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Lecture 57
Remote Sensing and GIS Application in Agriculture and NRM - Part 03

So, in continuation of the topic Remote Sensing and GIS Application in agriculture and NRM, in this part 3 we will be discussing about the role or uses of remote sensing in agriculture. We mentioned it, discussed it also that how different way remote sensing and GIS can be useful for various purposes. Land use and capability we have discussed about. Now, today we will look at that how remote sensing can actually help in studying different aspect of agriculture.

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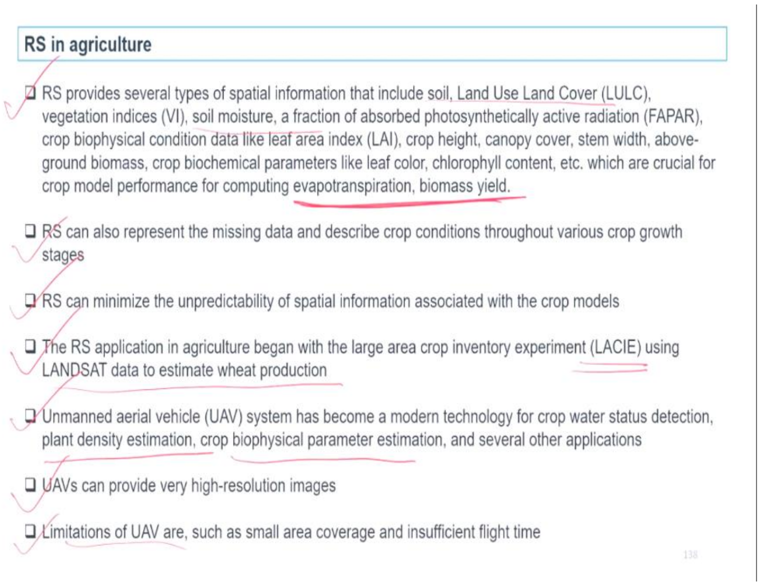

Remote sensing, it provides several types of spatial information that we have already discussed like information about soil, Land Use Land Cover, vegetation index, soil moisture. So, a fraction of the absorbed photosynthetically active radiation that we call FAPAR, crop biophysical condition data like leaf area index, crop height, canopy cover, stem width, above-ground biomass, crop biochemical parameters like your leaf color, chlorophyll content or various other aspects which are crucial for crop model performances for computing evapotranspiration, biomass yield.

Because these are the aspects that we need to know, need to study about agriculture. And if you recall that in the modeling lectures, we discussed in great detail that how inputs comes from different climate model, remote sensing or information. These all also can come and can be integrated today in a couple manner.

So, we also discussed if you recall that, that how a coupling of hydrological model, crop model can also be done and utilization of artificial intelligence, GIS, remote sensing these days are possible. Now, remote sensing can also represent the missing data and can describe the crop conditions throughout the various crop growth stages. I have given you often the example of rice because most of us actually well aware of the rice crop and rice crop has different stages and very different color and also structure.

So, remote sensing can be used very efficiently to find out missing data and also the crop conditions across the different crop growth stages. Remote sensing can also minimize the unpredictability of spatial formation, especially, which are associated with crop models. Remember, in crop modeling lectures we discussed that, that in crop modeling we try to mimic the natural condition and we try to close as much as possible.

They are also remote sensing play important role. The informations of remote sensing can be used in crop model and the resolutions or the spatial informations about a particular crop in a certain area actually can be improved by the help of good quality remote sensing data. The remote sensing application in agriculture began with the Large Area Crop Inventory Experiment which we call LACIE. LACIE used LANDSAT data to estimate crop production.

So, especially, in developed country where you have huge amount of land covered under single crop, there certainly will get very very useful remote sensing information. But in case of India, here as the land size is small, probably in one land to the very next line you can have 2 different type of crops. Yet remote sensing can help us to understand the different crop coverage in an area.

Unmanned Aerial Vehicle, (UAV), all of you are aware of UAV system has become very popular in various developed country as well as it is now slowly coming into use in our country because UAV technology. UAV system can be used for crop water status detection means how much water is there whether you need to apply irrigation or not.

One of the major concern in case of irrigated agriculture is that we irrigate even when it is not required. And irrigation means utilization of energy, electricity. Huge amount of groundwater wastage. So, UAV can help you to understand the crop water status and thus you will be able to actually irrigate the field when it is needed. It can also help you to estimate plant density, crop biophysical parameter and also various other aspect of agriculture.

UAV can provide us very high-resolution images. And as if we get high-resolution images, certainly, our evaluation of the cropping area, estimation of various resources, everything will be almost error free. But having said that there are few limitations of UAV as well such as it has a very small area coverage and also very insufficient flight time. Means, after certain time it has to come down you have to get it down and then again send it up. Because there are also certain issues with its energy, how long it can actually fly. So, these are few issues which are still being addressed at the R&D level.

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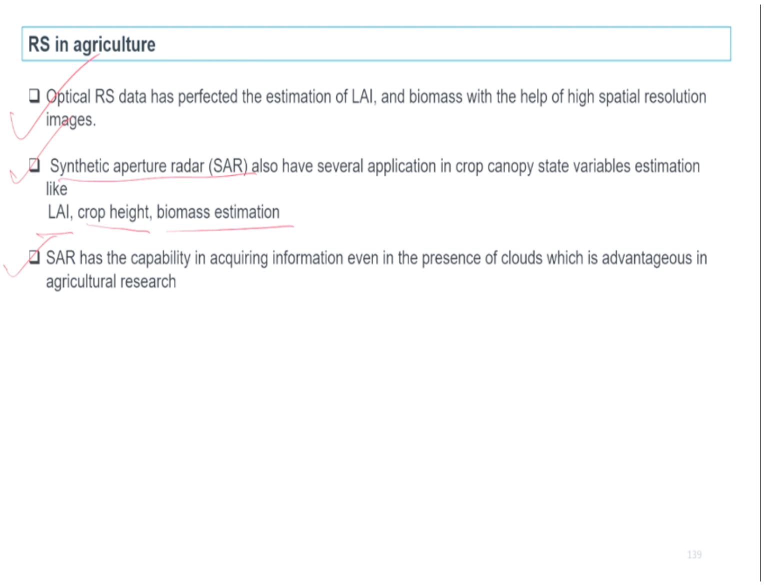

Optical remote sensing data has almost perfected the estimation of leaf area index and biomass with the help of high spatial resolution images. Because if you get high-resolution images then actually it is very very easy to actually capture the real fact of the ground. Better the quality of the picture better will be your outcome of the analysis.

Now, SAR also have several application, Synthetic Aperture Radar has also have several application in crop canopy state variable estimation like leaf area index, crop height, biomass estimation. SAR also has the capability in acquiring information even in the presence of clouds and that is advantageous in case of agriculture research, especially, Indian agriculture where you get often cloud cover, we have a long rainy season also and various parts gets rains in different time. So, in our situation SAR can be a useful tool.

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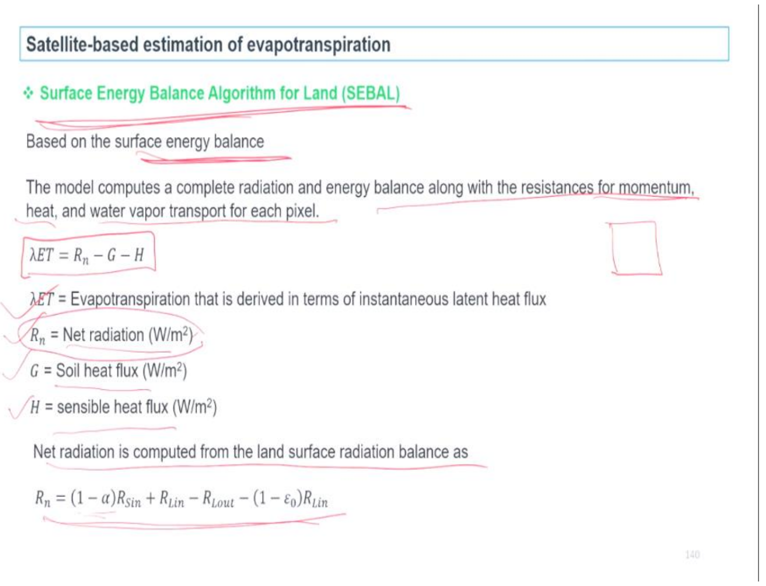

Now, satellite-based estimation of evapotranspiration. This is another utilization of satellite-based technology. Surface Energy Balance Algorithm for Land, this is what we call as SEBAL. This is actually used and it is based on the surface energy balance theory. The model, it computes a complete radiation and energy balance along with the resistance for momentum, heat, water vapor transport for each pixel, for each pixel. So, this is the equation that is used for this

Lambda ET is equals to Rn minus G minus H

What are those?

Lambda ET is evapotranspiration that is derived in terms of instantaneous latent heat flux. Rn is net radiation that is the unit. G stands for soil heat flux. H stands for sensible heat flux. And then net radiation is computed the land surface radiation balance as

Rn is equals to (1 minus alpha) multiplied by RSin plus RLin minus RLout minus (1 minus episilon 0) multiplied by RLin

So, this particular equation helps you to get the net radiation which is expressed as RLin.

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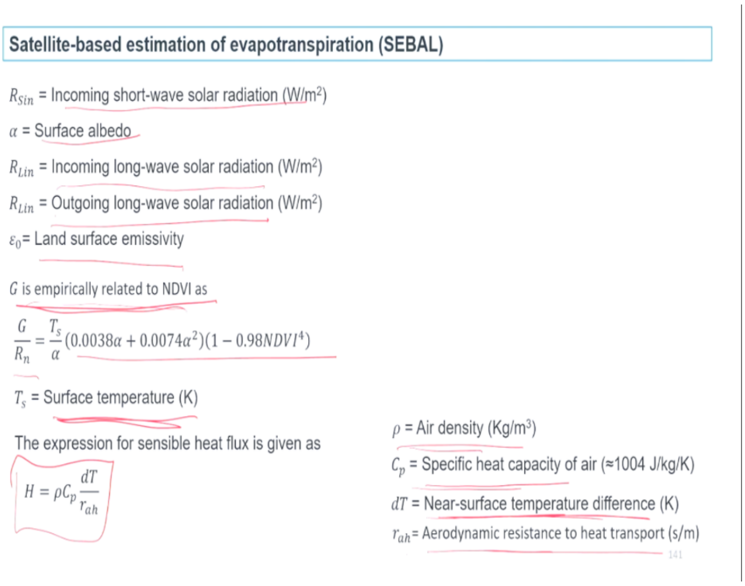

Now, RSin equal is actually the incoming shortwave solar radiation where alpha is the surface albedo, RLin incoming long wave solar radiation then outgoing long wave solar radiation land surface emissivity epsilon 0, G is empirically related to NDVI. How?

As G by Rn is equal to TS by alpha and then you have it this particular equation.

G divided by Rn is equals to TS by alpha multiplied by 0.0038 multiplied by alpha plus 0.0074 multiplied by alpha square whole multiplied by 1 minus 0.98 multiplied by NDVI to the power four

Where T_S stands for surface temperature in Kelvin.

The expression for sensible heat flux is given by this equation.

H is equal to rho multiplied by Cp multiplied by dT divided by rah

Where rho is the air density. Cp stands for specific heat capacity of the air, dT is the near surface temperature difference in kelvin rah is the aerodynamic resistance to heat transport. So, these are the different way that you actually get the various estimations under SEBAL calculation.

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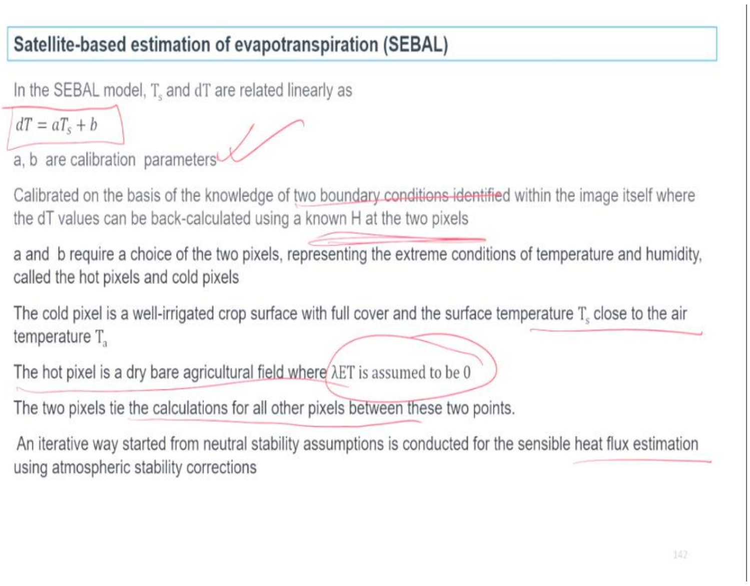

In SEBAL model, Ts and delta dT are actually related linearly. As you see here,

dT is equal to a multiplied by Ts plus b

is a linear equation a or b are calibration parameter and these are calibrated on the basis of the knowledge of 2 boundary conditions identified within the image itself. And dT values can when we back-calculated using a known H at the 2 pixels.

So, you have cold pixel and you will have hot pixel. So, a and b require a choice of 2 pixel representing the extreme condition of the temperature and humidity. And these 2 extreme conditions, one is hot and the other is cold pixel. The cold pixel is a well irrigated crop surface with full cover and the surface temperature Ts will be close to the air temperature Ta.

But the hot pixel is a dry bare agricultural land where lambda it is assumed to be zero. So, this 2 pixel tie the calculation for all other pixels between these 2 points. And iterative way started from the neutral stability assumption is generally conducted for the sensible heat flux estimation and you do it using the atmospheric stability corrections.

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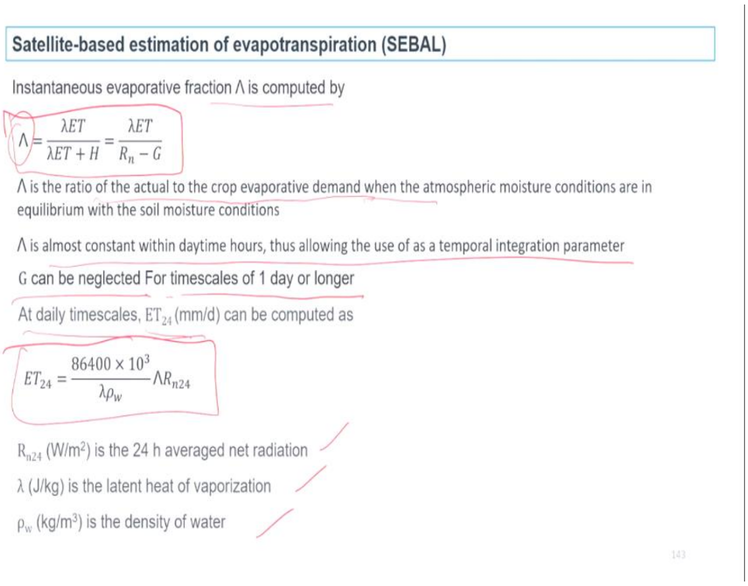

So, SEBAL model, in fact, allow you to understand the different extremes of weather events like humidity, temperature. Because ultimately, you are going to also calculate the evapotranspiration. So, the instantaneous evaporative fraction is computed using this equation.

Lambda uppercase is equals to (lambda ET divided by Lambda ET plus H) plus (ET divided by Rn minus G)

So, the ratio of the actual to the crop evaporative demand, especially, when the atmospheric moisture conditions are in equilibrium with the soil moisture condition. So, that is what is your instantaneous evaporative fraction. Now, this fraction is almost constant within daytime hours and thus it allows to use as a temporal integration parameter.

Now, G can be neglected for time scales of one day or longer. In case of daily time scale, your evapotranspiration for 24 hours can be computed through this equation.

ET24 is equals to 86400 multiplied by 1000 multiplied by uppercase lambda Rn24 divided by lambda rho w

Here are the details about different parameter. These I am just you know sharing with you because these are the aspect which is required probably when you want to go very deep into remote sensing and GIS.

But under this course I am just giving you some highlights of the application of different satellite-based technologies for natural resource management. So, if you want to get into further detail, if you are interested to learn then you have to take a completely separate course on remote sensing and GIS.

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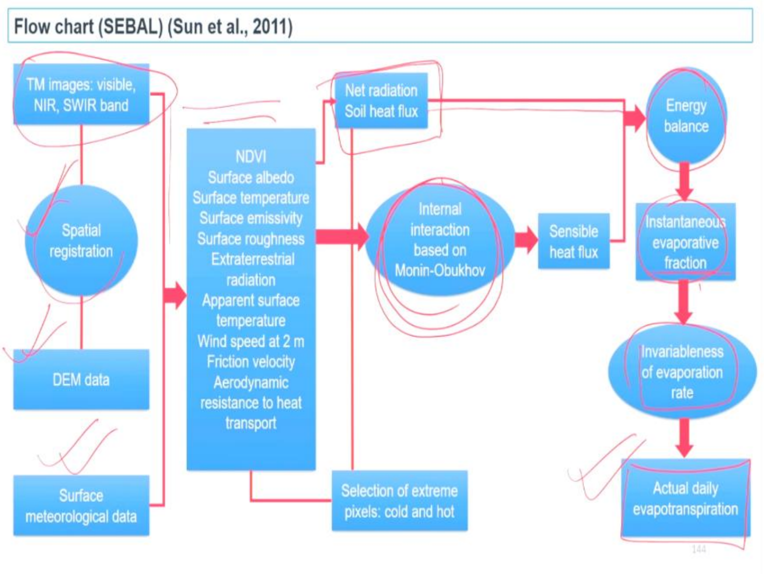

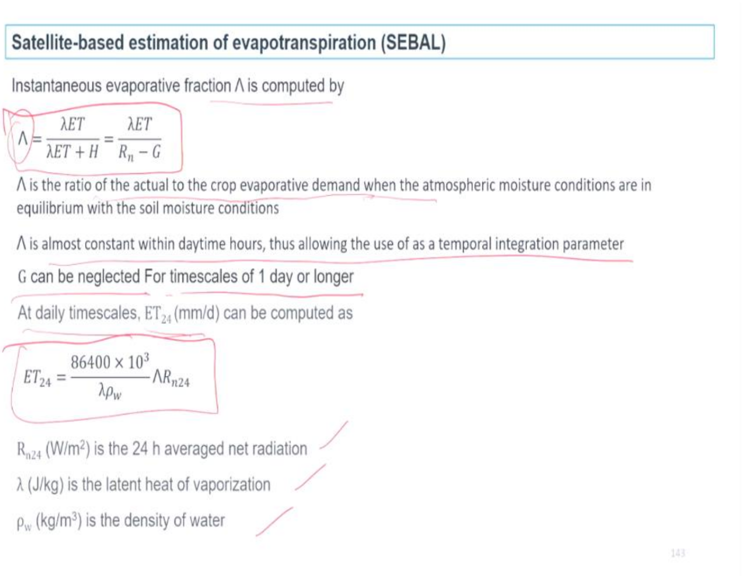

Now, if you look at the SEBAL structure, so, it actually starts with your TM image, visible NIR also SWIR band under that whatever information that you are capturing through the satellite spatial registration takes place digital elevation model data is also required. Surface meteorological data also needed.

So, when these are with you then you go for NDVI, surface albedo, surface temperature surface emissivity, all these kinds of analysis or function that you can actually run. Then through this you can get net radiation soil heat flux, you can also get internal interaction based on various equations. Once you get net radiation soil heat flux, you go towards energy balance then instantaneous evaporated fractions that you get which I discussed here.

Once you get instantaneous evaporative fraction then you go to the next stage, invariableness of evaporation rate, and then finally you calculate actual daily evapotranspiration. So, your ultimate aim is to get that per day how much actually water is getting evapotranspirated. Because that will actually tells you that how much water is present there and how much water you need to put back into the soil in the form of irrigation or otherwise.

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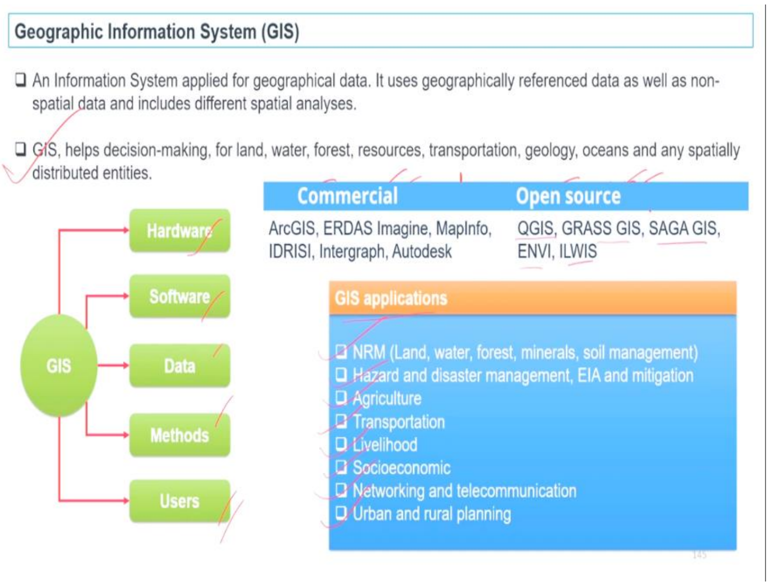

Now, GIS, Geographic Information System. This is a tool information system which is applied for representing your various data analysis in a very user-friendly manner. So, this tool uses geographically reference data as well as non-spatial data and also includes different spatial analysis as well.

GIS also helps in decision-making for land, water, are all natural resources, transportation, even geology, oceans, anything. You can actually see in front of you in a pictorial form. So, for GIS, to work with GIS you need good quality hardware, software, data, various methodology and also skilled manpower.

Now, there are few open source for this GIS tool like ArcGIS, ERDAS, Imagine, Mapinfo, IDRISI, Intergraph, Autodesk. Various commercial also aspects. So, these are actually basically the commercial one and these are the open source. So, ArcGIS, ERDAS, Mapinfo these, one has to buy actually, procure the right to work with. But there are, few are which are available in the free domain like QGIS, GRASS, GIS, SAGA GIS, ENVI, ILWIS.

So, these are some of the software. And then application of GIS are plenty. We already discussed in the previous lectures, in natural resource management, hazard disaster management, agriculture, transportation, livelihood, socioeconomic aspect, networking and telecommunication, urban and rural planning, any kind of decision-making processes GIS plays a very important role.

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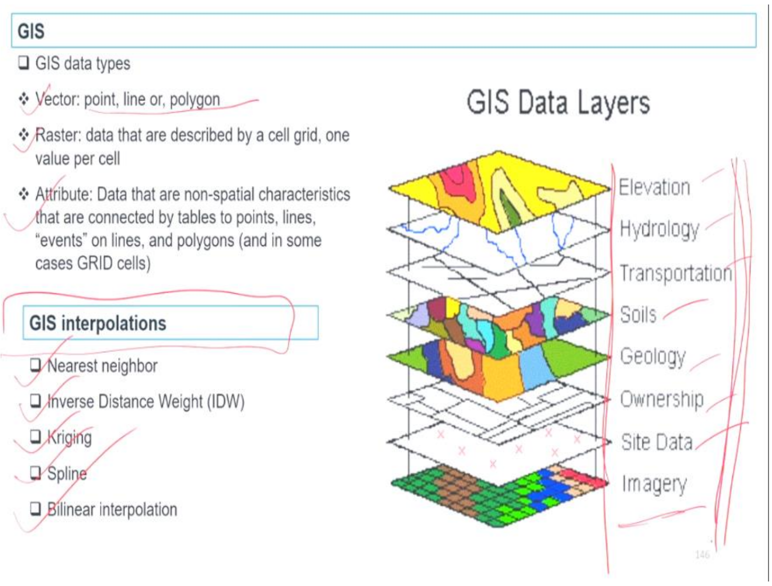

So, if you look at the data types that GIS tool uses they are basically vector and raster data. Vector data are in the form of point, line or polygon. Raster data that are describing by cell grid, one value per cell. Then you have attribute data that are non-spatial characteristics that are connected by tables to points, lines or events and polygons in some cases also grid cells.

Now, in case of GIS interpolation, if you want to have GIS interpolations then Nearest Neighbor one is method, then Inverse Distance Weight is another method, kriging is one very very popular method then spline, you can do bilinear interpolation. These are various kind of methods that people uses for various kind of interpolations within GIS platform. These are the various GIS data layers in general one can actually see it. So, you have elevation, hydrology, transportation, soils, geology, ownership, site data, imagery. So, various data layers that you can actually put one after the other.

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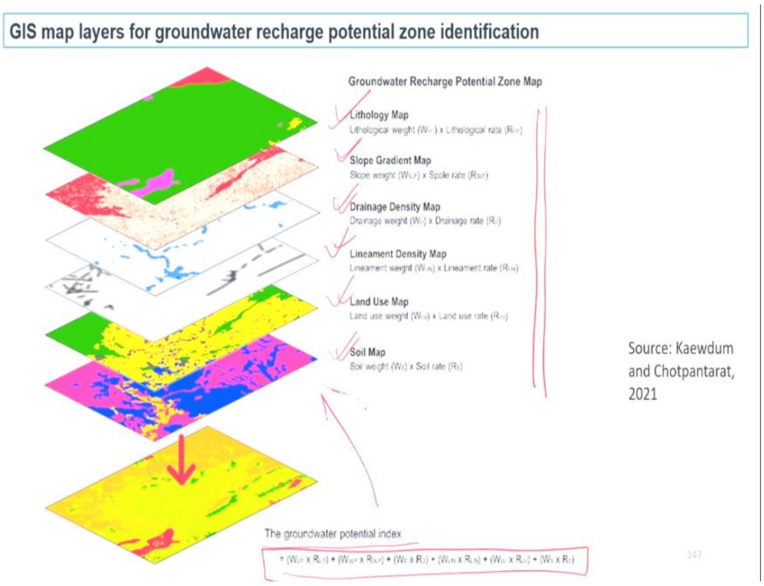

GIS map layers for groundwater recharge is very interesting and lot of work has been carried out across the world. So, especially for groundwater recharge if somebody wants to study then you can see that you need various layers, means various level, various type of information. Lithology map is one, slope gradient map, drainage density map, lineament density map, land use map and soil map.

So, all these information layer after layer in GIS actually you put in and then these, all these layers will interact with each other you analyze and then finally you can calculate the groundwater potential index utilizing various layers these are mentioned above. So, in GIS you can actually carry out various kind of interactions also, you can overlay one layer above the others, you can actually find out the interrelation between various layers. So, those kinds of different analysis also are possible within GIS platform.

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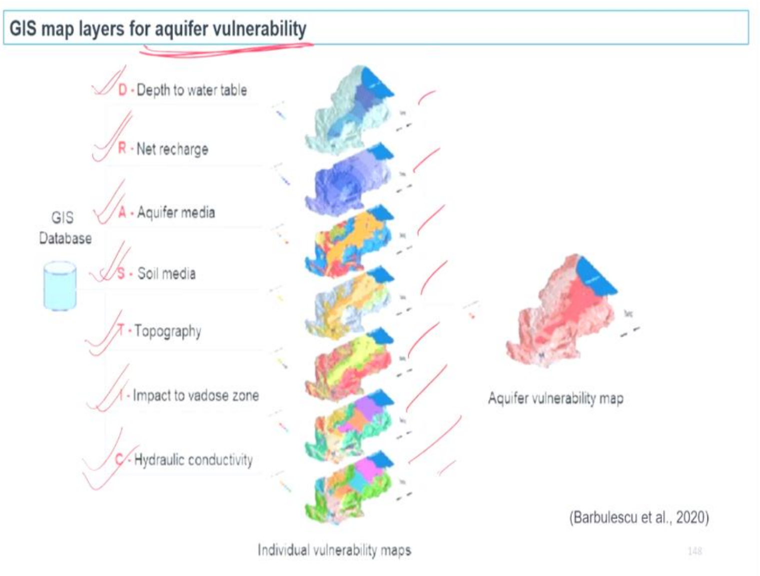

GIS map layers of aquifer vulnerabilities, another very interesting field that people actually work a lot. And there are many studies available. So, in understand the aquifer vulnerability, especially, people study in drought prone area, you will find that they will get different information layer, depth of water table, net recharge, aquifer media, soil media, topography, impact to vadose zone, hydraulic conductivity. So, all these layers after layer, they will put and then these layers actually can even interact with each other. Then you can carry out various interactive analysis to find out the aquifer vulnerability.

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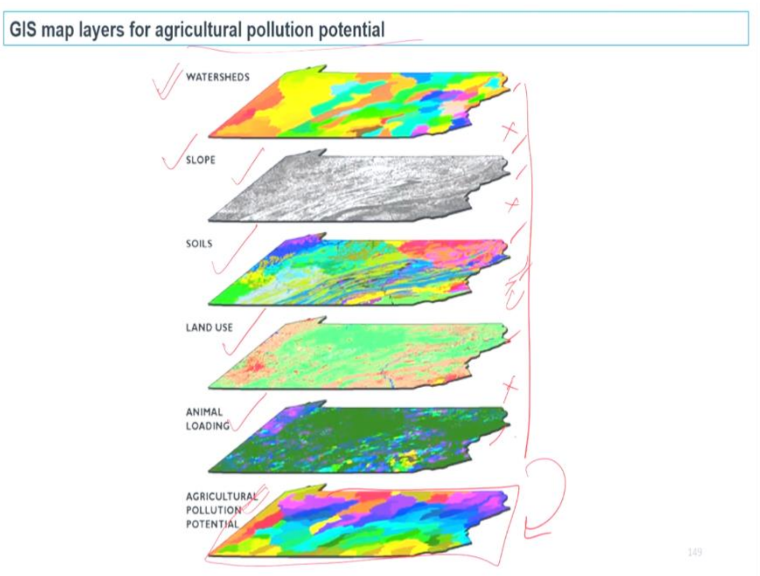

There are also lot of studies available using GIS tool; GIS map layers of agricultural pollution potential. So, there people who actually have various layers like watershed, slope, soil, land use, animal loading, agricultural pollution potential the final. So, interaction with all these layers then finally they can find out the agriculture pollution potential through the interactions of various layers of information within GIS platform.

So, this actually gives you very clear-cut information which is visible and this also helps to present your study in a very meaningful manner and also for layman, suppose, people who are not expert of GIS they can see the picture and looking at the maps they can understand, okay, this area is required our attention.

If policy makers, you are sharing your result with the policy makers they will appreciate when you actually show and understanding, your analysis result through this kind of GIS maps. So, that is what I think that these days for any kind of study, especially, in the field of natural resource management GIS plays a very very important role for data representation.