Advanced Aquaculture Technology
Professor Gourav Dhar Bhowmick
Department of Agricultural and Food Engineering
Indian Institute of Technology, Kharagpur
Lecture - 02
Topic - Aquaculture Systems and Input Factors

Hello everyone. Welcome to the second lecture series of module 1, Introduction to Aquaculture. My name is Professor Gourav Dhar Bhowmick, from the Department of Agriculture and Food engineering, IIT Kharagpur. In continuation with the discussions that we had in the last lecture, I will share here, I will share the aquaculture systems and the input factors in this particular lecture.

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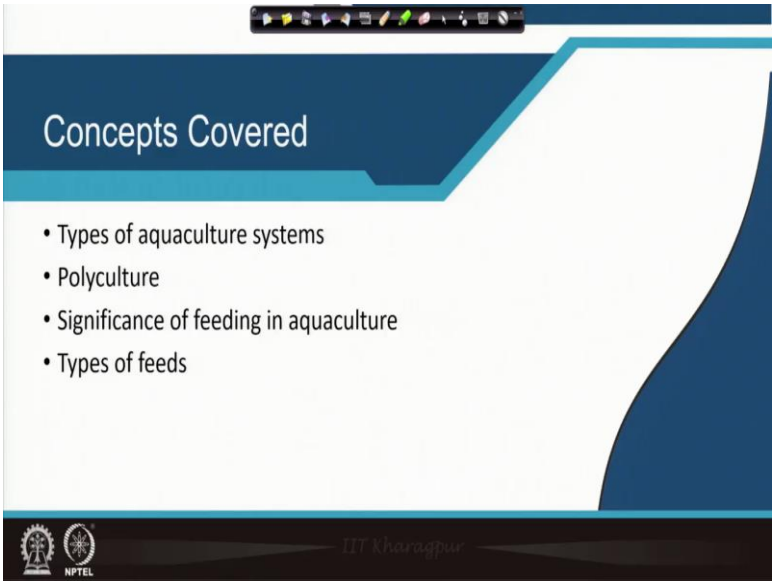

So, what are the concepts that I will be covering in this particular lecture is the types of aquaculture systems, what is polyculture, what are the significance of feeding in aquaculture, and what are the types of feeds that we normally use in aquaculture systems?

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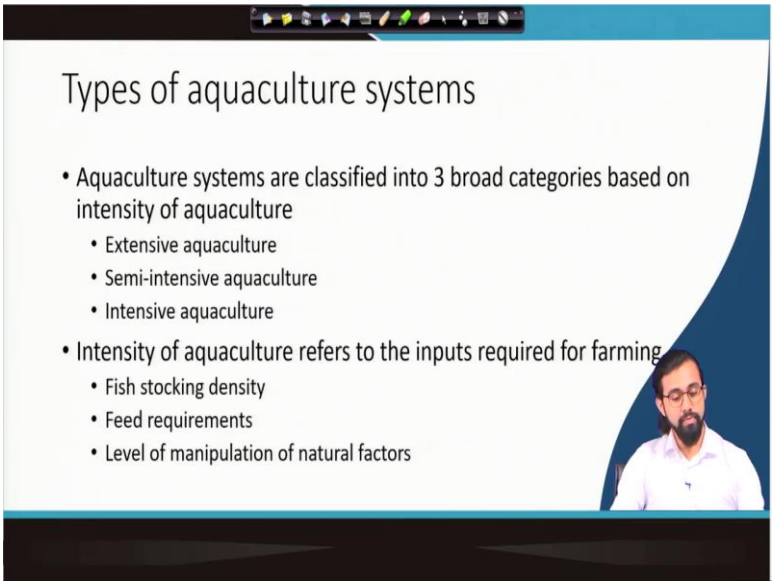

So, in general, the aquaculture systems classic is like it is the systems are classified into 3 broad categories. The first one is extensive, the second is semi-intensive, and the third one is the intensive aquaculture. So, what is this extensive, semi-intensive and intensive aquaculture? I will show you in later slides.

Other than that, the intensity of this aquaculture that we are talking about based on which this these broad categories are being classified, they are actually based on the inputs required for farming. First of all, the fish stocking density, second is the amount of feed that you need to provide with the time for that specific culture spaces or whatever the number of species that you are culturing there, the level of manipulation of natural factor. These three basic inputs are actually very much responsible for the classification of these 3broad category of aquaculture systems.

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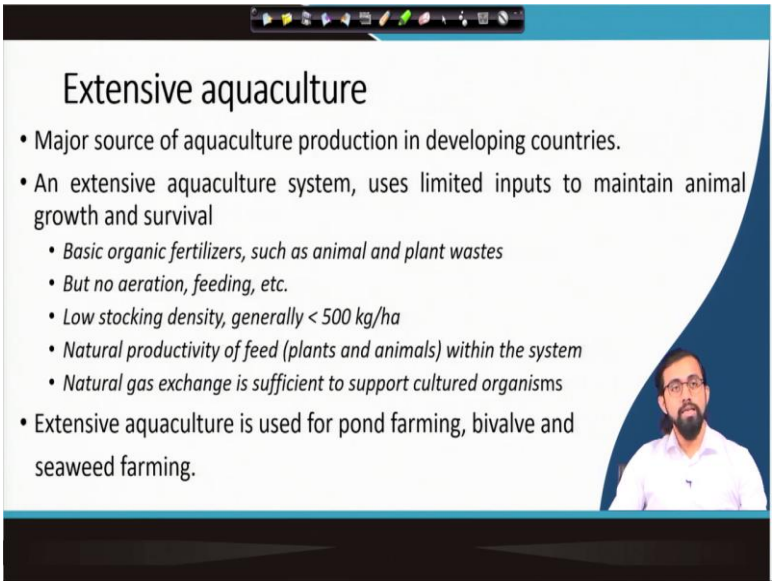

So, the first one is the extensive aquaculture. If you must have seen like we earlier days people used to do the aquaculture, even in the developing countries nowadays also like in India also we normally do it the aquaculture in a large pond or the large lake where we, not large lake, a small lake and the large ponds and all way we normally provide try to provide the seed in the system, introduced to seed into the system. And what happens because it is extensive size, because of all the natural benefits that is available in the system, because of the very low stocking density that the all the cultural species that we are introducing, they have.

Because of all this reason what happened, this extensive ecosystem doesn't need much of an anthropogenic activity, we do not need to involve much and very minimal inputs are needed for maintaining the this features go growth or the Aquatic species growth and the survival. Basically, the all the in case of extensive aquaculture systems, very basic organic fertilizers use time to time if even if it is most of the cases is not needed. When even if it is used, it is only the animal or the plant wasted, we simply just throw it into the water body. We don't need any additional aeration, feeding, nothing because the aeration and feeding these are the major economical factor that involves with the aquaculture economics, which we do not have to worry about in case of extensive aquaculture.

It has a very low stocking density as I already told generally less than 500 kg per hectare, you know hectare 10,000 square meter. So, other than that, the natural productivity of the feed like the plants and animals within the system is actually used for the whatever the culture species that you are producing there or culturing there. Another important thing is the as I

already told the aeration is not needed because the natural gas exchange is happening. From the atmosphere whatever the dissolved oxygen that is required for the culture species to survive in your system, in your aquaculture extensive aquaculture systems, its ample enough. So, in general, we do not have to go for this additional aeration cost and addition aerator installation in this kind of extensive aquaculture systems. They are normally used for pond forming, bivalve and seaweed farming in general.

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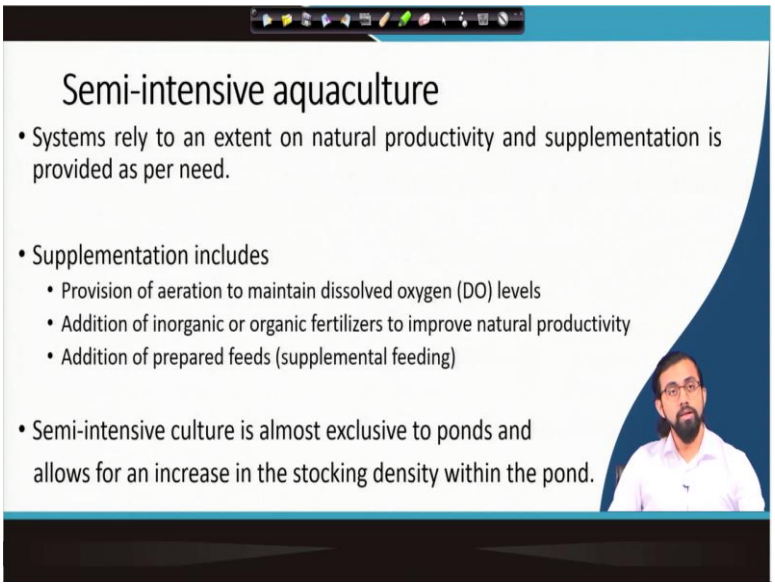

The second is the semi-intensive aquaculture. In this particular type of system, it is not extensive like it is not completely rely on the natural productivity and supplementation, but it rely up to an extent on natural productivity and supplementation and additional feeding or additional aeration is provided only if it needs.

So, in that particular case, we call it semi-intensive aquaculture systems. So, there are provisions that you have to ready with, so that you can provide the aeration, you can start the aeration to think like the your culture species is struggling with the available oxygen. Or you can just provide the aeration time to time basis to maintain the dissolved oxygen level of your tank or of your culture unit.

Addition of inorganic or organic fertilizers to improve the natural productivity, addition of prepared food, it is called supplemental feeding, it is not that is very much necessary and you have to provide each and every day, it can be very, the duration for alternative feeding can be very high. You can even not do that. If you think like if you your aquaculture system has ample amount of natural feeds available for its survival. It is almost exclusive to ponds and it

allows for an increase in the stocking density within the pond. So, it is not something that we normally target in the tank or the raceway systems.

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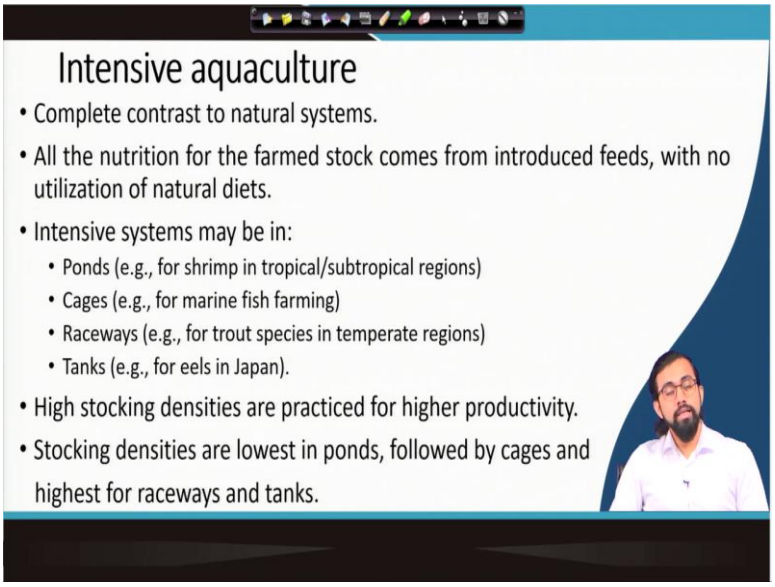

The third and the most productive one and also in ways it was one of the notorious one at one point of time, but now with thanks to the advancement in the technology, now, we have cracked that the problem that the major issues that we were facing with this intensive aquaculture. This is actually completely contrast to the natural systems, it has a very simple you know a food chain, you provide food, then only your culture spaces will survive then otherwise not. So, there is no hierarchy in the food chain in this particular type of aquaculture systems.

It can be these intensive systems may be in the ponds example shrimp in the tropical and subtropical regions, cages in the marine fish farming, the raceways. In the temperate regions, they go for trout species, culturing of the trout spaces, they do it in the this intensive aquaculture systems. In the tanks, in Japan, they produce eels in the tanks so that also this production of eel is actually they producing in the intensive aquaculture facilities. All the nutrition in this farm stock, it is actually comes from the introduced feed and no utilization of natural diet is at all present in this kind of aquaculture systems.

Very high stocking densities are practiced with a very higher productivity and yield. However, it comes with a lot of additional issues, lot of additional economic environment, so, that I will be discussing later slides. So, in general, if you compare, like the intensive aquaculture in pond, intensive aquaculture in cage or intensive aquaculture in raceway or

tanks, the stocking densities are lowest in pond, followed by cages and then the highest in the raceways and tanks because in raceways and tanks, we have, how to say, more of a flexibility to control the environment to control to make optimal situation for your target species to survive here.

So, once you have that control in your system in your, for your target species to survive in your system, then it that is why the stocking densities are very high in this case of in this case is like raceways and tanks whereas in case of ponds it is very low.

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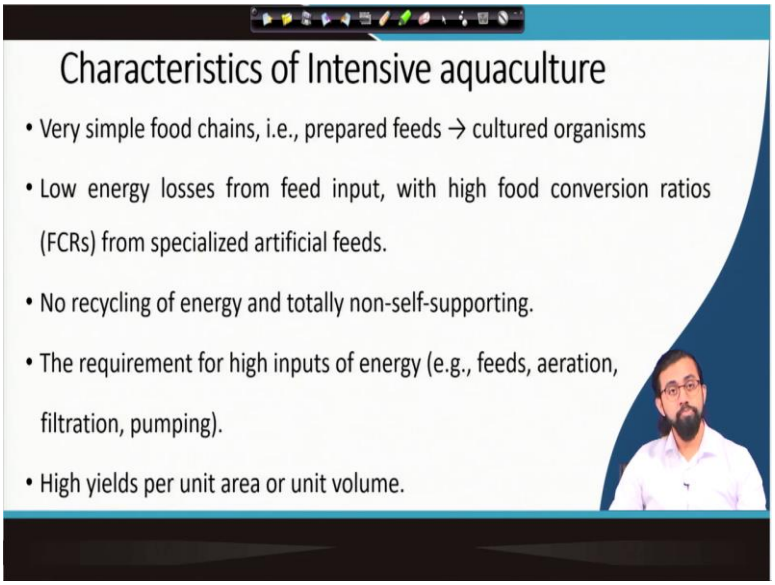

As I discussed the characteristics of intensive aquaculture the very a basic one is like it has a very simple food chain just prepare food, supply it, your organism will survive otherwise, they do not have any other source to other source of food in your systems because your culture density is very high, stocking density is very high. If you want to have a good amount of production, you have to go ahead with the preparation of proper amount of food and supply that particular feed to your cultured organisms time to time and you have to take care of that feed demand for your culture organism ecosystem.

In general, the low energy losses from the feed input with high food conversion ratio from specified artificial feeds can be achieved in this kind of, in this kind of culture systems. What does that mean? Suppose you go for extensive aquaculture or say semi intensive aquaculture systems, in extensive we do not want to, you are not going to put any feed. But in case of semi intensive you can put feed, you can put feed time to time supplemental feed if it requires, but whereas you are not you cannot be sure about the food or the feeds or the feed

that you are providing. The nutritional, the benefits that it has, whether it is actually transfer to the person who is consuming that fish or not, what does that mean?

And also, like see, first of all the fish it has to consume that feed so that that fish that is food conversion ratio has to be very high that fish, that food has to provide ample amount of nutrition for that fish. And then there comes another type of food conversion ratio that we considered that is not the thing that we are talking about here.

But in that case, we also talking about the how that biomass that is present in the fish are actually being utilized when we assimilate that organism, assimilate that particular culture species or not. Anyway, so, in this particular case, what we are talking about the food conversion ratio of feed to the fish biomass or to the culture species biomass. Okay, So, because of this specialized artificial feeds, this ratio can be very high.

Earlier days, like you know a aa like people use natura l even the seaweeds earlier they use, the normal seaweeds, they simply put it into the system and then try to do to, make it make it used as feed for some type of some particular type of species aquatic species. Later on, they find out like why to utilize the seaweed, let us go for, they dry it, they make a proper feed out of it, they make it in such a way that the ultimate product is very, like they can consume it much better. They this conversion ratio for their ultimate biomass is like in a fish biomass is very high if you can make it in a specialized way. And then you supply it for as feed.

So, it is just an example that I am giving like, so, these kind of scenarios are we were facing earlier days, but now, still research is going on to make it make this fish feed in this in a proper proportionate way so that it can be highly beneficial for the target species that you are culturing in your system.

So, in case of intensive aquaculture, no recycling of energy at all and it is totally non-self supporting, what does that mean? It completely depends on the higher high input of energy that you are providing to the system, because see, is just a normal stagnant water body or say like a running water body, but there are some cultural species that say, they do not have any other resources to utilize.

So, where from they get this resources. Artificial means by means of anthropogenic activity like we do, we provide them feed, we provide them aeration, so that the dissolve oxygen level will be higher, we provide them with the filtration techniques, so that the whatever the wastewater that is generating from that system can be filtered.

So, this filtration system also you have to provide because unless until you filter the water and you use it the aquaculture species they will be in stress, first of all, they will be in stressed for time because they cannot sustain more ammoniacal, nitrogen or any nitrogen species present in the aquaculture pond or aquaculture tank or else whatever you are using.

So, they will be in stress, first of all, second, they will die. At the end if it goes up to a certain extent they will die. So, filtration rate is one of the major factor that plays a major role here in aquaculture sectors. Otherwise, what you have to do, you have to get rid of the water, you have to go for fresh water exchange and which comes with a lot of price. Because you cannot fresh water does have a huge price nowadays because fresh water does not come easily. So, especially, if you talk about the rural urban areas if you want to have your own farm aquaculture farm in say like near in urban or say like semi urban areas, the water cost is very high.

So, you cannot just think of doing all this aquaculture activities aquaculture sector development unless until you come up with some adverse solutions. So, I will discuss about all those solutions in later a days I mean later lectures, where I will show you like what are the advanced technology that is developing by the scientists all over the world to treat that to improve this filtration units and to treat that wastewater.

So, that is freshwater exchange consumption is very, like it comes down to almost 0 nowadays. There are pumping because definitely like when the fresh exchange is there, there must be somewhere the sources and you have to use the power to get the water from that source and to utilize it in your aquaculture tank.

So, what is the major advantage, why still people are looking for this intensive aquaculture system is the high yield. It has a very high yield per unit area or unit volume of the aquaculture tank that your aquaculture tank or the rest with that your aquaculture or pond that you are utilizing.

So, because of this high yield, it comes with a very high economic benefits as well. So, once it comes with benefits, it can easily surpass all the requirement all the economic requirement that it has the inputs that it has for the energy or for the supply chain and all. So, it can easily, we can easily a you know neutralize this demand and not only neutralize we can somehow improve the amount of yield and we can get economic benefit out of this kind of systems.

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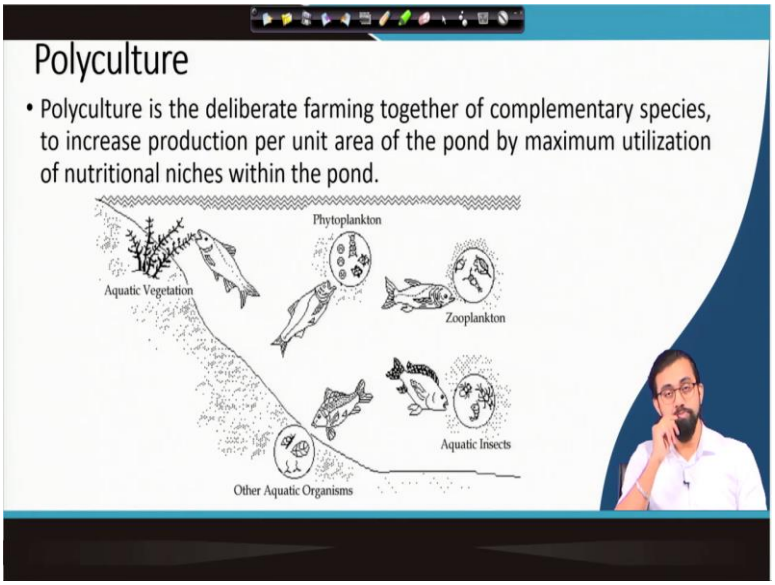

The next thing that I want to discuss about the polyculture I think we do not go for single culture anymore, because in order to utilize the whole pond system, because see, first of all, there are different type of aquatic species, they have different zone of dwelling. What they do, like there are a couple, there are types of fishes who prefers to stay in the surface of the water body.

And they only go for this larva's, they go for this the phytoplanktons and all. There are some there are they can be even piscivorous as well. But there are some type of fissures or equity species they normally try to dwell on the column or the middle zone we call it, we call it column dwellers.

Okey So, in the column dwellers are there who try to stay not in the surface, not on the bottom, but more in the middle area, like the column area we call it. Then there come the benthic zone where, which is like almost on the bottom of the tank or the pond, where there are some dwellers who love to stay there and love to have feed by the all the, they normally there in the benthic zone only.

So, if you go for a culture system, if you go for developing a farm, aquaculture farm, you definitely want to utilize all these sectors, you do not want to go for culturing a species which will only stay in the top whereas you can increase the productivity, increase the yield, if you can start doing two, three culture species culturing together and let them have their feed they will not interact with each other's feeding like habitats and they do not go for, there will be no conflicting feed for this kind of species.

Not only that there are fishes who loves to have phytoplankton, who loves to have zooplankton, some of them likes to have the aquatic insects, some of them likes to have the aquatic organisms or the detritus in the benthic region, some of them like are only herbivores, they only likes to have the according vegetarians present in the in your culture system.

So, based on this, all these requirements, all this, you would just go before you target your culture spaces, you try to understand their habit, you try to understand their food habit, you try to understand what they prefers, where they prefers to stay, what kind of water, what kind of like a food requirement that they have, based on that you go for a deliberate farming practice, where you increase the yield like anything.

In a same water body, go for polyculture, increase the yield of the same water body that you are using earlier time, by just utilizing a proper science, you use the science, you change the you utilize the more amount of species in your system and make a maximum yield out of it. So, that is how this polyculture works.

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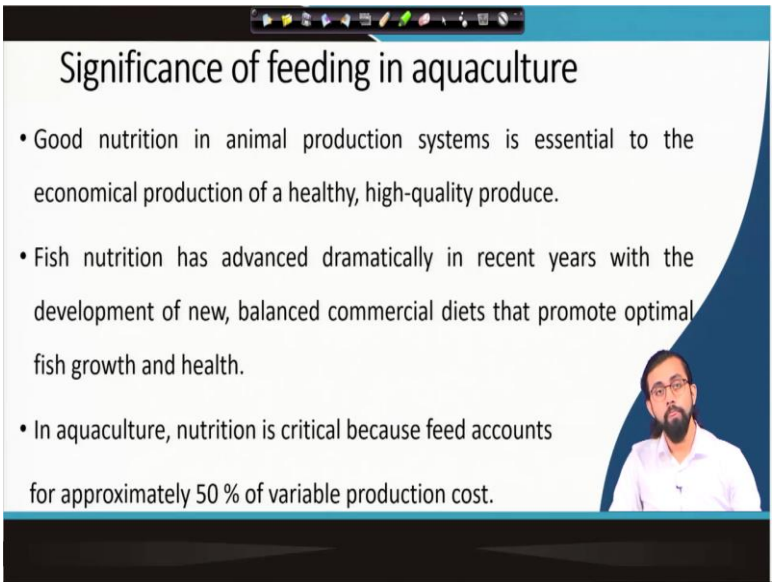

So, next thing is the feeding. Why feeding is important like in specially in case of extensive aquaculture, we do not have to worry about it because it is naturally being taken care of. In case of semi-intensive and intensive aquaculture we have to take care of the feed. So, first of all, if you want to have a high-quality produce, healthy produce, you have to have a good quality feed we have to supply them with a good quality, simple enough. Good nutrition in the animal production systems is very much essential for the proper economic production of a healthy and high quality production or the yield for your system, it is very well known fact.

Second thing is like this nutrition is critical because this feed the amount of the cost involved with this feed actually it accounts for approximately 50 percent of the variable production cost of a any farming systems. So, unless until you have a proper nutritional balance you maintain in your feed, unless until you have cheap systems available like low cost, but sustainable systems available for production of the feed or at least the supply of the feed in a system, it can cost you a lot, it can cost not only cost you a lot, it can it involved with everything, good amount of it gives you good production, good economic benefit also.

So, it is not always that you can go for cheap food and cheap low-cost code and low-cost nutritional input if you give to your fish, it will also give you the low income, it will also give you the low yield and which comes out as not beneficiary at all. So, this is a very important. Fish nutrition it advanced dramatically in the recent years in the last couple of decades and it now the new balanced commercial diets are available which can promote optimal fish growth and optimal health all over the world.

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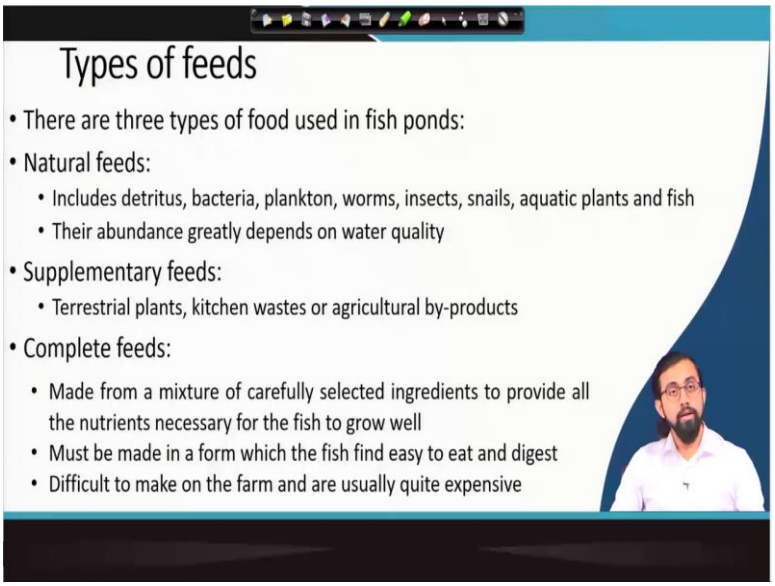

So, let us talk about the type of feeds that is available. So, normally, there are three types of food used in fishponds, natural, supplementary and complete feed. What is natural feeds? So, natural feeds, it includes the detritus which normally stays in the bottom of your tank or on whatever it is. Bacteria, it can be suspended one, it can be attached growth walls, whatever it is. There are planktons, it can be phytoplankton, it can be zooplankton, worms, insects, snails, aquatic plants, fish, etcetera, etcetera. Why I am talking about fish as a natural feed because fish can be feed for their higher chain features as well or other higher chain aquatics species as well. So, they can also be a feed, they are also a natural feed in aquatic systems.

Their abundance greatly dependent depends on the water quality. It is definitely because suppose in case of natural feed when we are talking about if suppose you are having a offshore culture or say if you are having a cage culture in a brackish water, where it is like river mouth, where river is or the estuary region, where the river is actually reaching the sea. In that region, it is very rich in nutrient, different nutrient, why what is the reason because it is coming down all the way from the mountain and washes out all the possible things from the villages, cities or whichever it passes.

So, at the end, when it reaches the sea, at that poor moment at that river mount, they have a huge amount of nutrition is present there. And this huge amount of nutritions, nutrition actually demands like it actually that it is beneficial for the four different types of varieties of aquatic species, you can see they dwell there because they love to have the abundance of food is already available. So, it depends on the water quality and depends upon the place where you are culturing your things.

First of all, if your water quality of your culture species suppose like if you are having a same pen culture, same cage culture in a same brackish water, but it is coming from the wastewater it is coming it is having it is near to a mouth river mouth where the wastewater from the local municipality or the local industry is actually pouring.

So, that wastewater has say like different kinds of xenobiotics, different kind of unwanted endocrine disrupting chemicals and all, what will happen, these chemicals will affect your yield because definitely your cage culture whatever the species that you are targeting there, it will not survive here, it cannot survive there because of the higher amount of the pollutants that it receives. So, natural traits is it depends on the water quality as well.

In case of supplementary feed, we normally provided to whom in case of semi extensive, semi-intensive. In case of semi-intensive, what we do, we provide it with terrestrial plants, kitchen waste, agricultural byproducts. But make sure it does not contain any chemical fertilizer or chemical pesticides. Whatever the byproducts I am talking about it should be organic in nature supply to the to your tank or to your aquaculture production, it will be very much healthy it will make a very healthy ecosystem in there in your pond.

The third thing is called the, it comes to complete feeds. Complete feeds are the one which you have to have in case of intensive aquaculture systems you have to it should be it normally

made from a mixture of carefully selected ingredients to provide all the nutrients necessary for your aquatic species to grow properly healthy and well.

So, this is actually target specific, target species specific, why I say target species specific, suppose you are culturing say like bivalve for bivalve you do not have to worry about feed at all not much, say you are culturing any others other than fish you are culturing some say like any small fishes and all.

So, when you are culturing any small fishes and all, you have they have a very higher feed requirement, okay, but their feed has to be has the size which is good enough for them to swallow or for them to utilize them to have it. You cannot have a system or you cannot have a fish feed, you cannot have a fish feed which is not sufficient enough which is not you do not have the ingredients which are good enough for them to have it and unless until they will have it they will die and definitely it does not make sense to provide this kind of thing. So, this must be taken in the form so that the fish is they find it easy to eat and digest and difficult to make and the form and in sometimes quite extensive quite expensive in general this.

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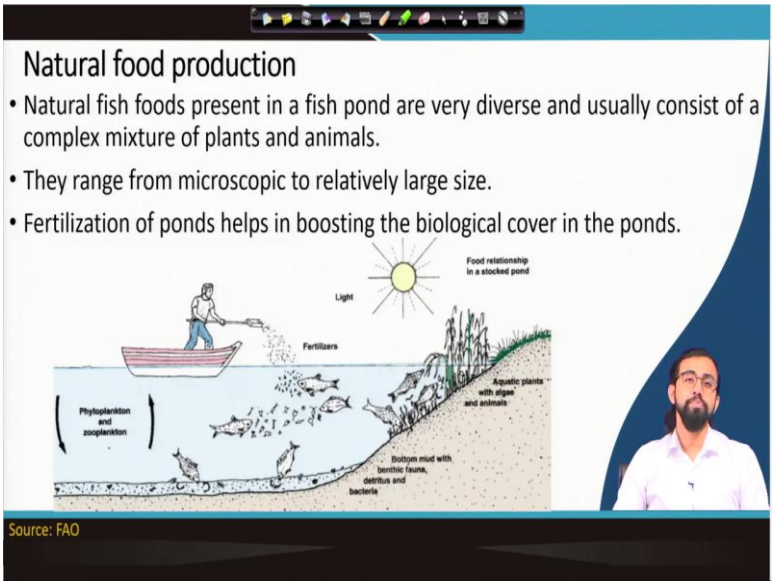

As I discuss about this natural food production. In general, natural fish foods present in the fish pond are very diverse usually consist of a complex mixture of plants and animals, they range from the microscopic to the relatively larger size. Fertilizer of ponds, we normally go for this fertilization sometimes time to time, it is not something that we are introducing a feed or introducing a fish feed to the system. We are actually trying to fertilize the system. So, by

means of fertilizers like it is like sometimes we introduced some iron-based compounds. So, what it will do? It will help to grow the phytoplankton in the system.

So, once it will help to grow the phytoplankton in the system, it will definitely helpful for the all the phytoplankton loving an aquatic species or say like zoo plantains which are actually in the higher tropic in the supply chain, sorry, in the food chain, then accordingly the whole system will evolve, whole system will be beneficial out of it. So, that is why sometimes we can provide the fertilization we provide this to boost the biological cover in the ponds.

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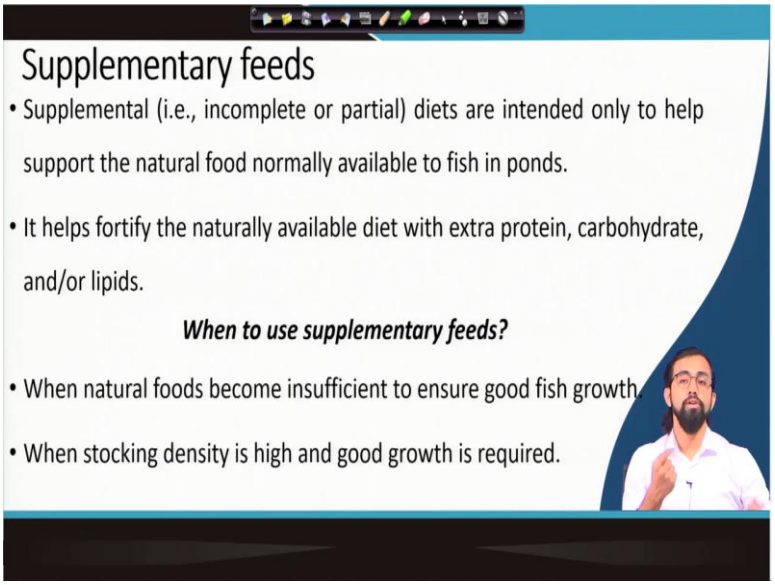

The second thing is supplementary that I already told you it is like it is incomplete or the partial diet which are intended only to help to support the natural food which is already available in the pond and so that the fish will not feel in stress that they do not have ample amount of food available for them to survive. It fortify the normally fortifies the naturally available diet with extra protein carbohydrate and all lipids. When to use supplementary plates, when you see that it becomes an insufficient it is the natural foods are insufficient at that particular moment of time to ensure proper fish growth or proper aquatic species growth.

At that moment, you have to take care of it and you just go for supplementary just you just need to supply it, there are you have to do it continuous monitor continuously monitor your farm and you have to make sure that fishes are not in stress and if it is then provide them with a natural foods. When the stocking density is very high and the good growth is requires at that moment of time also you have to provide them with a supplementary feed. So, suppose you have a very specific amount of say like 100 kg per unit area, you have a production and

all of a sudden you think of having like due to market demand you increase it to the 200 kg or select 300 kg per unit area of the pond or the tank or raceway that you have. When you try to increase it to these two or three times, you have to supply it with these supplementary feeds.

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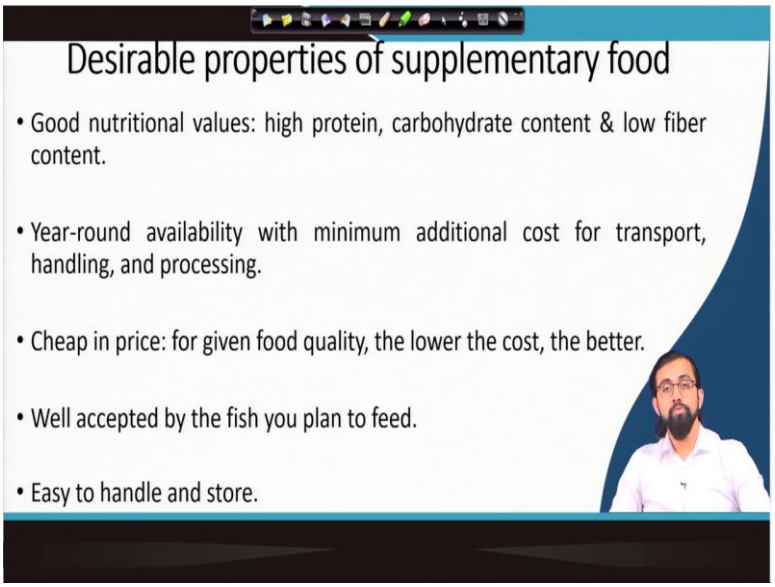

What are the desired properties of the supplementary feed? It has to have a high protein carbohydrate content, very low fiber content, it should be around availability should be there with minimal additional cost for transport handling and processing. It should be cheap in price for given food quality and lower the cost is better obviously like for the, from the economic point of view. It should be well accepted by the fish, you plan to feed because for them it is a sudden feed, it is like they are faced all of a sudden you providing them with a new food and all.

But if you suppose who does not like that particular type of food, if you supply them, they will like no, I am not going to have it like they will not find it cause and they will not find they are not going to have it and that does not solve our purpose. And also, it has to be easy to handle and store.

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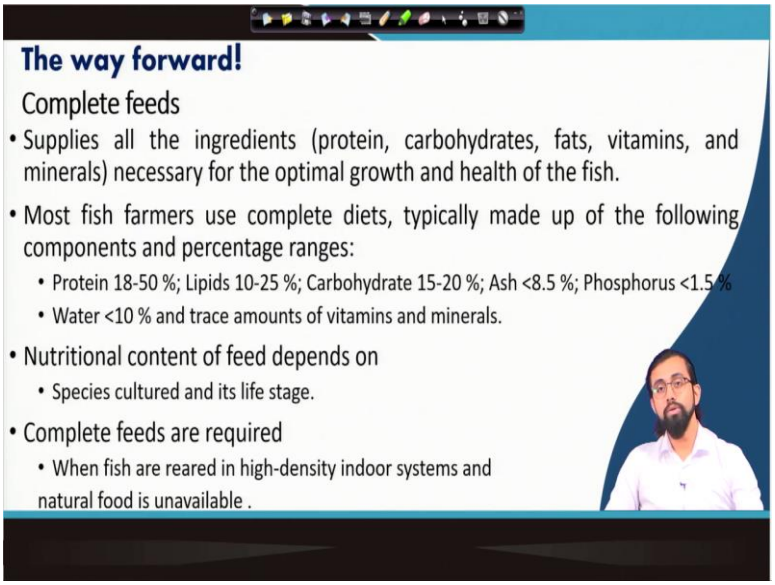

So, the way forward, the complete feeds, that is the feature. So, you have to because especially because we are talking we will be talking about intensive-aquaculture all lecture long in the coming lectures also, where we will be discussing complete feeds. Complete feeds should have all the ingredients, protein, carbohydrates, fat, vitamins, minerals.

Like at a particular ratio which is very much beneficial for the optimal growth and the health of the fish. Most of the fish farmers they use the complete diets typically made up of the following components like the protein has to be around 18 to 50 percent, lipids 10 to 25, carbohydrates 15 to 20 percent, ash content less than 8.5 percent, phosphorus content less than 1.5 percent, water, try to make it less than 10 percent.

I will discuss about it in later slide like what is different type of fish feeds and all, there are type of weight feed, there are type of moist feed, which has a quarter content can be as high as 30, 40 percent as well. They are also do, There also do, people are using those kind of fish feed as well. And obviously crash amounts of vitamins and minerals which are beneficial for your target species that you are culturing there.

The nutritional content of the feed it depends on the species you are culturing and its life stage, definitely it depends on the life stage, you are not going to give a enough when it is fingerling amount of food that it requires for its adult stage. So, most of the feed will go wasted and it will cause the environmental harm, nothing else and the wastage of money. So, complete fish are required when, when we want to rare high-density indoor systems and where natural food is completely unavailable.

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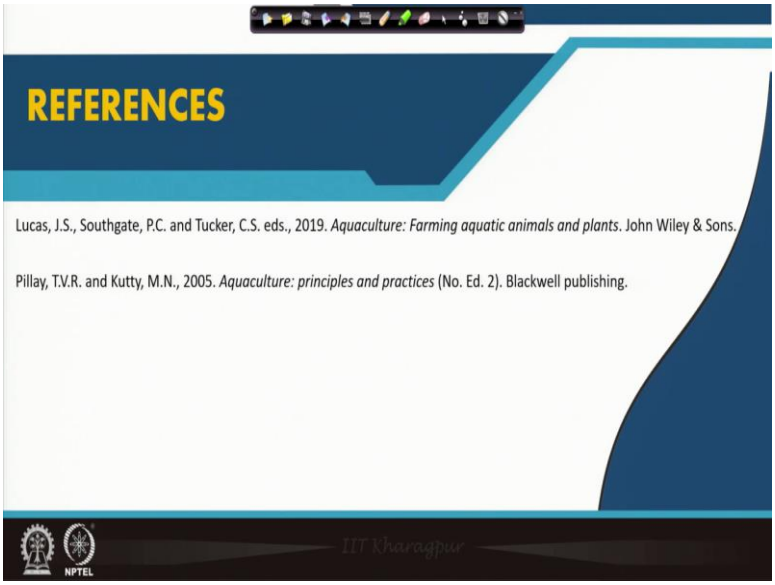

So, these are the references that we use while preparing the slides. You can use you can go ahead with the studying these papers and this research papers. If you need I can share you these slides in these lectures, research papers as well with you so perhaps to, for you to have a better overview on the system and all. So, that is it for the day for this lecture. Thank you so much.