Remote Sensing: Principles and Applications

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Lecture-63
Land Use, Land Cover Monitoring and Change Detection-Part-2

Hello everyone, welcome to the next lecture in the topic land use, land cover monitoring and change detection. In the last lecture we got introduced to the concept of land use, land cover, change detection and the different ways in which we can do land use, land cover mapping. In this lecture we will see a few commonly available land use, land cover data sets and few examples to tell us how this can be applied for real life issues.

Whenever we want to do land use, land cover classification we need to remember one thing, which is called LULC classification scheme. This will be really important whenever we want to create some LULC map for ourselves or when we want to interpret some already existing data or when we want to do change detection. For an example, let us say I want to compare the changes in land use, land cover from the year 2000 to 2020 for some cities in India. Let us say I have a LULC map of the year 2000. Now I am going to sit and create an LULC map by myself. If I want to compare them and come to some sort of meaningful conclusion then definitely there should be some correspondence between the different classes. Say whatever I classify it as forest same classification should be followed in both the maps.

I might have classified something as just forest, the old map may contain an evergreen forest, deciduous forest and so on. But anyway they correspond to forest, I can just combine the different forest type into one forest. I can do some analysis to reclassify them, that is possible. Say I classified something as forest but according to that old map if the same definition goes to a shrub land then I cannot compare it. So, there should be some sort of uniformity between what we define as one particular class. So, for helping us to maintain consistency, people have developed classification scheme. So, a classification scheme will tell us or will define what a certain class is, if a class satisfies certain criteria, then the pixel should be categorized as this particular class. So, an LULC classification scheme will define such things which is advantageous and they will be consistent. If we use the same classification scheme for multi-temporal images, there will be consistency.

If whether I do LULC classification or if someone else does the LULC classification, if we follow one particular classification scheme there will be a consistency, a forest should have this definition and urban area should have this definition, like that everything will be defined properly. So, a classification scheme contains taxonomically correct definition of classes, organized according to some logical criteria. So, that is really important.

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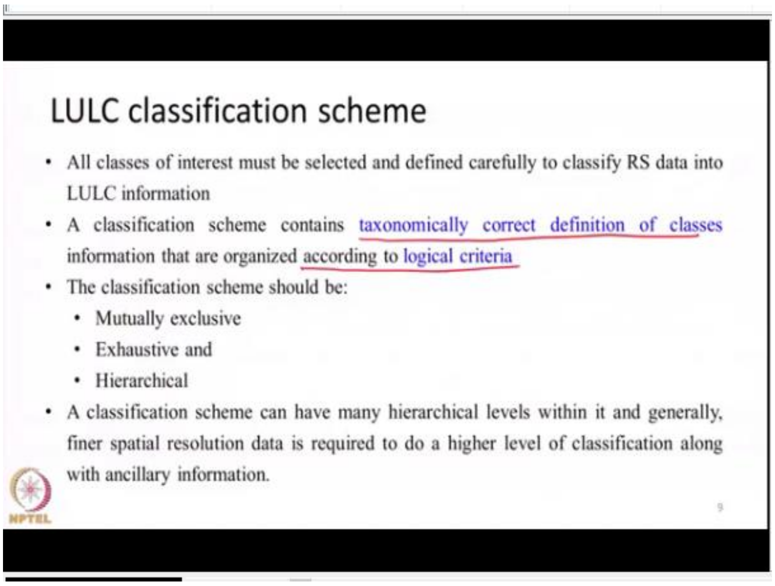

Taxonomically correct definition according to some logical criteria. It should not be illogical, a forest should not be classified as a crop land. So, it will act as some sort of guidelines to whoever does the classification. A classification scheme should be mutually exclusive, that is there should not be overlap between different, different classes. Say this is a shrub land, this is desert vegetation, there may be some clash because some shrub lands tend to have vegetation growing in deserts. So, this is a mutual overlap or a clash. Such clashes should be avoided. The classes defined in a classification scheme should be mutually exclusive; there should not be any overlap.

Then it should be exhaustive. Exhaustive means it should contain whatever classes we need for our purposes. Say our goal is to identify the major classes present within a given area, then all those things should be present there within the classification scheme. Say I want to identify some particular land cover known as marshlands, salt pans and so on. So, these are different categories of land, but if I am going to use a classification scheme which does not have a definition for a salt pan, then I cannot use it. So, I have to improve it or add the definition of salt pan. So, for our own purpose the classification scheme that we are going to select should be exhaustive, it should contain to the maximum extent possible what we need.

Then it should be hierarchical. Hierarchical means there can be a broad definition and within that there can be subclasses, say forest, within the forest evergreen forest, deciduous forest, evergreen broad leaf forest etc.,. So, you should have some sort of hierarchy. So, a classification scheme should be mutually exclusive, exhaustive and hierarchical.

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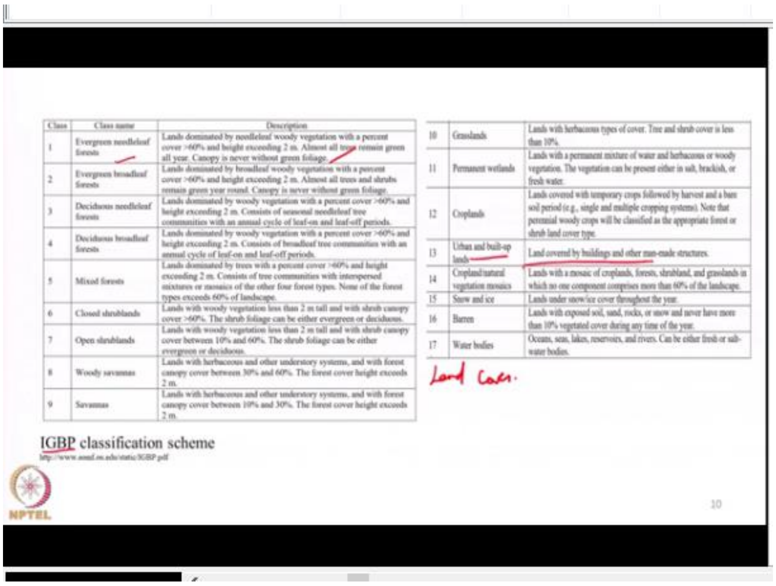

Say this is one such example taken from an IGBP classification scheme, international geosphere biosphere program. So, they have defined 17 different land cover classes and so on. If you want to define something as an evergreen needleleaf forest, it should satisfy these criteria. If you want to categorize something as an urban and built-up plan this should categorize this criteria. Like this there will be some sort of criteria defined and if you look at those definition then whoever does the classification they will follow this, this is a classification scheme we have adopted for the project, we will go by the same definition. There would not any confusion. So, this is one sort of example.

Then the next example is given below. This is again a general LULC classification scheme developed by Anderson and others in the year 1976, which is still used by many. So, this is developed by United States geological survey where you can see 2 different levels, level 1, urban or built up land within that you have residential, commercial, industrial, transportation and so on. So, if someone stops with just saying, this is urban, this is agriculture land, this is forest land, then I call this map as level 1 map. Then if someone says within the urban this is residential area, this is commercial area, then we call it as level 2 classification. some classification scheme may have 3 or 4 levels, say within residential you can have a single income residential, multi income residences and so on. So, this is level 3.

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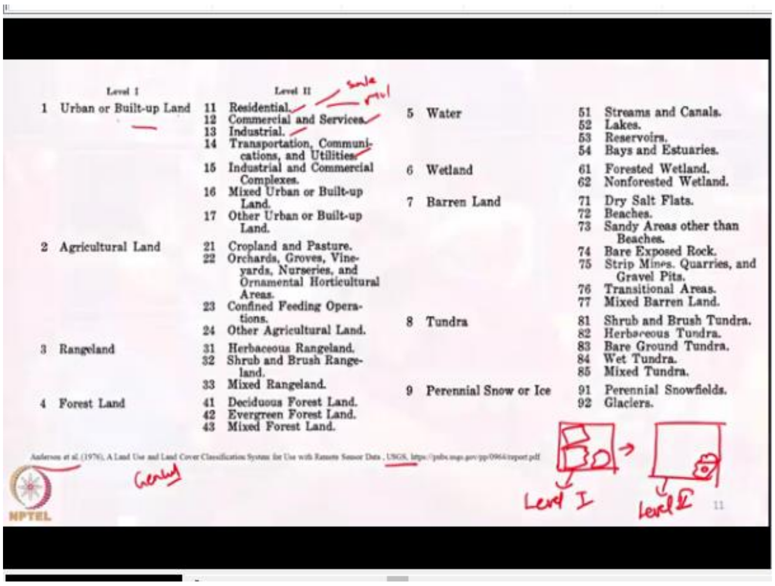

Whenever we want to start a project or some sort of application activity, we should be really careful, either if we do classification on our own or if we take data sets from other already existing maps or images. We should be first thoroughly understanding what is the LULC scheme followed there, what are the definitions and so on. And as I told earlier if we have 2 LULC maps and if they follow different classification schemes, direct change detection is not going to work, we have to somehow bring both of them to the same classification scheme and then only we can do change detection analysis. So, this is extremely important for us.

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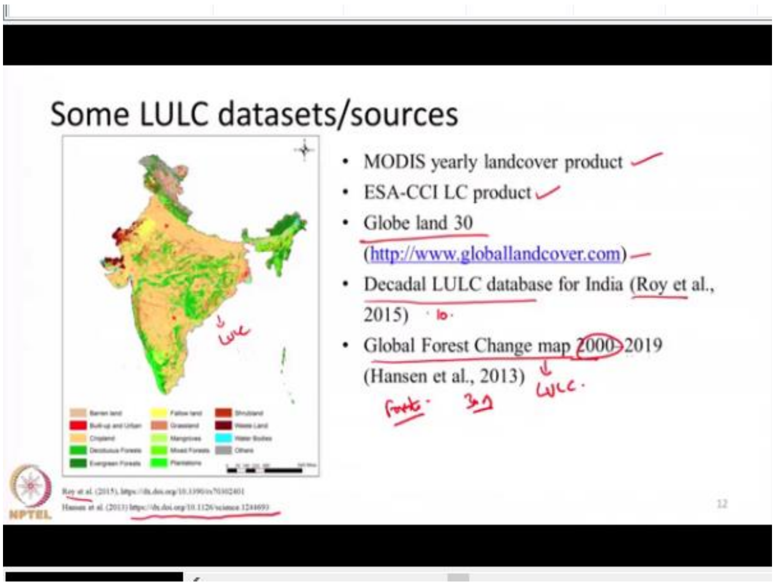

MODIS sensor produces a yearly land cover product. So, you can just look at MODIS land use, land cover product and get it, it is produced every year at 500 meter special resolution and they use different classification schemes. So, based on the needs there are multiple classification scheme available, we can just download the image and use it. European space agency produces a land cover product. So, they have a different resolutions and they are also producing at 5 year intervals, in the recent past they are producing at 1 year interval and so on. So, that is available. These are global products available across the globe. Then there is another product called globe land 30 which is again widely available. So, this is produced using Landsat data sets, but this is not an operational product, they have just produced different instances of map which you can download and use. Then for India there is what is known as a decadal LULC database produced by Roy and others in the year 2015 where they had LULC map at every 10 year gap. Say 85, 95, 2005, and all 1985, 1995 and 2005.

So, this is just one such example of an LULC map taken from Roy and others published in the year 2015. So, this again an openly available data and it is available only till 2005 and also there is a global forest change map. So, forest change is not an actual LULC map, but this will identify how forests have changed with 2000 as the base year. From 2000 how forest are changing. So, this is done at 30 meter pixel level and this is again this is one of the widely used data set, but this will just tell forest and its change, from year 2000.

In addition to this in the lecture about data portals I told about Bhuvan data portal. So, the Bhuvan has LULC map for India at different scales. So, that also we can use for our application needs or research needs. So, Bhuvan has it. But these are downloadable data sets which we can use for our projects. Now we are quickly going to see few examples of how this LULC map can be used for real life application.

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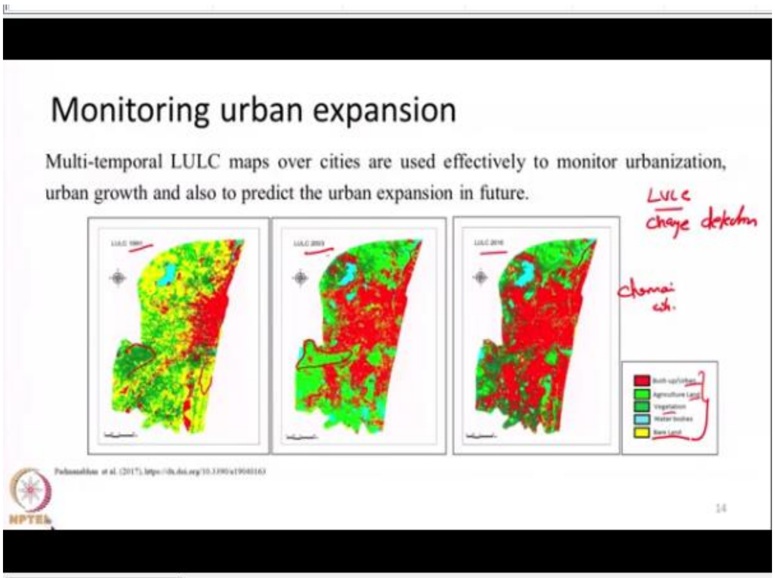

So, the first example what we are going to see is monitoring urban expansion. We can create LULC map over different time intervals and then do the change detection. So, this is post classification change detection or we can do change detection directly. So, here we are going to talk about one example where the authors have analyzed the growth of Chennai city using a simple classification scheme.

So, this is how the LULC map for Chennai city looked in the year 91, 2003 and 2016, with each color representing the class given here, built up, urban, agriculture land or dark green represent general vegetation, barren land which is not being used and so on. So, we can see how the urban area is expanding from the year 91 to 2003 to 2016. Similarly we can see how agriculture land is expanding, may be natural vegetation are kind of like removed and it has become agricultural land, maybe how water bodies are shrinking that is also we can see, some small water bodies might have gone. So, this kind of LULC classification and comparing them at different time intervals will help us to understand how different LULC features are changing. Say this corresponds to urban growth.

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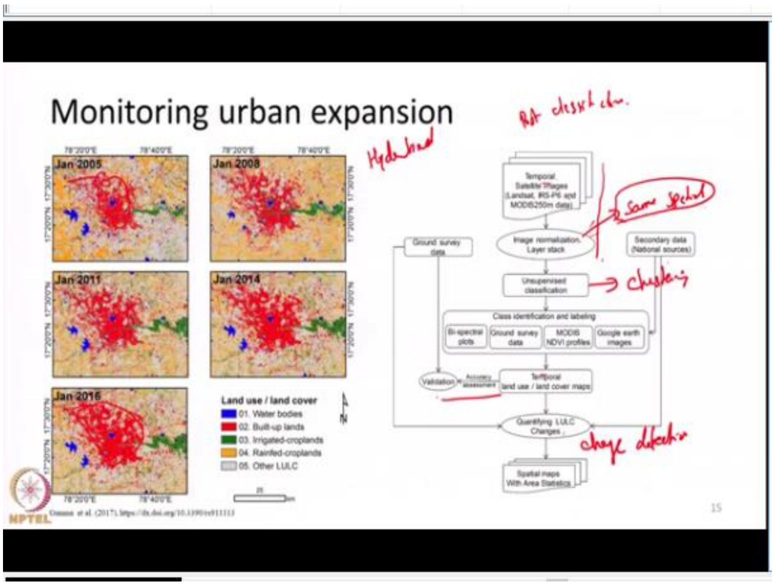

A similar example has been carried out over Hyderabad city. So, this is over Hyderabad you can see starting from January 2005 to January 2016, how built-up area have grown tremendously. So, this is again an example for using LULC maps for understanding urban expansion. This is really necessary when someone wants to do some sort of planning to develop a township. Say within the last 20 years the city might have expanded drastically which will put a several constraint on the resources available, say water, land, air quality problem and so on. So, government may think, the city has grown tremendously, we may need to develop a satellite township at the outskirts, such policy interventions may come from the government side.

So, in this particular paper they have used a very simple classification scheme, it is not really complex, they have taken multi-temporal satellite images with the same spatial and radiometric qualities, then they have done unsupervised classification. That is they have asked the computer to do clustering first and then using other information, they have categorized temporal land use, land cover maps.

Whatever map we produce we have to check the accuracy with respect to ground data, this accuracy assessment is one of the important task in land use, land cover mapping and change detection. So, they have done validation and then they combined other data sources in quantifying the LULC change. So, basically they have done post classification change analysis. So, the important steps are they have identified multi-temporal images, brought all the images to same spatial radiometric qualities, done classification, validated and done accuracy assessment and then done the change assessment or change detection. So, this is the broad steps involved. This is the conceptual way of how to do this, but the exact algorithms we need to use the exact way we need to process the satellite data we may not be able to discuss now. But this is the broad scheme of things in which one should work.

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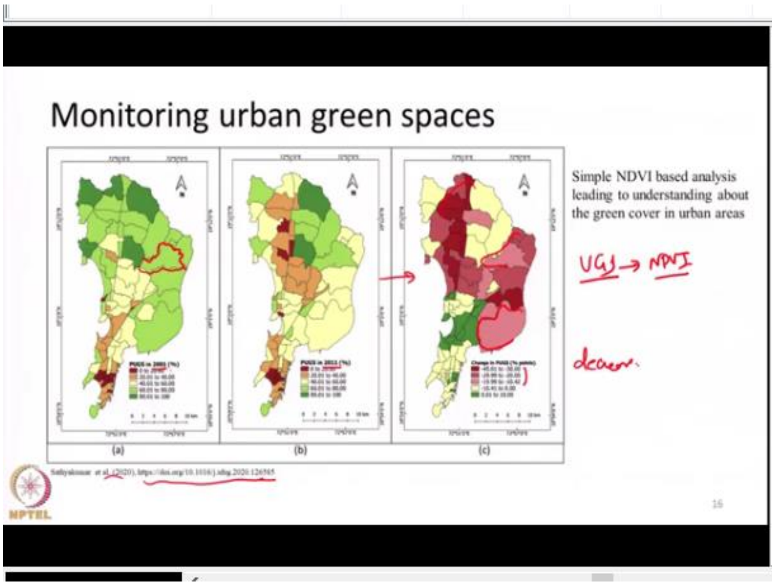

Say if our interest is in identifying what is the change in green spaces over a city, even a simple NDVI map and careful analysis over such data will provide us huge information.

One such study is being cited here, one of our own students from IIT Bombay has done this work. So, this is urban green space map for the Mumbai city at year 2001. This is the green space map over again MUMBAI city at 2011. So, the urban green space are defined using simple NDVI images, no LULC classification are being done here. Using simple NDVI we can identify all these green spaces, maybe parks, grasslands, forest and so on. So, these are all classified as urban green spaces.

One more simple example is given here. so within each boundary here is kind of ike a census ward or census section within Mumbai city. So, within each census ward or census section how much is the green cover present in different years and in those 10 year period from 2001 to 2011, how this has changed? Say, you can see over most of the places it is of a negative change.

So, this actually suggests in most of the census sections there is a decrease in the green cover. So, which is not really a good scenario, we have to improve the green cover for a sustainable and happy living. So, this is a very simple example of how to use remote sensing data sets, no need to even do classification, but this is a very simple change detection analysis, you can think it off.

Create NDVI maps, properly define urban green spaces, once everything is properly defined and classified, we can do simple change detection technique and say land cover has changed like this. So, this is one such example of producing really important study using careful analysis of remote sensing images even using simple techniques.

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Next major thing we are going to see is how LULC change map will tell us about deforestation effect. So, in this particular slide we have a true color image or a natural color image obtained over Amazon forest in Brazil. So, this is in the year 2000, so just by visual display we can see, these are all cleared lands and the rest of the green patches are Amazon forest. In the year 2012 it became like this, the cleared lands remained as clear lands but whatever is labeled as forest here, they are now have been cleared. So, just by visual looking we are able to tell, such huge area of forest has been removed for some other purpose. So, we can actually quantify what is the area of decrease in forest.

So, these are very simple example, we have not done any sort of LULC classification, you can just look at like the spectral characteristics, maybe you can take simple differencing in maps and say how forest has changed, this is how deforestation has occurred within this particular country. So, this is an example of a simple visual change detection.

And when you do it in a computer and do perfect statistical analysis you will be able to tell what is the range of deforestation or the extent of deforestation that has occurred in that particular region. Till now we have seen examples using optical data sets, like the LULC maps were all produced using visible and NIR data sets or even the simple change detection examples I told you, are all produced using visible and NIR bands.

But even we can use thermal infrared remote sensing for identifying large scale transformation in the land cover pattern and one such study we are going to discuss now.

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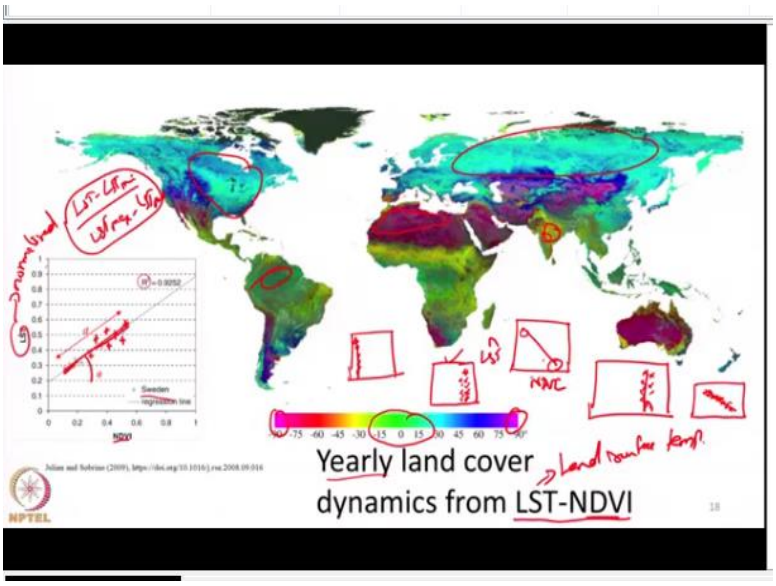

What is known as a yearly land cover dynamics by combining LST and NDVI? Here LST means land surface temperature and NDVI is a simple spectral index which will tell about the vigor of vegetation. Say the study is very simple conceptually to understand. We will normally have multi-temporal images within a year, say I already discussed same pixel will be repeatedly imaged by the satellites what we call as the repeat cycle.

So, we will be getting land surface temperature and we will also be getting vegetation. As the land cover changes the way in which the LST and NDVI for that particular pixel orient will change. That is let us say this is the LST and NDVI for one such pixel somewhere in Sweden. Say for each image for that corresponding pixel they have plotted the NDVI value in x-axis, LST value in the y-axis. So, it will define those points. Based on the features present there and if you perform a regression analysis, based on the feature present there the regression line will take one particular angle with respect to horizontal and one particular slope either in positive direction or negative direction. This tells when NDVI increases LST also increases.

So, here we have normalized LST. Normalize means with respect to some minimum and maximum, $(LST-LST_{min})/(LST_{max}-LST_{min})$, some sort of normalization. So, we are converting all the LST to between 0 and 1. So, this particular image represents, for that pixel if NDVI increases, LST increases. So as temperature rises, it tells us that particular pixel's vegetation growth is controlled by temperature. Some areas in winter they can be covered with snow and all. So, vegetation will not grow, there will be very less temperature, sunlight and everything. But during summer time vegetation will grow healthily.

So, that means as temperature rises when winter recedes vegetation will grow. So, such vegetation growth is controlled by temperature. Over places like India semi-arid kind of places, water availability will control the vegetation growth. So, especially some pixels over India semi-arid region the graph may look something like this.

This is NDVI, this is LST cap that is whenever there is a dry bare surface, LST will be high, NDVI will be low. But over vegetated surfaces LST will be less. So, this will signify vegetation is actually doing cooling of the surface. So, this sort of pattern will be seen over semi-arid region. Over deserts NDVI will be more or less constant but there will be different values of LST.

So, it will be very steep straight line, over again humid forest like Amazon rainforest which will be green always the graph may look something like this, very high NDVI value and LST will varying only with respect to that zone. So, these are some examples of how LST and NDVI will orient themselves for the same pixels. Here people have done multi temporal analysis, for the same pixel say get 8 to 10 images per year or more than that and plot them together.

So, how these points are orienting in the LST, NDVI space, whether it is positive slope or it has a negative slope or if the slope is just a straight line with 90 degree angle from horizontal, all these things will tell what sort of land cover is there. So, basically these are like semi-aird lands or cropland kind of thing. These are places where the slope was very steep.

So, this actually signifies there may be deserts or something like forest and so on. Say whatever the slope is between -15 to +15 actually those places show a very good temporal change in LST and NDVI. All these things will tell us really good amount of information about the land cover present there. So, this is not actual land use, land cover classification but this will tell us conceptually that is a humid zone, that is a desert, that is a vegetated area where vegetation growth is controlled by water availability, may be over certain regions like over here and the higher latitudes vegetation growth may be controlled by temperature.

During summer vegetation will grow, during winter all the vegetation will shed the leaves and they will go into some sort of hibernation mode. So, these are really good examples of understanding about the land cover pattern by combining thermal information with NDVI information. So, this sort of maps has been produced every year.

So, we can create this, do this sort of analysis for every year. Even across the globe this has been done and it can be seen how each pixel has changed. Let us say a pixel was forest before. So, if it is a dense forest, for that particular pixel the NDVI values were very high and LST was oriented like this with a very steep angle. Suddenly if deforestation has occurred and now it has transformed to kind of a crop plant, then the next year or whenever deforestation has occurred that pixel may look something different, there will be reducing the temperature. Let us say water availability controls the temperature there, some pixel here actually, tropical region. So, the slope has gone from very steep slope to a negative slope value. This will indicate some drastic land cover change has happened over that particular pixel. So, this will tell us the change in broad classes of land cover across the globe. So, this is what people have defined as yearly land cover dynamics observed from LST and NDVI maps.

So, as a summary in this lecture we have discussed about LULC classification scheme and we have seen few examples of how this LULC classification or in general remote sensing information will be helpful for understanding land use, land cover as well as understanding the changes happening in land use, land cover. Here I just highlighted to you what land use, land cover classification is and what are all the different ways this can be put to use. So, all the corresponding references are given in the slides within the video itself. So, with this we end the topic of LULC application. So, with this we end the topic of LULC application and also this particular lecture.

Thank you very much.