Geo Spatial Analysis in Urban Planning
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Module – 04
Modeling Spatial Relationship
Lecture - 17
Landscape Metrics and its Applications

So, welcome back dear students. We are in the module 4 and we are I mean, going to see how a Landscape Metrics can be applied in planning and what is landscape metrics. So, we shall in the following slides we shall see the concepts of landscape metric and we shall have one more lecture on this to see an application of landscape metrics with respect to urban planning.

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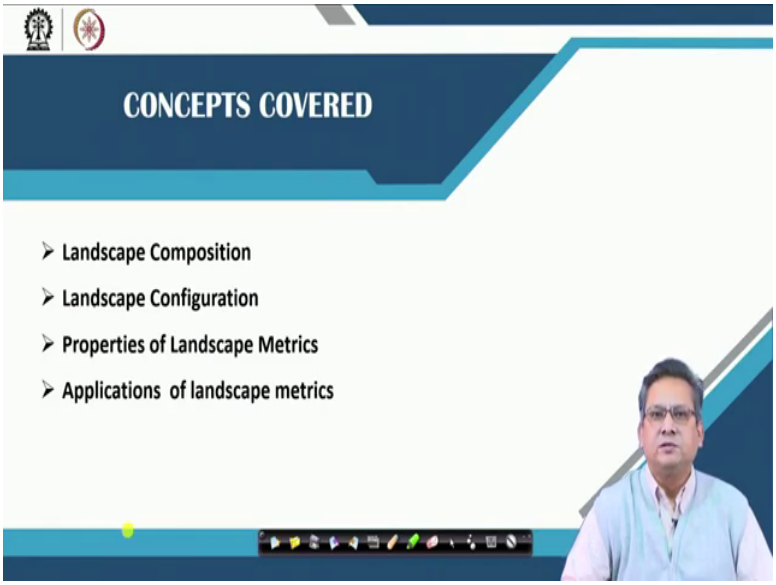

So, the topics that we are going to cover today; the concepts that we are going to cover today is what is landscape composition and how I mean, it has an impact on ecological assessment. We are going to talk about landscape configuration, we shall see what are the properties of landscape metrics, and then some application areas of landscape metrics.

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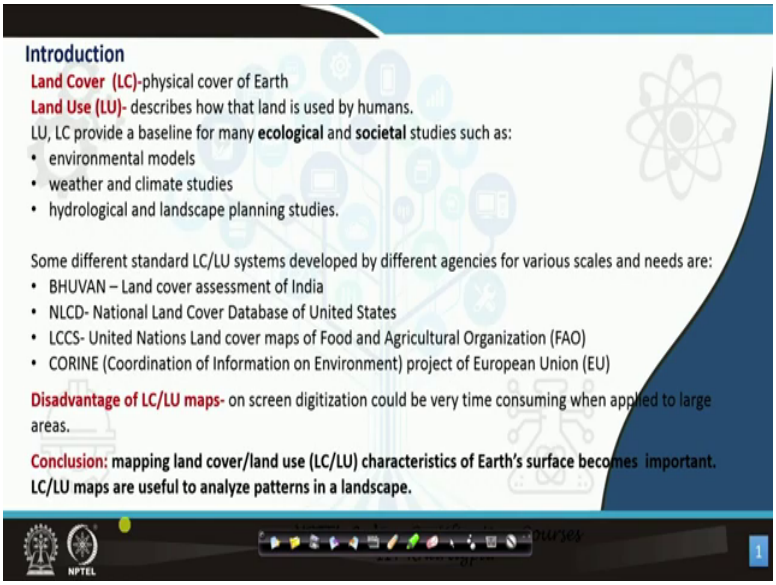

So, we know about land covers; so, just let us do a recap. So, a land cover is the physical cover of earth; I mean, depending on what type of coverage you have it maybe soil, it maybe vegetation, it maybe forest, it may be urban areas, buildup areas. So, the physical cover on the earth; I mean, gives the land cover where in land use is the use of a particular piece of land by humans.

So, it these two metrics that is land use and land cover it gives us a baseline for a lot of studies, such as societal studies or studies related to ecological parameters or ecological

assessment. So, these studies could be in for environmental modeling, it could be related to weather and climate studies. We can also do hydrological or landscape planning studies using the land cover and land use metrics . There are different standards of land use and land cover developed by different agencies across world and varying in skills.

So, some of these important ones are the BHUVAN land cover assessment of India which is developed by ISRO. We have NCLD that is the National Land Cover Database for United States. We have LCCS that is the United Nations Land cover maps of Food and Agricultural Organization. We have CORINE which covers European Union it is the Coordination of Information on Environment.

So, we see there are different; I mean, land cover and land use nomenclatures systems developed in different countries by different agencies. Now, the disadvantage of preparing land use maps or it could be the time consuming process, I mean which is if we are doing on screen digitization of high resolution images. So, there what we do is we bank up on machine learning algorithms or say different land classification algorithms by which we can create; I mean, or digitize or I mean automate the process of land use creation.

So, in remote sensing once we get the satellite images, there are different processes methods by which we can automate the process of land use maps and then we can go for an assessment of accuracy. So, the I mean, this land use and land cover maps they give us the characteristics of the earth surface and this is important for the different types of applications in environmental modeling, weather systems modeling or interaction of weather climate systems we say we urban development. So, we can do a micro scale or a major scale model, we can also work on hydrological and landscape planning I mean interaction models.

So, these are some of the important things which can be studied using the land use land cover. Now, land use and land cover become the basis to analyze the patterns in a given landscape. So, by landscape we are; meaning, that it is the area of study that I mean you are enforcing different types of algorithms or measures or indices. So; I mean, these become very important

base maps; I mean, the land use and land cover they are useful for analyzing the patterns in a given landscape.

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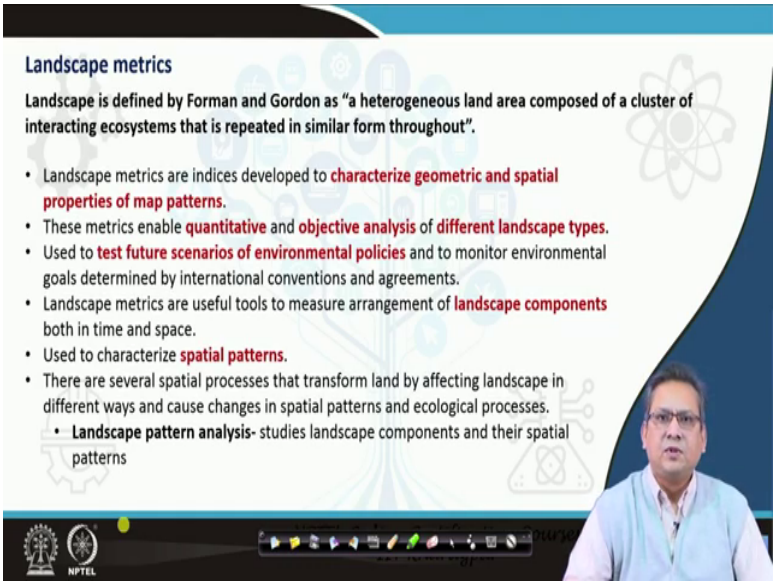

So, now talking about landscape metric; I mean, your Gordon, Forman I mean, they had talked about landscape and they have defined it as a heterogeneous land area. I mean, of dissimilar elements, dissimilar; I mean types of landforms land patterns land use which is composed of a cluster of interacting eco-systems. So; I mean, it may have sub ecosystems which would be interacting with each other and that is this ecosystems would be repeated in the landscape.

So, Gordon and Forman they formulize this landscape metrics the study of a landscape using different types of metrics to characterize the geometric and the spatial properties of different areas; I mean, of say map patterns or say land use patterns in I mean different areas. So, we

can use this different metrics for assessing the quantitative or we can do and objective analysis of the different landscape types. Now, we had said in a landscape type it is composed of interacting ecosystems.

So, we can do an objective as well as quantitative analysis of this interactions happening within the ecosystem using landscape metrics. So, I mean it can also be used these metrics to assess the policies; I mean, if we take a policy decision related to environmental management. So, we can do an assessment of future scenarios. So; I mean, the environmental goals I mean like we have the sustainable development goal and other I mean, different agendas so, by the international charter of agreements.

So, we can monitor what is the progress using this type of metrics. So, it is used for; it is a very useful tool when we want to measure the arrangement of the components. This components in a landscape in a temporal fashion or even in a spatial manner. So, in space and time we can use this tools very effectively to manage the landscape components.

Now, we can also characterize the different spatial patterns, if the area of an urban area or a regional region has us characteristics spatial pattern. It can be; I mean, assessed using the landscape metrics or even if these are varying across time and space as we have talked about. These spatial patterns can be assessed of the different landscape components.

Now, that there are different processes; I mean, in urban area we know that there are different way processes which goes on in transforming the land from one land cover type to; I mean, different land cover type one land use type to different land use type. For example, there are economic and ecological I mean, factors which are responsible for these spatial processes, it affects the landscape in various ways.

So; I mean, this would cause an; I mean, the outcome of these processes would be its impact on the spatial pattern and the how these different; I mean, ecosystems interact and thereby the ecological processes. So, this landscape pattern analysis it is the study of component of the spatial patterns.

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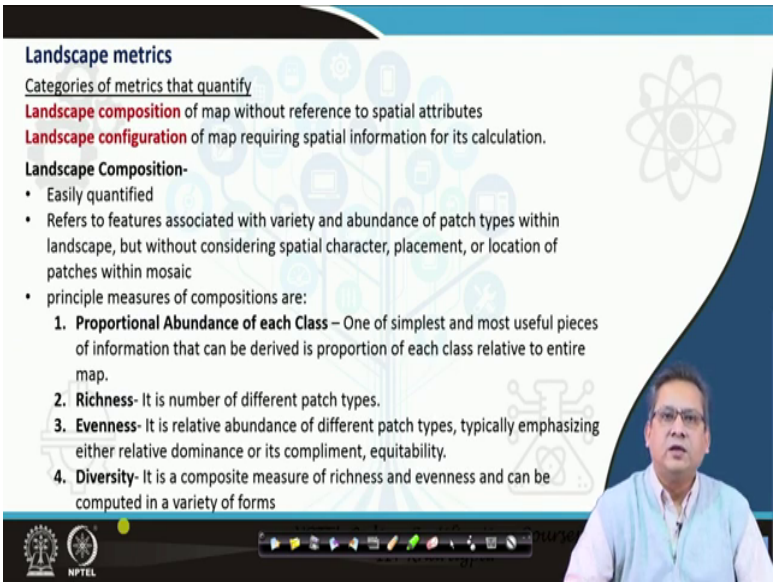

So, there are different types of categories which can be used to assess the landscape composition variation. So, we look to the spatial attributes of the landscape configuration. So, we also look for the, I mean spatial information to calculate these metrics.

So, for the landscape composition; I mean, it can be easily quantified using the landscape metrics. So, there is we can also assess if there is abundance of a particular patch type within a given landscape and without considering the spatial characteristics of how it is placed or I mean, how the I mean, what is the location of these kind of patches in the landscape mosaic.

So; I mean, this landscape composition are the principle measures I mean, of this particular landscape composition are the proportion of a proportional abundance of each class where in one class could be dominating over other classes. So, we can find out the abundance of the different type of classes that we have in a given landscape. So, it is a very simple and very

useful information and we can find out the proportional representation of each class in relation to the entire map.

Now, we can also find out the richness; in landscape composition we can find out the richness that is the variety in types of the different this landscape patches. So, we can also find out the evenness, if the distribution of this different landscape patches. In this particular composition are evenly distributed which typically emphasizes, if a particular class is dominant or it is I mean, complement, complementary or there is equability in distribution of the different classes.

So, we can have these different types of measures where in we can measure the abundance, we can measure the richness of different patch types and we can measure the evenness. Now, we can also measure the diversity. So, this is the measure of richness and evenness and it can be calculated or computed by different forms.

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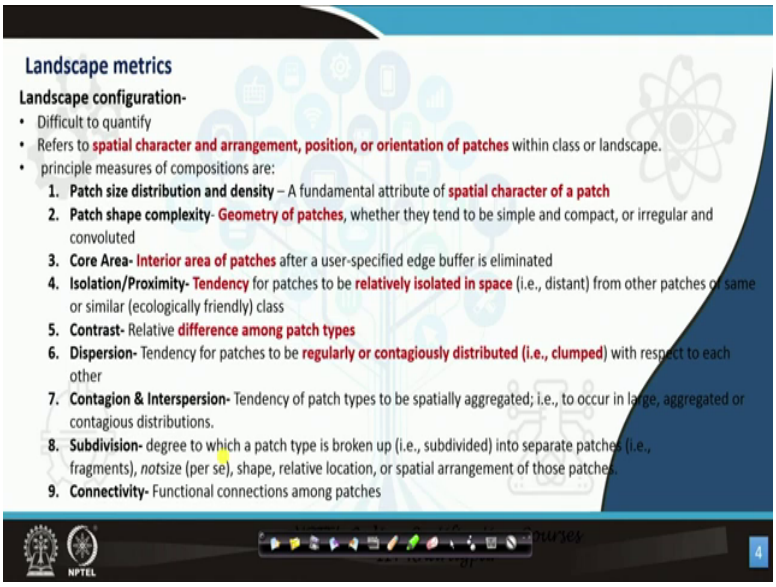

So, the landscape configuration is really difficult to quantify. Now, we have the different types of spatial arrangement, the character spatial character, the orientation of the patches positioning within a landscape for a particular class. Now, these landscape configuration I mean, this principle measures are patch size distribution and its density. So, it gives us the spatial character of the patches.

Now, the second type of landscape configuration measure is the shape complexity that how complex is the geometry of the patches. So, you can find out whether there are simple; these shapes are simple in nature or they are very convoluted or irregular, they are dispersed or whether they are compact. So, you can identify the diversity in terms of the geometry of the patches using such measures of landscape configuration.

We can find out I mean, the measure of landscape composition which is the core area identify the core area which is which signifies that it is the interior of a patch that is we can use a I mean, if we have a edge buffer we can eliminate that buffer region and then we can go into the core area. So, we can find out different metrics for the core area. So; I mean, in the landscape configuration first we had talked about the distribution and density of the different types of patches, the complexity in terms of the shape and then the core area, then we can also measure the isolation or a measure of the proximity.

So, the how proximal are the patches whether they are isolated or whether they are congregated. So, the distance between the patches between similar and dissimilar classes can be found out; I mean similar, classes or dissimilar classes means that is they are ecologically compatible or ecologically incompatible classes.

Now, we can also measure the contrast. So; I mean, the difference between the different types of patches can also be measured; I mean, we can do a relative assessment of these measure using contrast metrics. We can also find out how these patches are dispersed using dispersion metrics. So, whether they are contagiously distributed that is they are clumped or they are close together aggregated or they are regularly distributed with respect to one another.

Now, the next metric is the contagion or interspersion metric wherein there is a tendency of the patch type to be spatially aggregated that is to occur in large or aggregated contagious distribution. So, we can use the contagion or the interspersion metric to find out how they these patch types are spatially aggregated or distributed.

We can also find out the subdivision of the patches that is the degree to which the patch type is divided or subdivided into separate patches or fragments. So; I mean, this could be in terms of shape its location relative location or the spatial arrangement; so, we can also look for the subdivision. So, for landscape configuration, we have the patch size distribution that is the density, we are talking about the complexity of the patches, we are talking about the core area metrics to identify the core area, we can identify whether the patches are isolated or relatively; I mean, distant from each other or close together aggregated.

So, isolation or proximity could be studied between this patches. Now we can also look for contrast, the difference among the patch types; we can look for dispersion that is the regularly or contagiously distributed patches whether they are clumped or disaggregated we can look for contagion. So, I mean, it is basically a metric for identifying whether the patches are specially aggregated together and interspersion; how they are distributed amongst in that particular landscape that are different patches how they are distributed and then we can find out the subdivision.

So, using this type of metrics, we can assess the different interactions between the; I mean, sub ecological ecosystems existing within a landscape. Now, there are also connectivity based metrics that is to find out or assess whether there are functional connections or they the patches are connected in some way functionally.

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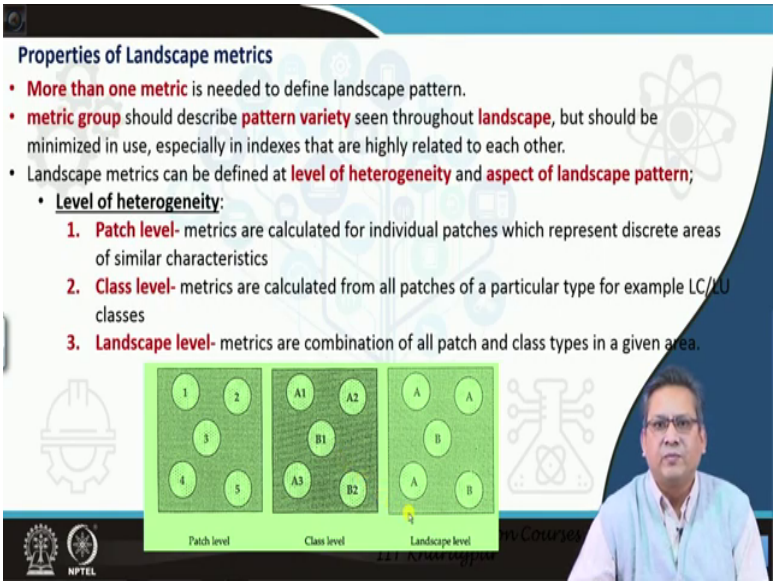

So, we can have some kind of connectivity measures to assess the functional measures. When we are assessing this metrics or calculating this metric on a given landscape on the different patches of say land covers or land use, it is important that we use more than one metric. Because, of single metric may not be able to pick out all the different variabilities within a particular land landscape.

So, we may have to use more than one metric, this metric group could describe the variety in terms of the pattern and it should be minimized in terms of use, and when actually this metrics are related to one another or have there are a lot of metrics which are very similar to one another. So, we should avoid using the similar type of metrics, because they would be giving; I mean, similar type of a result in terms of the distribution of patterns or study of the patterns.

So, we should use the different metrics from different metric groups we have already talked about these different groups. So, this metrics can be defined at the level of heterogeneity and aspect of landscape pattern. Now, if we talk about the level of heterogeneity, we can see the level of heterogeneity at the patch level where you can have patch level metrics which represent discrete areas having similar characteristics; similar exhibiting similar characteristics.

We can have class level metrics. So, first we are assessing each and every patch and finding out the patch level metric, then we can have different classes aggregate this patches by different classes and see how these classes are distributed or how these classes interact. So, we can have class level metrics; so, I mean we can have class level metrics for specific classes in say land cover and land use and then we can have an overall landscape level metric, which includes all the different patches and the I mean, the class types given in an area.

So, in this particular figure, we can see that at the patch level we have some metrics. So, we have some metrics at your class level; this A1, A2, B1, A3 and B2 these are the class level metrics and then we have the landscape level metrics at different levels. So, we can assess the different measures.

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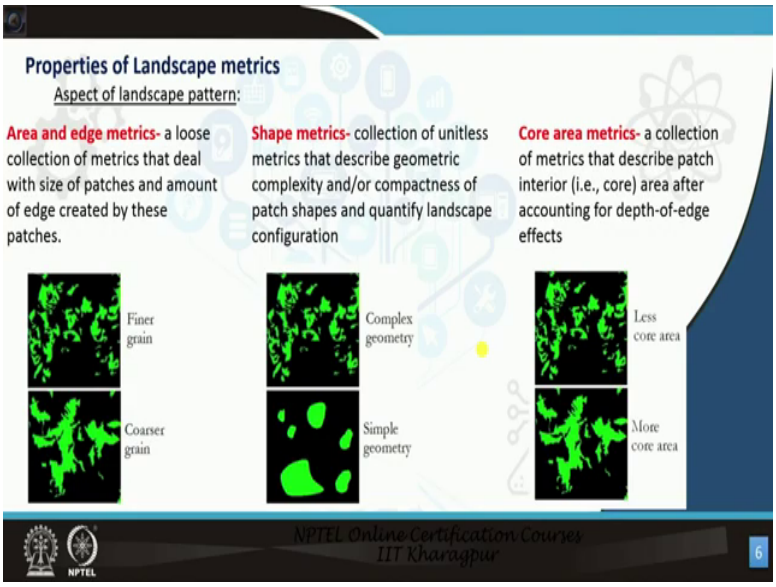

Now, we can also assess the aspect of different land use patterns landscape patterns using area and edge metrics. So, we have; we can deal or assess the sizes of the different patches and by the amount of the edges that is created by this different patches. So, you can see that in this particular figure we have two images where in you can see there are final grains in the first image; top image and in the bottom one you can see the grains are coarse. So, we can identify the edge as well as how the area of the patches are distributed in a given landscape.

Now, after the area and edge metrics we can look for shape metrics which I mean, gives an idea regarding the shape complexity, whether are shape is simple or it is cirated and very complex in nature, whether the patches are compact and we can find out how is the landscape configuration.

So, you can see in the first one that same image, we have complex geometry in which I mean, the geometries are not really regular; I mean, the surfaces as created and the edges are very complex. So, there are; there you have a complex geometry and in the bottom one you can see that you have patches which have simple geometry.

So, we can use shape metrics to identify whether the shapes are complex or whether the shapes are simple, then we had talked about the core metrics core area metrics. So, I mean, this describes the patch interior area after you are accounting for the edge depth of edge effects like we said we can do a buffering and remove the edge areas. So, we can remove the account for the depth of edge effects and then we can assess the core area.

So, in this case you have the first image you have less core area, you can see in the edges, you have more I mean, different patches; more number of patches in the edges than the core area. And, in the second image you can see that you have I mean, the patches are congregated or they are clumped together in the core area.

So, we can find out the aspect of landscape pattern using these three groups of metrics; one is the area metric or the edge metric where we look for the size of the I mean, patches and the edge complexities. Second is the shape based metrics when we see the geometry complexity or compactness of the patches and third is your core area metrics. So, we can find out whether I mean, how is the core area once you remove the depth of edge effects.

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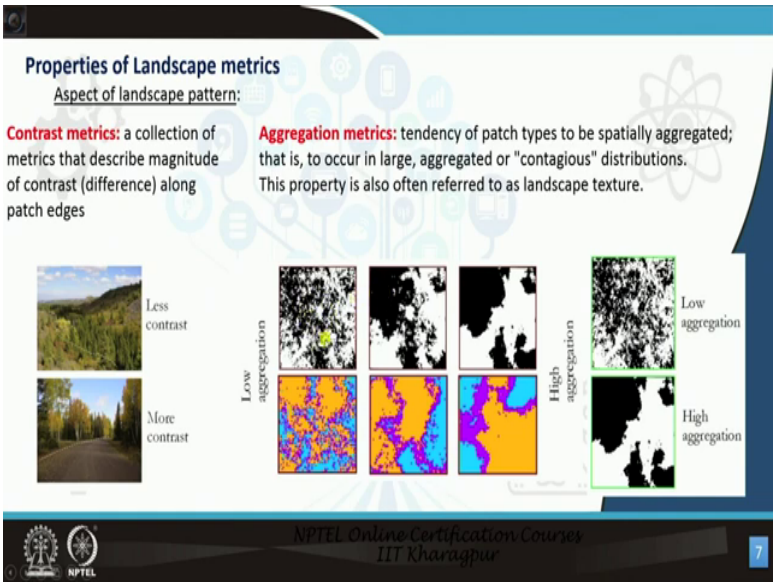

So, the aspect of landscape pattern can be studied also using contrast metrics. So, we had talked about this; I mean, we can identify describe the magnitude in terms of contrast. So; I mean, we can find out the contrast in the patch edges. So, in this two particular images you can see the first one, in this particular image you have less contrast within the image where in along the edges in the second image you have more contrast, you have different types of plant species. So, there is more contrast.

Now, we can also look for aggregation metrics which has I mean, gives the patch types; I mean, which is spatially aggregated; I mean, in this aggregation metric we can see whether the patches are contiguous or they are aggregated in terms of its distribution. So, we can study that using the aggregation metric.

So, it is often also referred to as the texture; the landscape texture. So, in this particular image we can see that in the very first image we see a lower level of aggregation and as we move to the right. I mean, we can see a high level of aggregation in which these points are clumped together and the I mean, patches are aggregated, you can see it is aggregated in some few patches 3 or 4 patches out here in this particular image where in it is more or less dispersed. So; I mean, these are basically a comparison of high and low aggregation measures.

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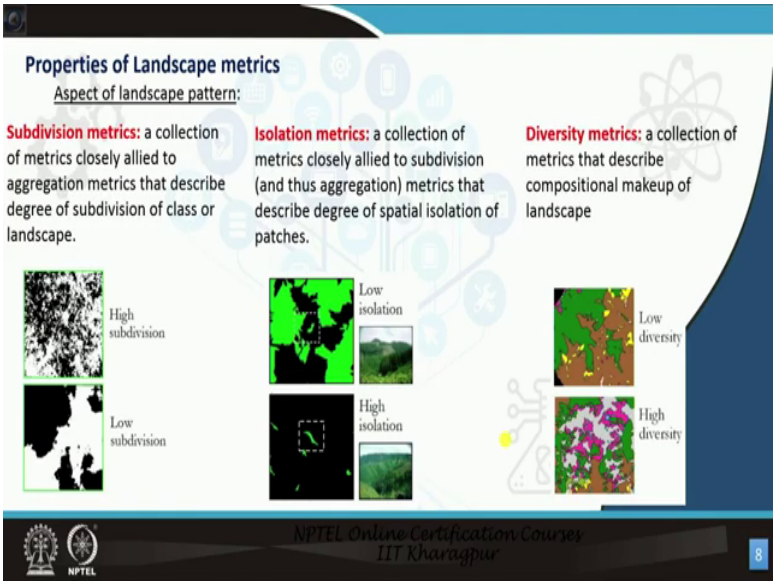

Now, if we see the aspect of landscape pattern, we can refer to the subdivision metric which we had already talked about. So, it is allied to the aggregation metric that describe the degree of subdivision of a particular class or the given landscape. So, you can see those same examples; I mean, where in you have high sub division and the bottom one where in you can see low subdivision.

Now, we can also identify the aspect of the pattern of landscape using isolation metric which gives; I mean, how the I mean aggregated your landscape patches are I mean, it gives us I mean an idea regarding the subdivision of the patches. So, that would describe the degree of isolation of the different patches.

So, in the first image top image, you can see there is a low isolation; I mean, you have if we take a search window then you can see that I mean, in close proximity of this central patch, you have similar patches; similar I mean patch. So, the isolation is in that case low, but in the next image this isolation is very high. So, in the ecology or in terms of you are when we are analyzing the land use pattern or the land cover pattern in an urban area. We can use this type of subdivision metrics to assess the aspect of the different types of landscape pattern using your subdivision metric as well as isolation metric.

Now, we can also find out the diversity of the different type of patches that gives us the composition of the landscape. Now, if we go to this particular image we can see that in this case there are only few types of patches. So, there is in this case the diversity is very low, but in this image which is the bottom image, in this case you can see there are varieties of different types of patches; so, the diversity is high. So, we can do this kind of analysis in using your raster data, because your data size would be smaller and there are also tools which we would discuss about.

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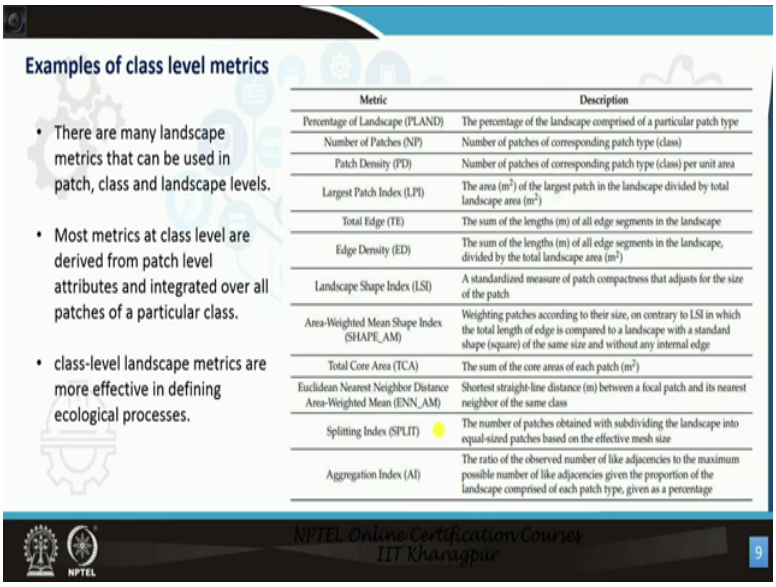

So, I mean these kind of tools are available as plug ins in qgis, you will also have I mean, your standalone softwares like I mean Fragstats or Apache or there are different other software as well. So, let us see some examples where this class metrics have been used; I mean, it can be used in patch, class or the landscape level and these are used I mean, these are derived from the patch level attributes for the each patches.

We would also have the attribute of these patches like which class does this attribute. This patch belongs to and whether these are integrated over the; I mean, in the landscape for a particular classes; for a particular class of patches. We can also I mean do a class level metric analysis for effective I mean, ecological identifying the effective ecological processes.

So, in this particular table we can see the different type of metric and how it is being used. So, you can see the, this these are the abbreviations of the metrics that you will come across in

different softwares, the percentage of the landscape. So, it gives us the particular percentage of or specific patch type in the given landscape then you can count the number of patches. So, number of patches or by class type you can find out using the number of the patch.

Now, the patch density would give you the patches of different classes per unit area. Now, we can also find out the large patch index; largest patch index. So, I mean the area of the patch largest patch divided by the landscape area. So, it is like a fractional measure, we can find out the total edge parameter. So, this is the sum of lengths of the edge segments, the total edge that you have for a different patches. So, we can find out the total edge, we can also find out the edge density. So, it would give us the length of the edge segments divided by the total area of the landscape.

Now, the next metric that we are talking about is the shape index; I mean, we had already seen how the shape index is useful and how it is reflected in the image. This is the measure which gives us an idea regarding its compactness and I mean, whether it is adjusted by the size of the patches as well.

Now, we also have your area I mean, shape index which ways the patches according to size. So, you can use this two metrics alternately; I mean, either the Landscape Shape Index, LSI, or the area weighted mean shape index. In the your area weighted shape index what it does is it; I mean, finds out the I mean, shape I mean, size of the patch total length of the edge with.

And, it is; I mean, normalized with the landscape with the standard shape of a square or circle having an equivalent area of size of a given particular patch without any internal edges. So, we can do assessment regarding how complex the shape is when we try to compare it with the standard geometric shape. We can also I mean assess the total core area like we had said so, it comes us as meter square. So, some of these metrics have meter I mean, units and some of these metrics they do not have units. So, we can also find out the nearest distance using the Euclidean. Nearest neighbor distance area weighted mean ah; measure.

So, it gives you the shortest straight line distance between focal point and the nearest neighbor of a similar class. Now, we also have the next one which is the splitting index which gives you

the number of patches obtained by subdividing the landscape into equally sized patches based on the effective mesh size; I mean, you would have to define a mesh size while you are doing this particular I mean measure. So, you can give that effective mesh size and you can find out the number of patches obtained by subdividing the landscape into equal size of patches when you are sieving it through a mesh.

Now, the last one that is the aggregation index would give you the ratio of number of adjacencies to the maximum possible number of like adjacencies given in the proportion of landscape, compromised of comprised of each patch type and it is given as percentage. So, these are some of the metrics which I mean, cuts across different types of categories.

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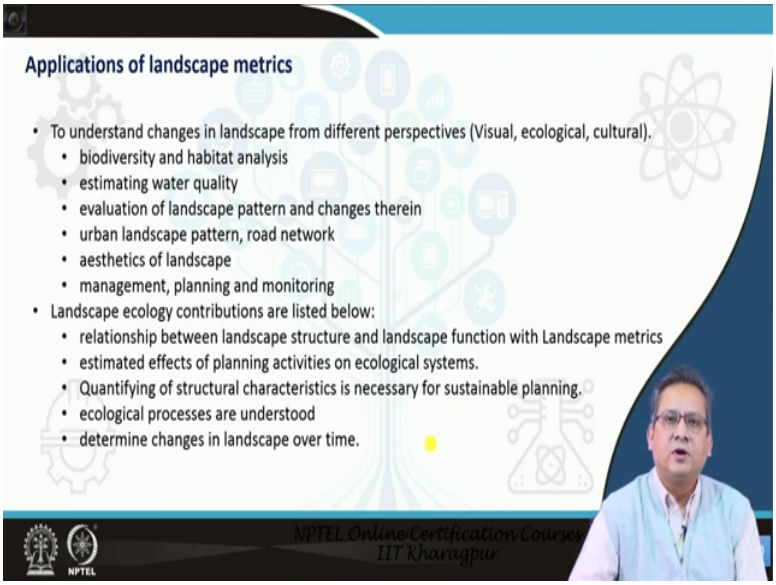

So; I mean, we can use or apply this landscape metrics to understand change in the landscape or I mean, with respect to the ecological aspects. I mean, how visually it is changing or the

cultural aspects of a landscape can be assessed. So, we can in this particular heads, we can do application related to biodiversity characterization and habitat analysis. We can do an assessment of the water quality and how it is impacted by the different types of land use that you have in an ecological set up in a landscape.

We can do an evaluation of the landscape pattern and the changes in that we can also assess the urban pattern and the road network I mean the different types of variations. So, you can see that high rise apartments would have a different type of a pattern than low rise apartment slums. So, I mean, by these patterns probably you might be able to relate the different types of areas and I mean, the uses I mean in urban area.

So, we can also assess the density of the road I mean, we can see how what are the number of edges and whether the places are well connected accessibilities high. So, we can assess the road network as well using the landscape metrics. So, specially like your edge metrics and other metrics can be used.

So, we can also; I mean, do I mean, applications related to aesthetics of the landscape, we can do proper management monitoring, planning in a given area. So; I mean, the contributions of the landscape ecology if you come across the literature I mean, it has been used effectively very effectively to establish the relationship between landscape structure and the landscape function.

So, these landscape metrics are very effective to give you an estimate of the effects of planning activities. So, you can do policy assessment that I mean, what is the impact of policies on a given structure of land use. So, you can and on the ecological systems. So, that can be assessed; I mean, this landscape metrics I mean if we use it we can also quantify the structural patterns the characteristics which are necessary for a sustainable planning. So; I mean, we can also understand the different underline ecological processes in a I mean, landscape using this kind of landscape metrics.

We can also identify the changes that happen in the landscape in a temporal fashion; I mean, how the changes are happening over time can be assessed.

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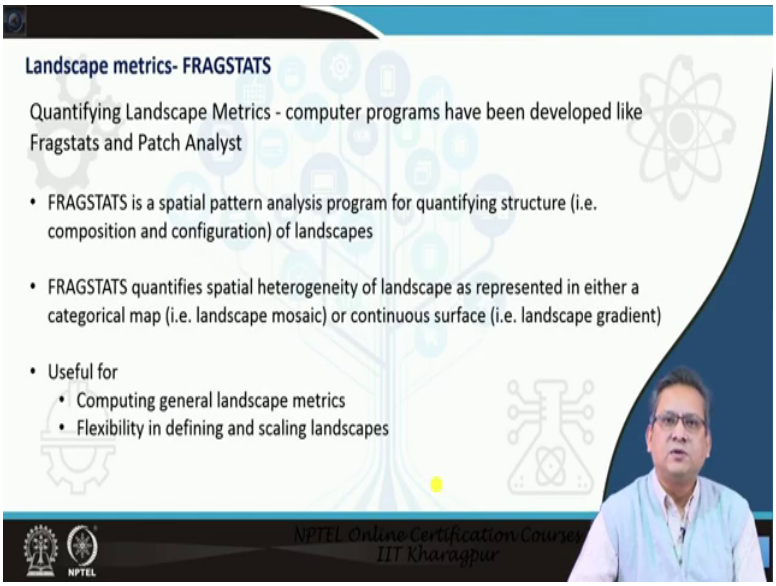

So, I mean, your Gordon and Forman they came up with the these different metrics; quantifying metrics. So, they came up with the computer program wherein they have a bouquet of these different types of metric and this software is known as FRAGSTATS. There is also a software which is known as patch analyst there is a software which is known as apac a plus you would have plugins in QGIS where in you can calculate the different fragmentation, porosity patchiness, a lacunarity, contagion metrics and all the different type of metrics that we have talked today.

So, we can; I mean, use this FRAGSTATS for assessing the spatial patterns and this FRAGSTATS quantifies the spatial heterogeneity of the landscape, we can find out the

gradient in the landscape or we can find out how the different patterns interact in landscape mosaic. And, this is useful for; I mean, this software FRAGSTATS is helpful for generating your landscape metrics in a given area ah. It is flexible and I mean, in the define definition and it can also scale the different I mean, the different patches in the or different zones in your landscape.

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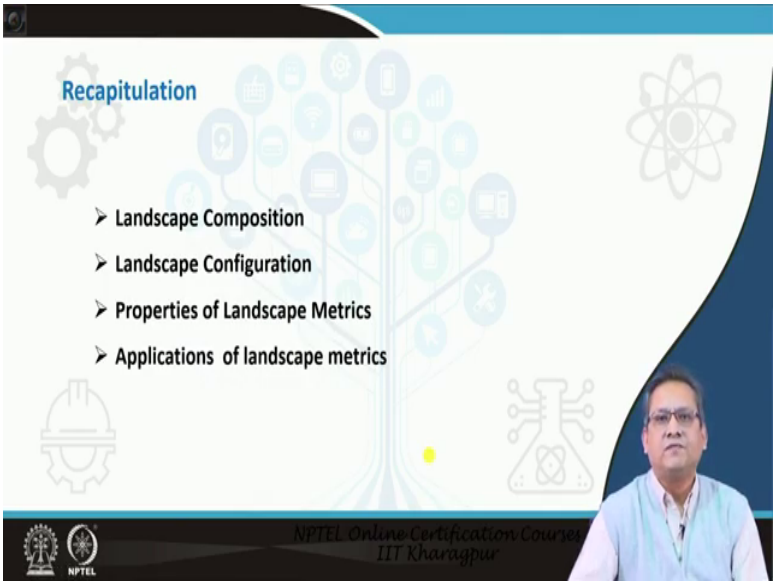

So, a recapitulation of what we had studied today. We had gone through the definition of landscape composition and we had seen how the different elements are composed and then we can; I mean, look into that configuration of those elements which constitute the landscape. So, we can we have also look for the properties of the different types of landscape metrics, we have looked into some of the applications of the landscape metrics and in the next lecturer we shall see an application of the landscape metrics.

So, thank you so much.