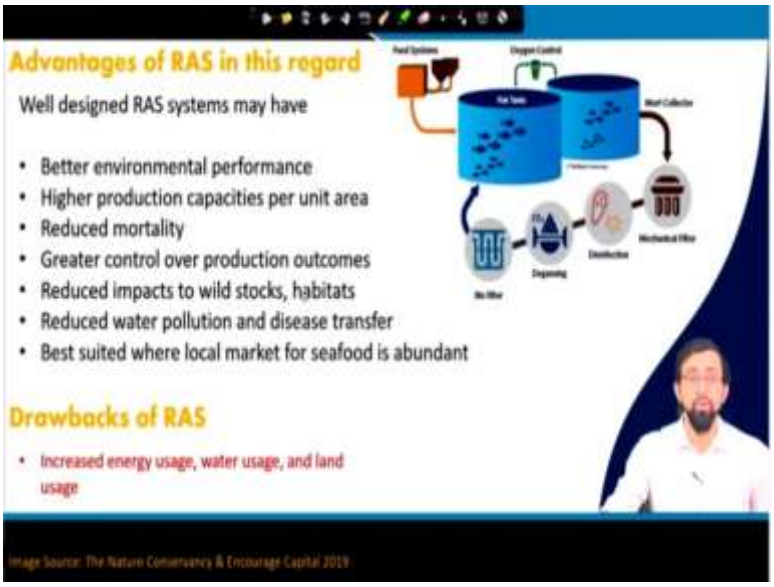

So, based on all these things, why we should, why still I prefer to request you to go for RAS systems which is much better than all the other aqua mariculture systems. Especially, the in case of RAS systems is recirculating aquaculture systems, you can develop the streams and all; nowadays it is possible. It gives you a better environmental performance because you are doing

the aquaculture practice in complete environmental security, in a complete optimal situation. So, because of that, you are actually controlling the environmental impact. And it can also give you a huge high production capacities per unit per unit area.

Definitely, because of the control situation, you can reduce the mortality rate. It will give you better control over the production outcome. The it can reduce the impact on the wild stocks on the habitats as it happens in the mariculture in general. It reduced the water pollution or the disease transfer or alien like an alien species intermissions. So, best suited for where the local market for seafood is abundant; so it is it has a lot of benefits this RAS recirculating aquaculture systems.

But, it comes with the drawback like it need, it needs actually huge amount of energy; and it needs a huge capital investment at the beginning. And however if you can design it properly, it can give you other benefits as well.

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So, what are the advantages and drawbacks of the offshore finfish production in general? It improves the feed conversion ratio. It improved the disease control it has offshore. I mean when we talk about offshore mariculture that is the best that is one of the best aquaculture practice in a like among the mariculture or the other mariculture practices and other. So, there are these three things you have to remember; first is RAS, second is offshore finfish, and third is bivalve and seaweed, these three are the future.

In aquaculture sector, these three are the future where we can get a maximum benefit out of it, without disrupting the environment at all. So, it offshore finfish has different other benefits as well; it improves the product quality, it improve the water quality and site availability as well as reduce the user conflict, and use the unit cost. Because, of the vast place already available in the sea high ocean. But, it comes with the high risk and a high capital investment. So, which we have to really have to worry about; and it needs a very high scientific scientist intervention or proper designing, so that we to get the maximum benefit out of it.

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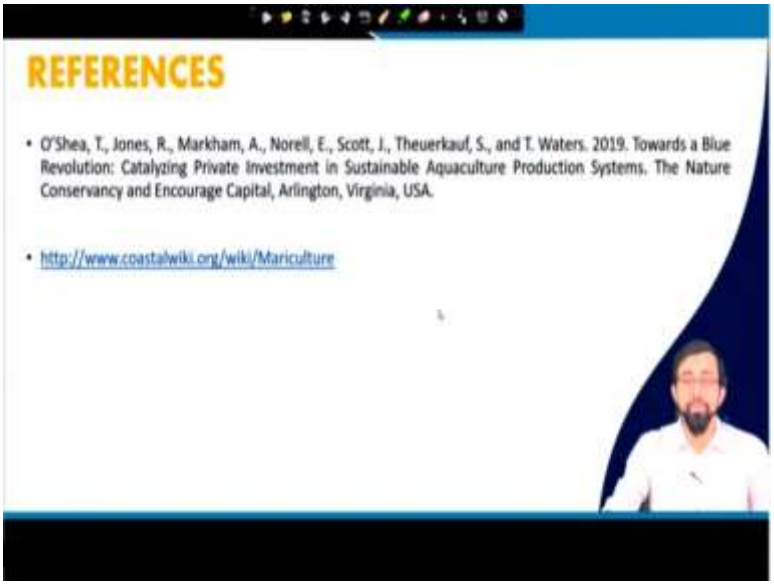

So, in conclusion, because of the freshwater scarcity in many areas of the world, it is expected that mariculture eventually will become the dominant form of aquaculture. And transforming how we produce a seafood through strategic investment in innovative more sustainable production methods, which will lead to a healthy, abundant and profitable food systems. These are the references that I have used in this particular lecture material. Thank you so much. See you on the next lecture.