**Sustainable River Basin Management**
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**Module 2-2**
**Part - 03**

Welcome everybody to Sustainable River Basin Management, part – three of module two-two.

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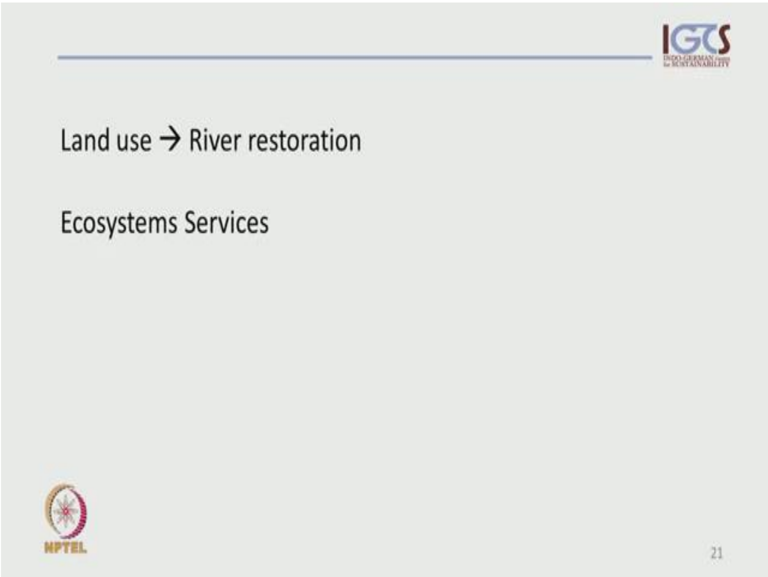


Today, we will be speaking about land use and river restoration and ecosystem services.

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Let us first of all look into what we, why river restoration may become important. And we last time talked about equilibrium, river systems and steady state river systems and natural processes, shaped, over shaped by human or wild life or flowing impacts. And this time, we will be using the term unstable rivers and talk about this.

What do you mean by an unstable river? Some saying like this, where the river banks are breaking, where there are slums taking place, where rivers are eroding in a way, that would not be the natural erosion ((Refer Time: 01:23)) in a, in a certain region. That erosion can take place and affect house, housing construction, roads and other urban systems, for instance, or may eat away very fertile land and that was important for agriculture. Now, what is problematic about is, that the water quality is negatively influenced. We use habitat, we destroy or change floodplain functions due to unstable rivers, we cause land degradation and we also change water availability.

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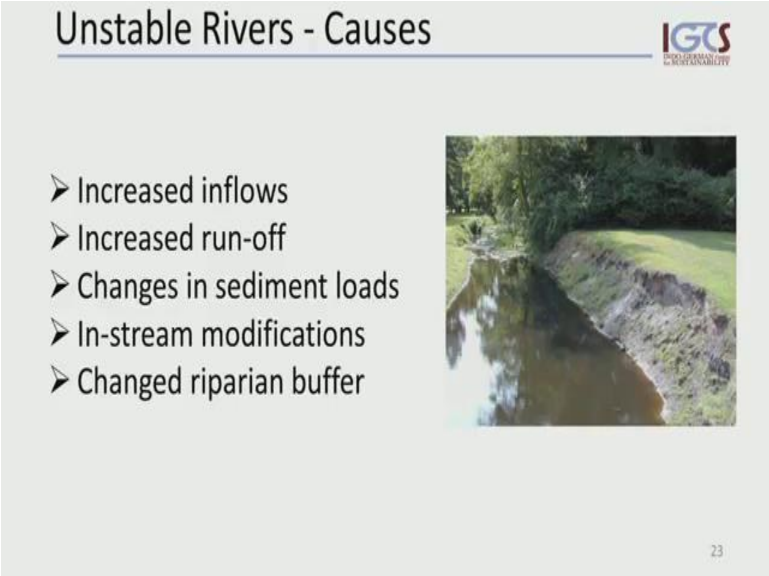


What causes such unstable rivers? And we can see an example here, where the local level is high here and in very recent times a lot of erosion has taken place and formed such a steep river bank within a very short time. The causes of this could be an increased inflow. We can speculate about where this inflow come from, it could be an increase run-off. Again, we will talk about it a little bit later. It can be the result of a change in sediment loads, it could be the result of in-stream modifications. It could also be the result of a changed riparian buffer.

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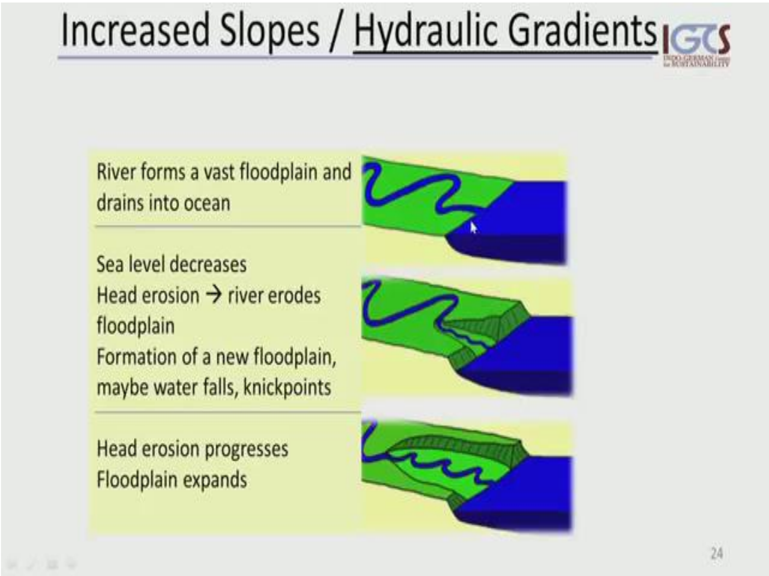

Now, let us look into the impact of increased slopes and hydraulic gradients. And I am not only using the term slope here, but also hydraulic gradient reminding us to the fact, that surface water and groundwater are connected. And changing groundwater levels means changing hydraulic gradients, which have a direct impact on what happens on our surface. So, floodplains made it rain fast, for instance, or areas, which used to be dry may become wetlands due to changes in hydraulic gradients.

Now, what the very generic model is which, from which you can depart and analyze any other system? We have two stages and in this case, the first stage, river draining into the ocean reaching the base level. It is meandering through a floodplain.

The second stage would be if we would lower the water level in our reservoir here, that we increase, we create a gradient here. We increase slopes and by that we increase head erosion, head erosions taking place and moving upstream. The river erodes into the floodplain and we form a new floodplain here and we have an old floodplain here and then, we may see waterfalls here or we may have, certainly we have an additional knick point here.

So, this is simply the side of that using that base level here and as it progresses, this uniformed floodplain becomes more established and or we developed an own watershed here, which increases the catchment of this part of the river here. So, just a minor appearing, minor change in slope here and change in base level has, can explain many of the river system features that we have observed in our real life.

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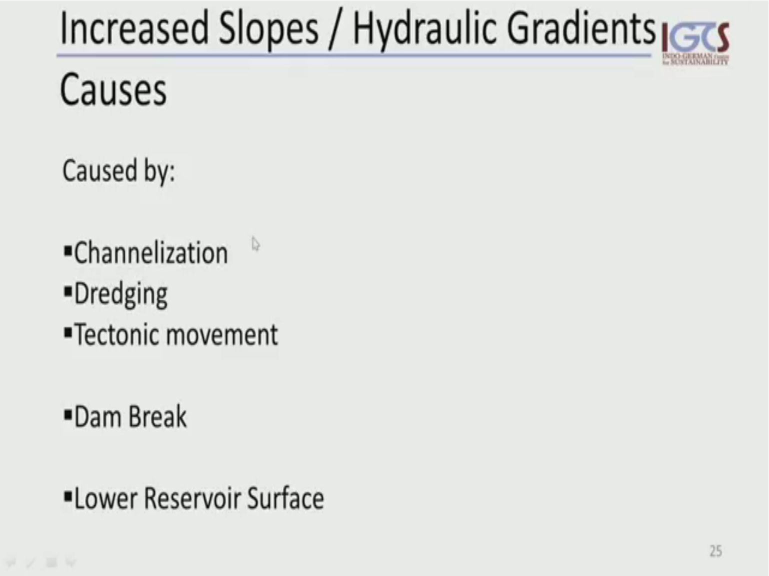


The situation maybe sometimes more complex, but the model actually is quite applicable to most of the situations. What are the causes of these increased slopes? They can be caused by our intervention, it could be because we channelize, we state in our rivers. It could be because we are dredging rivers, while to be dredging we may want to make ships, allow ships to pass through our river systems to reach far inland, to transport goods.

But that could be the result of tectonic events, but it could also be the result of dam break, it could also be the result of the lowering of reservoir surface. So, we lower our local base level, we increase our local flow velocity. All of those increase our slope and increase the instability of our river system.

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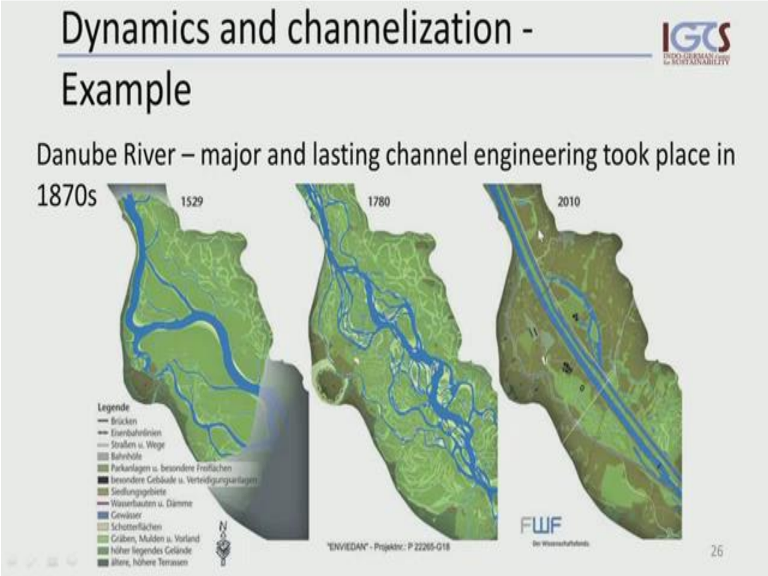


Let us look into examples of such change in dynamics and the results of channelization. We have, I have chosen here example of the Danube River in Europe. It is one of the major river, it is the major river system in Western Europe and it has been, have been trials to tame that river for over centuries, which were mostly not lasting long in 1 year. It is the next rainy season or flood season, all these effects of building birches and connecting islands.

And then, it was possible to use old maps, going back to the 16th century and to establish what the river system looked like at that time, the area of today's Vienna, the city, large city of Vienna and the river system in the late 18th century. What you can see here is, that this all before the major changes, major lasting engineering achieved reconciles, that the main, there was one main channel here and several smaller ones and which drained most of the water in some temporarily active ((Refer Time: 09:11)) high flow appears active channels somewhere here. And this changed completely over these few 100 years. And this formally active channel became abundant in Oxbow and the main channel moved shifted to this northward area. Probably, this has been going on for as long as the river accessed it.

What the result is of today's engineering or the last centuries, two centuries of engineering is a straight river. Looking almost like a road, like a highway and it has become a highway for the transport of goods and people to the cities, city area and some leftovers, for probably also some land use purposes in this part here. So, it has nothing else to do anymore with what the system used to be in the past.

Now, this has come along with a lot of cost, it has some proof for shipping, in transportation. Also, the usage of this land, more could be urbanized or used for agriculture purposes however. Because the canal was straightened, flow velocities increased, channel erosion increased and such fast moving systems are less able to cope with high flow events, those flood events, which still breaks those banks and floods now urbanized areas.

So, for that reason and for the health of the system itself, the aquatic life, the water quality issues, a lot of, renaturation of, rehabilitation is taking place to reintroduce or reconnect some of these older existing channels of the Danube to the main channel again.

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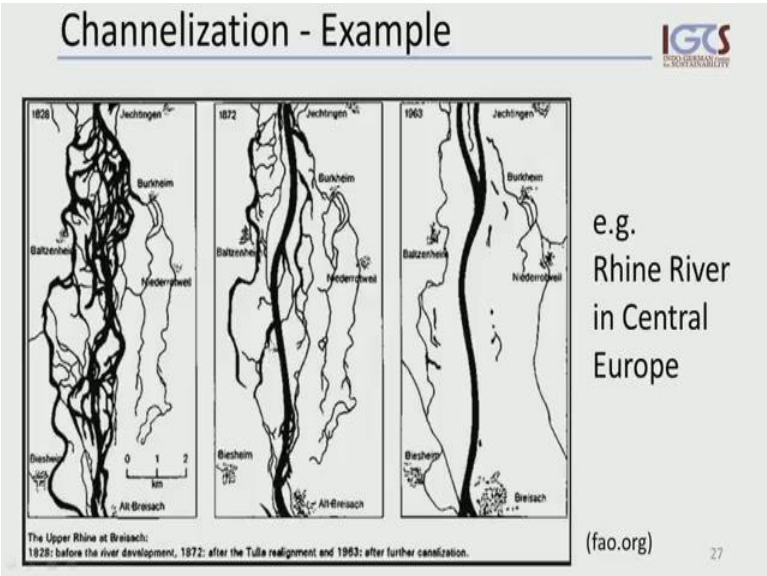


Other examples, which look similar, extreme of Europe, the Rhine River is one of the major examples, where the Rhine, the river bed is actually eroded to about 6 meter below the former surface, which shows the impact of increasing, straightening a river and increasing flow velocity in such an area. And again, due to do floods and water, quality issues, large efforts go now into reconnecting the main canal to some of these former, former streams.

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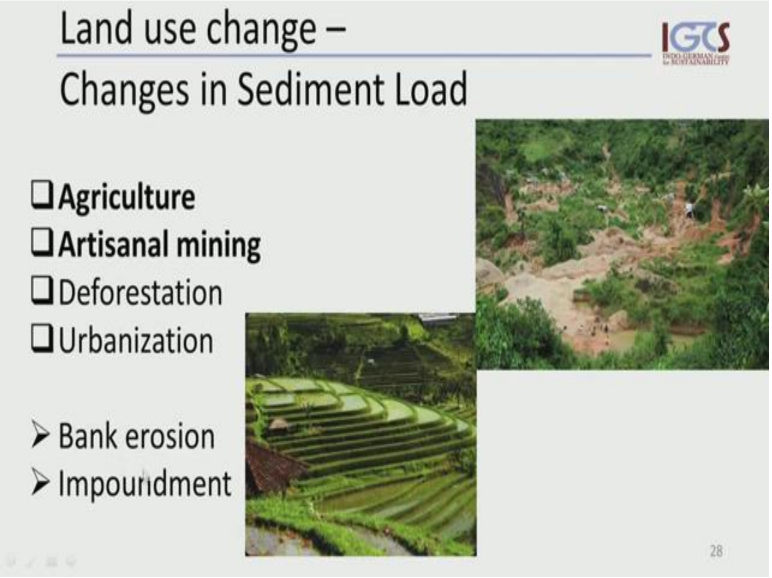


Now, land use change usually comes along with the change in sediment load, which again, also is a very important component besides the slopes and the velocities. Just examples, how we shape our landscape and in that we change flow in a river. We may have a stream like this where rice production is taking place and water is been taking, taken out of a stream or several streams have been cascaded across this landscape here and used for rice production and eventually, reaching the bottom and maybe, joining another stream or the same stream again downstream.

And we have one more example here of how land use in an extreme part changes the river system and sediment load. This is mining taking place. Those are people here. And you see, how the entire river has, river channel has been changed due to the removal of the riparian vegetation and also the movement of sediments from one side, from one area to another area where digging is taking place and washing is taking place. And was the next major rainfall event, all of these sediments will be moved again and deposited somewhere downstream and by that change local gradients.

So, agriculture are major factors, artisanal mining in this case, for instance, nature deforestation and urbanization have a major impact on sediment loads. All of them essentially, work on bank erosion and the impoundment of sediment loads.

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Now, another factor on land use change is that we change of flow connectivity, our stream flow patterns. We have seen this, I mean, in the examples of the channelization of streams. But, urbanization and especially the storm water management in our urban areas, have a major impact on these flow connectives.

Just an example of the Peri-urban interface where we have a floodplain here, then we have some canal, which is constructed to drain water from this urban area to somewhere else to move this water, remove it fast from this area. And then, we have housing right next to this very wet or wetland or floodplain area here and such urban areas have the tendency to expand and go beyond those limits where short boundaries probably only be will be very short lived, and very soon this part also will be a construction area and become urbanized. In that we change our river systems severely and irreversibly.

Another example where several rivers meet, this is a town in Germany. As an example, I could have picked any other similar example, Passau in the South, called The City of Three Rivers, this is where three rivers meet. And because of the land uses in the upstream areas, we nowadays often observe situations where flood peaks occur, flash floods occur and major disasters take place, when those peaks meet at the point where those rivers join. So, this is a major management issue, which also has taken, is one of the reasons why river restoration has become so important.

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Now, what are the techniques to stabilize river? There are traditional engineering fields dealing with this. We used to apply channel armoring, we are lining our systems so that water cannot infiltrate into the soil or not leave the canal. We use culverts and the usual picture of an urban environment with a river would be something like this. Again, I could have picked any other picture for that showing how rivers are somewhere built, completely taken over river systems. Drainage systems are completely, have completely disappeared and taken over by the urban needs of this region. And how rivers in detail would be in many cases look like in our cities in our urban areas.

We may have some space for to walk along here or to some cycle, cycling tracks. So, we may enjoy this, when there is water, but it is very artificial and not reconnecting to river system, is sufficiently channeling water from one end to another end without taking into consideration here, the usefulness of this water, maybe in this very location. So, all of these traditional engineering besides these aspects, which I have mentioned already have shown very limited success. And this is because the major events cannot be curbed with these engineering solutions.

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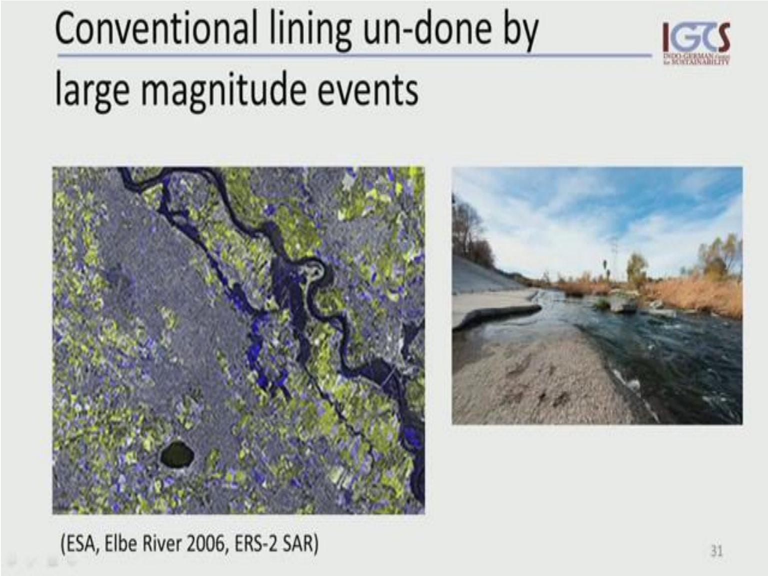


An example is here, this has been a lined, lined river system and once nature large magnitude events comes, all of this has been washed away like toys. And another example is here an experience from the other river in, in middle Europe, again major flood event, several flood events in recent years, the last major event was in 2006.

And this particular area is the city of Dresden. It is a large, large urban area here where the Elbe River was lined, and is lined and was the flood event. The Elbe River actually reclaimed, old former river channels became active and very predominant. The fact was, for instance, that one of the river arms, of the river arm and the nearest, that today's railway station, that railway station could wash out. It is a major railway station in this, in this city. So, whatever we do and we may be able to tame under low flow and moderate flow conditions will be in many cases completely undone under large events.

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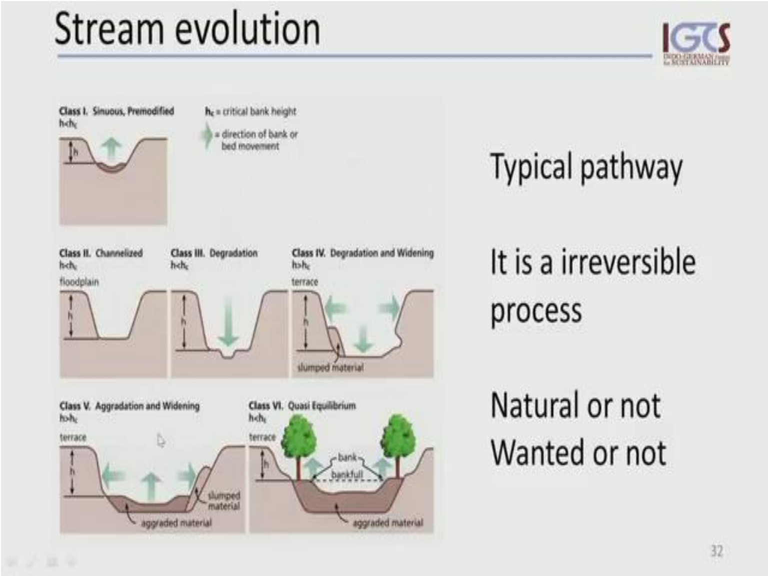


Let us look into a stream evolution and there are typical pathways to it. Just taking one of the examples of how the critical height and their base level height play together and form different valley shapes and sedimentation and erosion process, erosion taking place laterally, taking place along the channel or deepening a channel or combination of all. Some collapse taking place and the formation of alluvial flood plains, this old terraces and active terraces and so on.

So, this is a typical pathway and we can see in which path our particular river system is right now in this moment. However, all of these are irreversible processes; we cannot revert this by engineering application. So, this could be a natural evolution, this one would expect, but it could also be initiated by some unwanted processes or some human intervention, that was initially wanted. But when ran out of control, became, and became something unwanted, still those effects cannot be restored. We can only partially recover maybe river banks or change the depths of a river valley. But essentially, it is an irreversible process or becomes very expensive and usually not very successful.

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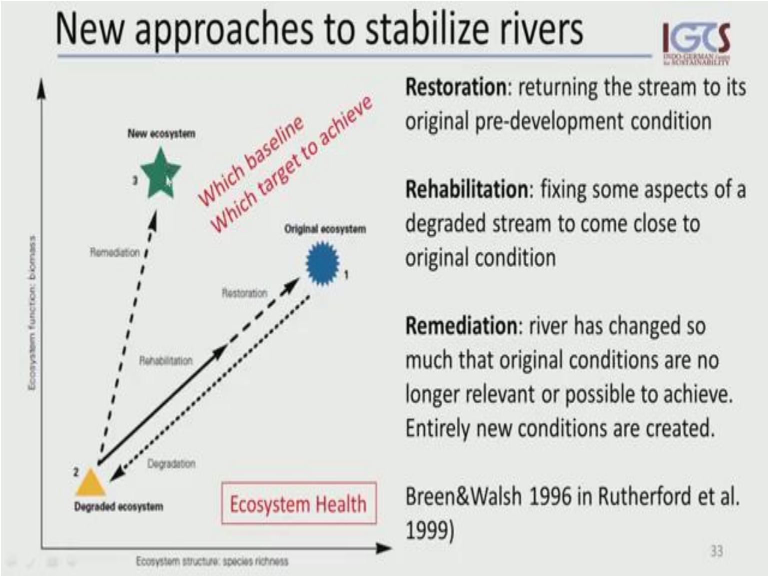


Now, because of all this there are new approaches to stabilize rivers and we have mentioned the term before, restoration, river restoration. What restoration in the strict context means is, to return the stream to its original predevelopment condition. That is very ambitious in most of the cases, more appropriate is the term river rehabilitation, which means, that we are trying to stabilize or fix some of the aspects in a degraded stream to restore it to bring it back to some, close to some original condition.

And then, the last term that we have usually used is remediation, which means, that we acknowledge, that we cannot restore the river. We cannot change the river back to an original condition. Because it is not relevant any more, it is simply not possible. It may be politically also not possible and by inter-weaning here, we simply create completely new conditions in the river, which may become better. It may become ((Refer Time: 24:48))

Now, this figure here shows this relationship. If here the ecosystem structure, which could be measured in species richness and we have here our ecosystem function, which could be measured in biomass. And then, what we can say, that our original ecosystem, this was before we degraded or changed it before ((Refer Time: 25:24)) for instance. It must have been a system that was probably in the specific climate condition, in the specific situation where it occurs rich in species, high biodiversity, functioning ecosystem structures and functioning ecosystem surfaces.

And then, as we have been using it, using it, we have degraded the ecosystem to a very low level, very poor in species richness compared to what would be normal for typical for such a system, untouched system and was remediation. We would try to achieve something like that, would be positioned here, it would be a new ecosystem and we would expect it to be suffering all of the ecosystem functions. We may, we are not able to restore species richness in any way. There may be trials to reintroduce species, but all of those trials, lots of examples of it have badly failed, because we do not understand the complexity of those inter place connections of species.

Now, we can say, that what you wanted to achieve is good ecosystem health. We want a system that is rich in biodiversity. We want a system, which is rich in functioning as such. Very difficult questions are usually, what is our baseline? We need a baseline to be able to classify something as a degraded system or to be able to say, we want to remediate or we want to rehabilitate or restore to this and that level.

What is our base line for that? Usually, a very difficult answer also, the question of which target we want to achieve. Probably, we can from a scientific point of view, we may aim at something like this. But form an economic or political view, some other real limiting points of views, this mean never be possible, we may have to compromise to something like this. So, and over what time period, we want to achieve such a target?

So, those are very difficult questions. In many cases, we ourselves have created wetlands or embankments, which over the centuries have stabilized in itself and have become very important in our life’s and important ecosystems. So, very often it becomes a question of values and of cultural conditions of the society pulling for or against some of this. Not in all of the cases, it is very obvious, that it is toxic completely degraded. And something has to be done and action maybe coming out of something like this.

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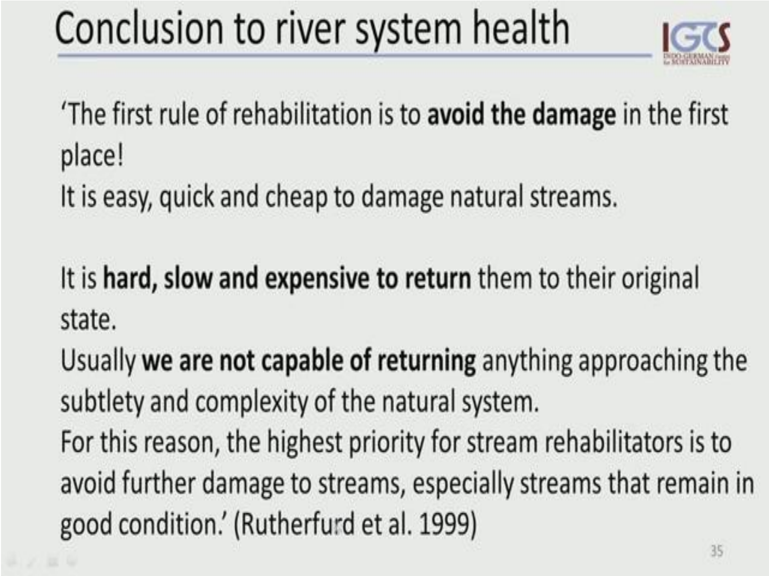


Now, let us conclude on river system health. And on this module, the first rule of rehabilitation is and I am quoting here, because this is, it says, all the first rule of rehabilitation is to avoid the damage in the first place. We can say, that it is easy, quick and cheap to damage natural streams and on the other hand, it is very hard, slow and expensive to return what has been damaged to in original state.

In many cases, simply impossible, we usually are not able to return this system or come anywhere close to the complexity of a natural system. And for that reason, the highest priority should not be in rehabilitating streams putting our efforts into becoming good in this but to avoid damages. Especially of those river systems which are currently in good conditions. This has been coming from this group of authors and you should try to get hold of that publication for yourself as well.

So, thank you and I see you on next time again.