Remote Sensing and GIS for Rural Development
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Week 8
Lecture 36
Introduction to Land Use Land Cover

Hello everyone. Welcome to the NPTEL course on Remote Sensing and GIS for Rural Development, this is week 8, lecture 1. I also have to share a very important aspect regarding this course, in last week I was in UP for a groundwater conference and I was very happy to see a student who came up to me and said this course has been very helpful for her preparation and to address rural development in a different lens. I thank for the feedback and hope to continue to give information and knowledge about Remote Sensing for Rural Development through these lectures. Let us continue for today's lecture.

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What we saw in the previous lecture was introduction to Google Earth Pro and DEM. We test Basics on Google Earth Pro and then DEM, since this is the week 8 first lecture, I thought I will give an overview of what has been discussed and then lead into today's topic which is very important for rural development.

So, in week 7 we have covered the Google Earth Pro intro. Google Earth Pro is a data archive, it is not a data source but a data archive, where multiple satellite and observation data is hosted. It helps researchers to identify data, download data and also download analytics which is very important for land use land cover classification and rural development attributes.

We also looked into extraction of ground control points from Google Earth Pro. Initially we had extracted them using paper maps, but then we also looked at how to extract from Google Earth Pro. We also looked into plugins, there are multiple multiple plugins but we focus only on one plugin which is quick map. These are very important plugins and data tools for rural development lectures.

Please note that you may not find tutorials and reading information about these plugins now and then because they keep updating and sometimes the plugins are stopped because it has multiple data sources and it works on multiple themes. In this NPTEL course we will not be able to cover all the data and plugins. But however, I am going to give you introduction on the most important ones and that is what the plugins that we discussed in the previous lecture.

Then we also discussed about the digital elevation model DEMs. In some aspects it is also called terrain models, digital DEMs or digital terrain models. We have given some intro and sources where you can download them. And then the DEM for an area was extracted using a mask. A hands-on tutorial was given to extract this data using a mask.

In week 8 which is the current week session, we will be looking at land use land cover which is shortened as LULC very commonly called. And then we have LULC change. So, how does land use and land cover attribute to rural development and we also have how does LULC change. Why it is important for Rural Development we will give an intro, so that when you download this data and use this data you will know how to use it for your rural development scenarios.

We will also look into specific water and land management because when you talk about the land use and land cover these are the 2 main features that get disturbed, water bodies, water use and land cover. So, land management is an, is a very important aspect of land cover. So, we will discuss that.

Once we clarify how LULC is very very important then we dig into data issues and proxy data that can help LULC. So, first we will discuss about data issues, why and how there is very less data about a land use and land cover. And then we will identify some proxy data that can be used for land use land cover estimations, especially remote sensing because this course is about remote sensing.

And then we will get into data issues and proxy for LULC which is the remote sensing sources, key sources out of which one is Bhuvan LULC maps and there is also NASA based

USJS LULC maps. As I say these get really updated fast. For example, when I was doing my PhD I used to download this data market and then classify into different land use and land cover, whereas now I will click of a button you will get it done, in those time it was a master's thesis, one year of hard work to make one map, but now it takes 2 seconds, so thanks to technology and science and development, it is very easily available I will go through the ones where it is very very quickly available.

But as the science and development happens the ground reality can be assessed and how it applies to the ground is different and that is where I would like to tell you that these technologies are good. However, if it is not tested and applied to the ground it is of less value. So, I hope most of you would use these lectures and try to use them for your studies, research, interest, life aims, goals for rural regions. We will also discuss on the fly remote sensing for LULC as I said USGS and also Google Earth Pro, these 2 aspects we will cover in this lecture.

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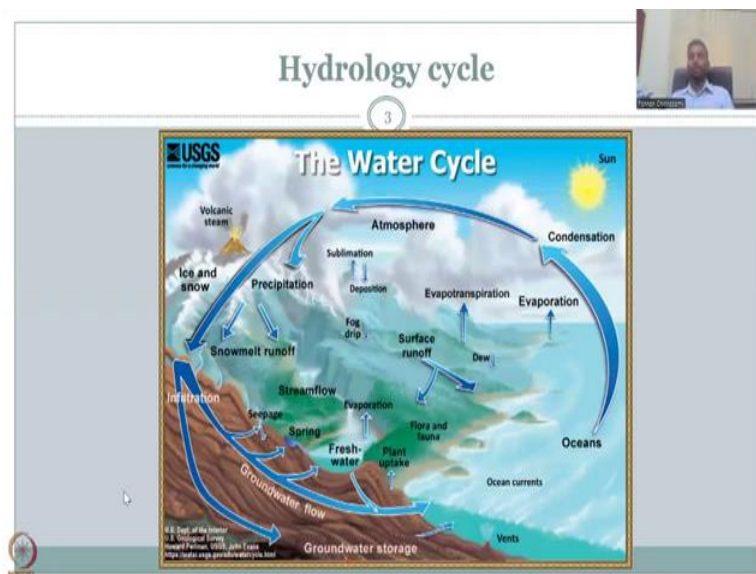
First let me introduce the hydrological cycle to show why the land use land cover is very important. As we discussed earlier, the entire rural system or life on Earth is focused primarily on water and water availability. Water drives life form across the planets. And that is why all these rovers and missions across the space is looking for water, there is no other material, no other resource they are looking at first, it is water. Once you have water there are indications of life.

So, coming back the hydrological cycle is driven by the sun and the availability of water on Earth. The hydrological cycle includes water converting from liquid to gas to solid phase and

then back to liquid. And for today's lecture or the week 8 series what is more important is get my pointer. What is more important is these processes have been discussed slightly or in depth in other NPTEL courses in this current course we have discussed very small aspects of evapotranspiration, rainfall, etc. But this land, the land, the geological unit plays a vital role.

For example, if the land is managed properly, then water can go in infiltrate and go to the groundwater which is a storage. It is like a bank account where you have money coming in, so the water has to pass through the soil and if you manage the soil well, water passes through and then gets stored in the groundwater aquifer for you to use in a later period, it is not a rigid storage, it is a leaky storage however, water is present.

If the land cover is not maintained well or it is used for different purposes. Let us say a Barren land which is not maintained well, water hits the barrel land and goes as ran off. Same, if you have a concrete jungle where like Singapore for example you have so much of concrete which was initially forest and agricultural land now everything is concrete.

So, once concrete what happens is water hits and then goes to the drain and then becomes runoff. If there is no drain like in Mumbai you see floods. So, the management of land and the use of land is very important for preserving water and soil nutrients. For example, if you are putting a lot of cement on top of the land, the soil underneath does not get nutrients, there is a lot of nutrient arresting mechanisms, biophysical mechanisms that help the soil to sequester nutrients. And if it is not exposed to sunlight, air, atmosphere it will not be as nutrient-rich as possible.

In other standings if you have a forested land, you will see that the climate is much much buffered, you do not see too hot or too cold. Same way wind is buffered and you have a lot of life form, life activity with forest cover. So, these are the aspects that we will be covering in this 8th week. I hope you understand the importance of land that it helps to provide a base where plants can grow, plants can root and then provide nutrients which is important for soil and eventually lead to rural livelihoods, thereby leading to rural development.

Our roads are important so roads have to be mapped into the land use land cover. Houses are important, it has to be mapped into the land use land cover. And that is why keeping a very updated land use land cover map is very very important. We will cover also in the next week lecture the mapathon and show how people can take part in the mapathon activities for updating the land use land cover.

So, moving on since now we know what is the hydrological cycle and how the land and land cover and land use play a vital role in getting water, soil, nutrients to the rural environment let us get into details of land use land cover.

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First let us look at the first part which is land cover. Land cover refers to as per the USGS the vegetation and artificial structures that are on top of the land and covering the land. So, if you have a land, what is on top, what type of vegetation and artificial structures. So, for example you have a big garden in IIT, Bombay we have big big gardens and around there, there is administration buildings. So, you have gardens, administration buildings. So, these are on top of the land.

Examples of land cover include trees, grass, crops, wetlands, water, buildings and pavements. So, land cover is something that covers the land, it could be artificial, it could be natural also. So, for agriculture where will this be? A rural development where will this be very important, yes, crops are very important.

Sustainable agriculture requires preserving the forest, so agro forestry is important. Water, wetlands are very very important to preserve the soil nutrients and to mitigate against climate change impacts like the Sundarbans are playing a key vital role in reducing the sea level rise in Bangladesh.

And buildings and pavements as we talk about bringing in mechanized agriculture, bringing in industrialization, small scale at least in livelihoods of rural population, there is a need for pavements which is roads, kind of roads in rural networks and some small scale buildings.

So, while land cover is very very important. Scientists also understand that land cover along with land use makes sense, just as land cover does not make sense, but what is the land used for makes sense.

So, let us first dive into more definitions of land cover. Land cover is the observed biophysical cover on the Earth's surface as per FAO, the food agriculture organization defines it as the land cover which includes the biophysical cover on the Earth's surface is given as land cover.

Physical cover is good but also bio is very important. Physical could be soil, water, wetlands, etc but what is the biology involved in it? Like for example the forest has a biological impact on the soil and the land that it is surrounding. Please think it as a rural entities if you are in a rural setting what would you like, you would like the soil to be highly nutritious, you like water resource to be there for farming.

You would like quickly for the produce to come out of the farms into the storage and back to the market. Again a rural livelihood will grow as long as the demand is met through a supply chain network. The supply chain requires good roads, efficient transportation for which there is a land cover which is going to be estimated.

Consequently areas with bear rock or bare soil or land not land cover because there is nothing covering it, it is just bare minimum. So, think about land cover as what you wear, the basic skin is just pure land, there is only bare soil, bare rock, there is nothing growing on it, so you cannot say that is land cover.

But when you are putting extra layers like jackets, like shirts, like t-shirts, then each one of it becomes a land cover. In global terms, in earth terms let us say the entire land was fully barren and then slowly the forest came up, slowly the water bodies came up into one pool, maybe first was full of oceans, then we had pockets of water which became lakes, ponds, rivers, streams, springs, etc. and these are land cover.

There are different classifications that exist which is a concern I will tell you why when we dive into a land cover aspects. FAO gives one example of land classification but there are multiple multiple different classification techniques.

The basic classification of land is land cover classification is by physical appearance, you go to a place, you look at how the land cover is there, what type of land cover is there and then you mark it. Let us say you first take a land and then you graded. Same as we did for our, same as we did for our rasters, etc.

So, you have the land, you divide it into grids. Let us say we have 3, 5 row, columns and 3 rows, so you go to each grid and then look at the physical appearance, it could be agroclimatic, agroecological classification. Agroclimate is the climate of the region then that grid and what is the crop that is growing agro ecological has more ecological weightage, technical attributes like soil profile, soil texture, agroclimatic conditions are noted. So, these are part of the classification technique.

And then land use classification is what it is being used for let us come back to land use later, but land cover is basically on a physical appearance, you may do a survey and then look at what is the land cover.

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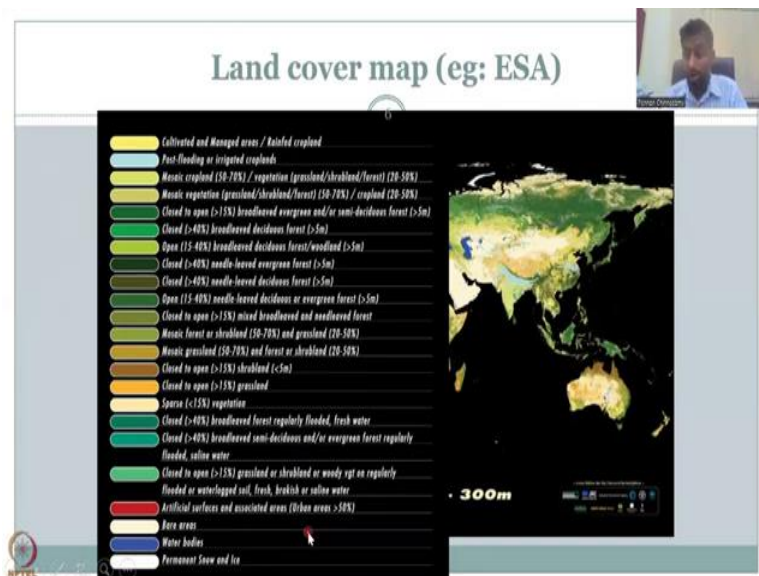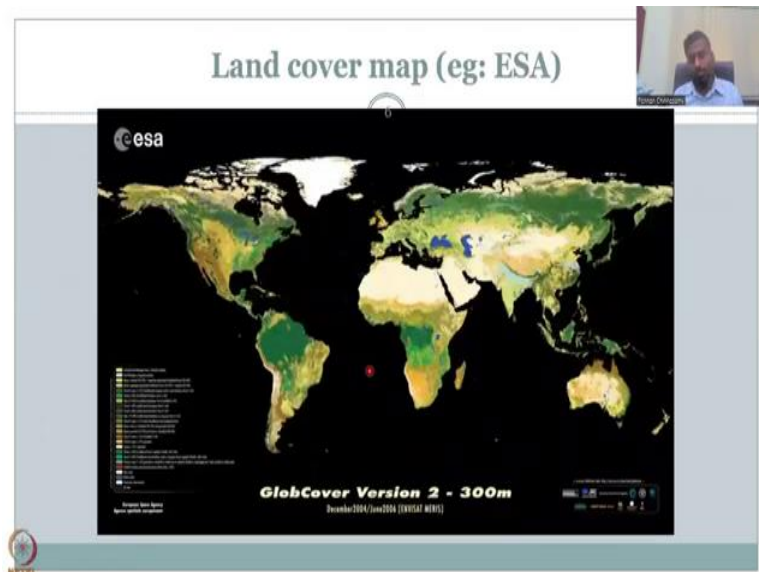
Look at this map which we have already shared, this is a older version 2004. I will be showing a new version in the hands-on exercise. You could see that this is the land cover map of the world taken by the European Space Agency mixing a lot of satellite data and you could see like how many legends, how many classifications are there.

In this legend you have at least 20, 30 classifications of the land cover. So, cultivated area, post flooding, sparse, mosaic, closed forest needle leaved, green forest, artificial surfaces and associated areas, water bodies all these are land cover. And how does that help? It helps because now you can identify where the key land covers are present.

So, maybe for example the evergreen forests are present, the dark green is broadly evergreen semi -evergreen, so all these are evergreen forest. In India you have post flooding irrigated

croplands, so the Ganges basin is one of the largest irrigated croplands in the world and that is being captured by satellites.

So, now let us come to the second half of the name LULC LC which is being already discussed land cover we first discussed land cover now we are going to discuss land use LU. And you and what is its role in rural development.

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So, land use is defined as a series of operations on land, carried out by us the humans, with the intention to obtain products, benefits through the land resources. So, you see land as a commodity, you convert it to a profit by your applications of technology, manual applications, etc and you harvest something out or you gain something out using the land and that is the land use.

So, there could be a product but there is a use for the product. If you buy a car and you just keep it, it is just a car. But if you buy the car and use it for transportation then the car's use is transportation to go up and down. You will see a lot of people just buy the car and keep it which is of no use just to show off their money, but use is actual use that the humans use it, and so they put petrol and it works.

So, same thing the land is there, it could be a forest cover, it could be a cropland, but if there is human interference and there is a profit that is being generated through the land then it is called land use. Refers to the purpose the land serves and a lot of examples including agriculture, wildlife habitat, recreation, etc, etc. Wildlife habit are not the natural forest but wildlife habitat is like mostly your resorts and stuff where you have enclosures and then you put animals in zoos, etc.

So, how is this important for rural development? Normally I would stop here in a live class and ask the students to think and give answers, given it is a virtual scene, I am just going to say that it is very important for rural development as it gives the land available for the rural development activities and options.

Let us say you have land, you want to start a chicken farm, so you need the land you are converting it with some stills, some coverage on the top and then you put a chicken farm, poultry farm so that is land use, that is a rural development activity. Same thing you have a land or a forested area you clear it little bit and put a school in there and that becomes a land use.

There is a land cover which was only initially a crop or a forested land you converted to a school. Same thing there are barren lands or croplands you put roads in between to enable better transportation and that constitutes the transportation aspect. So, all is you have to put it in which means this is supported by are not other factors but humans.

So, naturally a school cannot come, naturally a forest can come, so that is the land cover. But you cannot have natural growing schools, croplands, etc. it has to be through the interference of humans, that is called land use. Let us look at an example of limiting land. For example, if you do not map it suddenly what happens is the land available for rural development diminishes.

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Land use map –Mast[er]
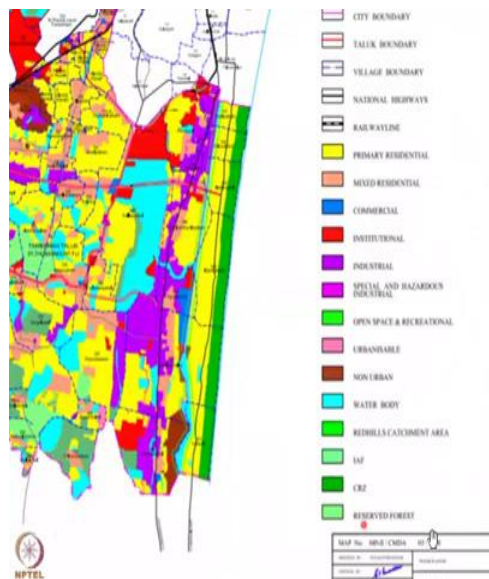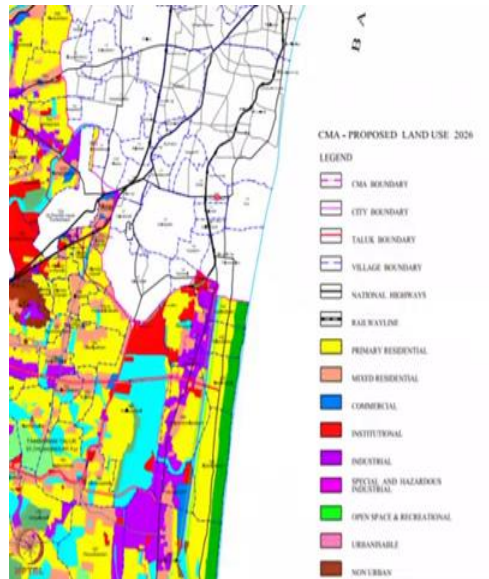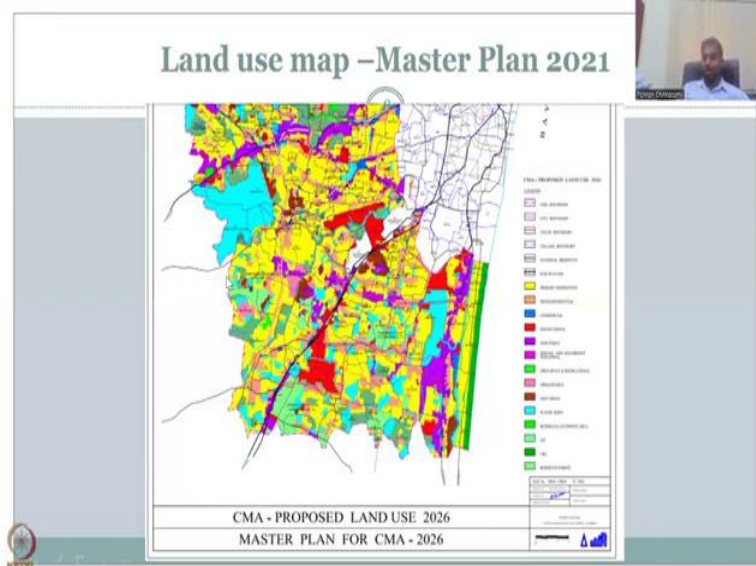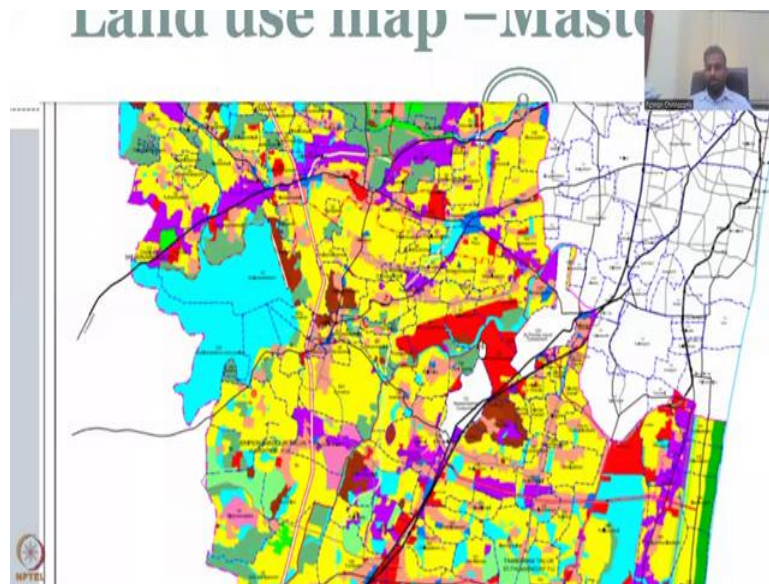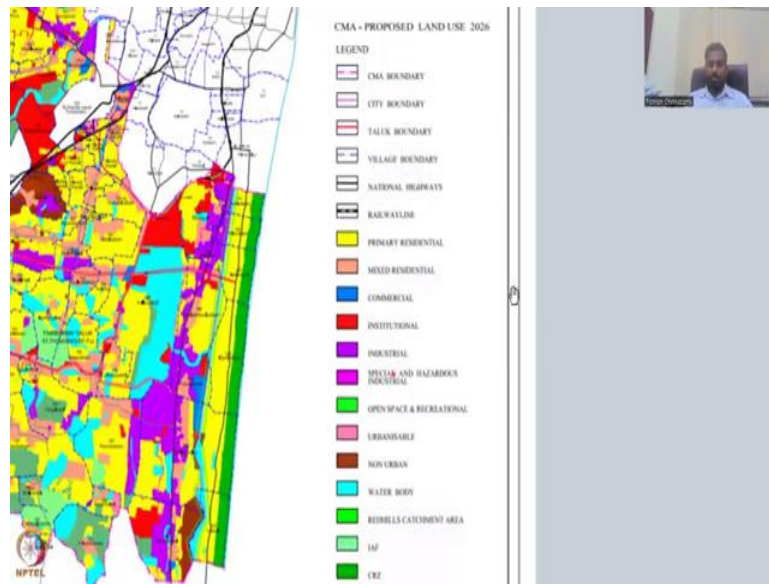
Let us take this example of the Chennai Metropolitan master plan. And you could see that it has been proposed for 2026, lot of land, lot of land, extensions have been happening but lot of this is under, still under the rural peri-rural areas. And the people living there also want to be attached to Chennai because of the Chennai's branding, it is a city, it is a metropolitan, a lot of good aspects come like metros, trains, connectivity, airports, water supply, drainage supply, power supply, all these are based on Chennai's city network plan.

So, lot of, eventually lot of the peri urban areas or the regions around the Chennai border would like to become Chennai and so this was the master plan where it looks as from 2021 to 26, how it is going to change. And you could see that if for example all these were initially some pockets were we can zoom in to see.

So, mostly it is city boundary, taluka boundary, village boundaries, so there are some villages and then you have not many agricultural lands but it is only reserve forest, coastal areas zones, there are some army and other regions also. So, you do have some pockets of villages and boundaries but what happens here is these villages were normally on the edges of the city and now they are converting to city land.

So, the there is a conversion of the land use land cover to urban and so rural entity is gone. When rural entity is gone the water supply for irrigation, crop management, fertilizer subsidies, everything goes away. So, there is lot of livelihoods there is left, the land becomes a city, land where the taxes could be high.

So, leave the administrative part what I am trying to get at is if the lands are taken and converted to urbanization then there is more stress on the rural environments to produce food, crop and water requirements for the cities.

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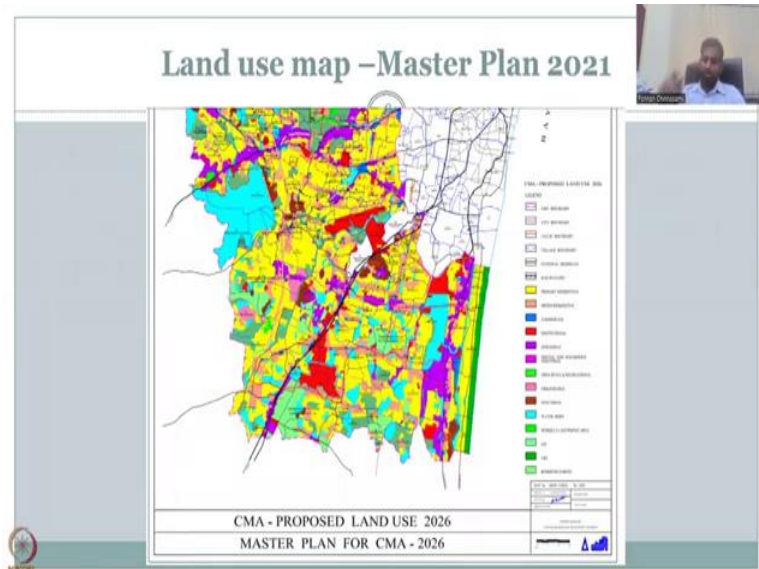LU: What is difference?

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- **Land cover** indicates the physical **land** type such as forest or open water whereas **land use** documents how people are using the **land**
- For example, a recreational land use could occur in a forest, shrubland, grasslands or on manicured lawns.
- In general one term **LULC – Land Use Land Cover**
- **LULC Change**

https://www.fao.org/3/x0596e/x0596e00.htm

Land use map –Master Plan 2021

CMA - PROPOSED LAND USE 2026
MASTER PLAN FOR CMA - 2026

What is the difference in the land use and land cover? Land cover indicates a physical land type such as forest, open water, etc, whereas land use documents how people are using the land, the physical appearance, the physical attributes of the land could be different, a forest, an open water body, etc. But if you are putting a land use on top of the water body let us say recreation, let us say fishing activities or you have water theme parks, so that is a land use.

For example a recreational land use could occur in a forest, you can have a forest which is natural, but if you put boundaries and then say you have tiger walks, tiger safaris in Jeeps then that is a land use, shrubland, grassland or manicured lawns. So, you have a naturally growing lawn if you go to the outskirts of the city you will see just grass is growing, so that is land cover. But when you manage the crop, manage the grass in your house garden that is land use.

Sometimes it is difficult to differentiate it. For example, the forest, it could be a man-made forest, it could be a natural forest. When you say natural how old it should be? So, all these questions come and this is a time specific image, when I say land cover for which year you should ask, so same thing we asked here master plan for 2026. So, there is a time-bound information in these data.

So, you should always put it as a time bound information and because of the time boundness there is also a land use associated with land cover, so both are merged together and called as land use land cover. It is one term, you will find it just Google it as land use land cover for India, for your district, Trichapalli district Tamil Nadu state, South India all you will get data.

The next is LULC change, so land use land cover is a one-time snap for a particular time snap what is the land cover and land use, land use land cover change is how that changes with respect to another time, let us say current and I want to do pre-independence. So, 1940s what was the land use land cover and in 2023 march what is the land use land cover, we can compare and then show graphs of increase in agriculture or decrease in agriculture, definitely increase in urbanized land, etc. We will do all these exercises in the hands-on tutorial.

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So, now you know that what is the difference between land use land cover and it is a time stamp data. What you also have to remember is that the classification and the legend always is tricky. So, how do you classify land? What does green refer to in a satellite image or what is crop, what is forest, what type of forest? Is it deciduous, evergreen, is it needle pine, all these things.

So, we found out that there is no global rule which means a particular land use land type is not the same in Finland as the same in India. However, some general classification exist, very general, the U.N's kind of scheme is there, FAO scheme is there, SNA, etc. So, the worry comes here is, is there one specific for India and there is not. So, to discuss in live class I would always throw this question and ask is it needed?

It is needed because only when there is a uniform classification of land across India then the management schemes can come, then the transportation schemes can come, schools, livelihood, libraries, all these can be given to a particular land use land cover. And if the land use land cover differs between states then we do not have any normal baseline value to work on.
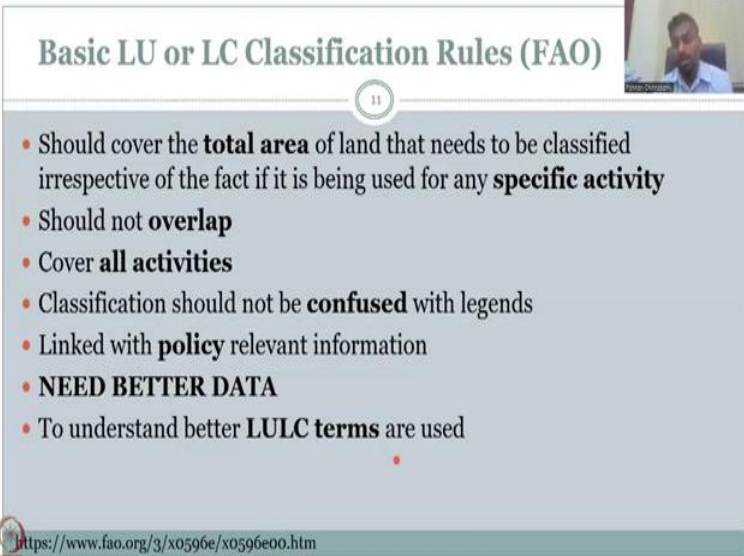
So, India is very fortunate to have diversity, but there are some things that has to be normalized and this is one thing I feel definitely the classification of land use land cover has to be normalized across India. What do you mean by crop? What do you mean by forest land? What do you mean by forest buffer, the riparian zone? What do you mean by coastal regulation zone, all these have to be one rule across the country, one classification across the country.

What is the key in classification we also need to avoid overlaps in the legends. So, how are these classifications made, so the more important note here is each government agency will do different classification. For example, there is central water commission, they will take the land along the rivers as flood plains but that will be marked as alluvial fans in agricultural land.

You see how the same land has different classifications with different agencies, then how do you bring them together in one database, we cannot. Luckily you can bring them all together in one database in a GIS when you start with the GIS layer. So, for example, I start with the GIS layer or a satellite image remote sensing and then I put the boundaries of the central water commission, I put the boundaries of the agricultural department, I put the boundaries of a forest conservation, green tribunal, etc.

Then there is a match, then you know that the same piece of land is being labelled differently by different agencies which is a big big concern. Why should the same land be differently labelled? Maybe for some aspects for administration purpose it is fine. When the rule comes, when the law comes it is needed to have one basic land use land cover classification.

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Let us look at the basic principles and rules that is needed for basic LU and LC classification according to FAO. When you say the grid, inside the grid if I say forest, the total area of the land need not be full of forest but majority of the land has to be forest. Should cover the total area of the land that needs to be classified irrespective of the fact if it is being used for any specific activity.

So, for example, the same forest can house an army training, a rock climbing, etc, etc. But if the granularity, if the resolution is small enough to capture the just that we can put it or we will have to fully classify it as forest land and put a point inside to say that there is some military training camp.

It should not overlap, there should not be multiple land use land covers for a single land as I gave the example. It should cover all activities that are present, it has to have detailed information. What do you mean by, for example I say, it is a military base camp, forested military base camp, then it should tell that there is part of the land which is forest, there is a part of the line which is under the bay the army training, there is a conservation forest for example IIT Bombay we have a conservation forest on top, the Sanjay Gandhi forest. So, all these are have to be labelled and they should be covering all activities.

The classification should not be confused with legends, legends are that entire group the classify is how you classify the land use land cover. All these should be linked to the policy recommendations and policy works. Again all we want to do is to manage the land properly, better management, better leading to rural development for which there are a lot of policies and the policies should know what is forest?

Let us say the very basic land use land cover. Let us say there is a forest and agro forest if the policy does not have the term agro forest, then how can you label a land and then link it to policy? So, there is always a need to link all the database to the policy so that it can be applied for the land.

As I have been striving across this lecture series there is a need for better data and the better data will come from satellites. There is a need for high resolution, spatial and temporal, we will go through some exercises in this row database and you will find that why I am pushing for the need for better data. And to understand better LULC terms that are used. There are multiple terms that I used, we will be looking at what does it mean in real terms.

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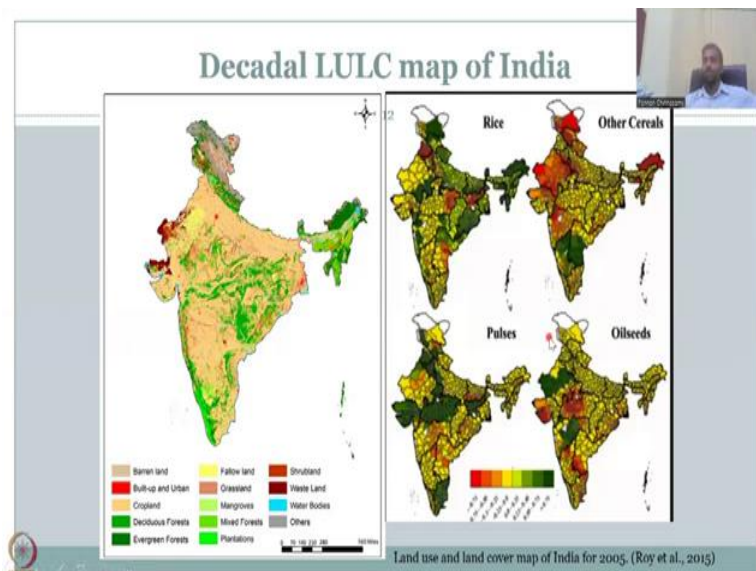
Let us take an example here, this is a decadal LULC map of India. On the left hand side you see the land cover, it is just basically what is on top of the land, there is barren land, built up crop land, deciduous forest, evergreen forest, these are land cover but in the right hand side you see so this is the land use, you do not see the forest here, there is no overlap.

So, for example all these are forests but you do not see forest here because in that district what is the land use has been mapped. So, in that district pulses grow in the medial range. What grows high in this range is other cereals, rice, yes, Vembanad, Kuttanad all these are very very high rice producing regions, Kollam, etc.

You know that Chhattisgarh has a lot of rice, Orisha, Odisha has a lot of rice, all these are showing that rice is very very important cultivation on this land. So, these are the differences

between land cover on this side on the left and then land use on the right. We will see more of this in the upcoming lecture series. Thank you.