Geomorphology
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Lecture – 34
Coastal Geomorphology - II

So friends, welcome to this lecture series of geomorphology, today we will going to discuss this coastal geomorphology part 2. So, in part 1, we have seen that the coast is a combination of many processes and landforms corresponding to those processes, some of the land forms are relict and some processes and landforms they are going on in front of us today and we concluded that the wave and tide, they are the most dominating factor in reshaping the coastal land forms.

And along this shore zone, the wind also plays important role for reshaping, so now the question arise is what is the mechanism of this generalisation of waves and tides and to what extent, they can modify the coastal processes and the coastal land forms. So mostly, if you see here, this water on the ocean floor, they are under pressure; certain pressure that is called atmospheric pressure, it is measured at the sea level.

So, by increase and decreasing of this pressure, either there will be swelling up of this water surface or there will be squeezing of the system that is called high pressure and low pressure.

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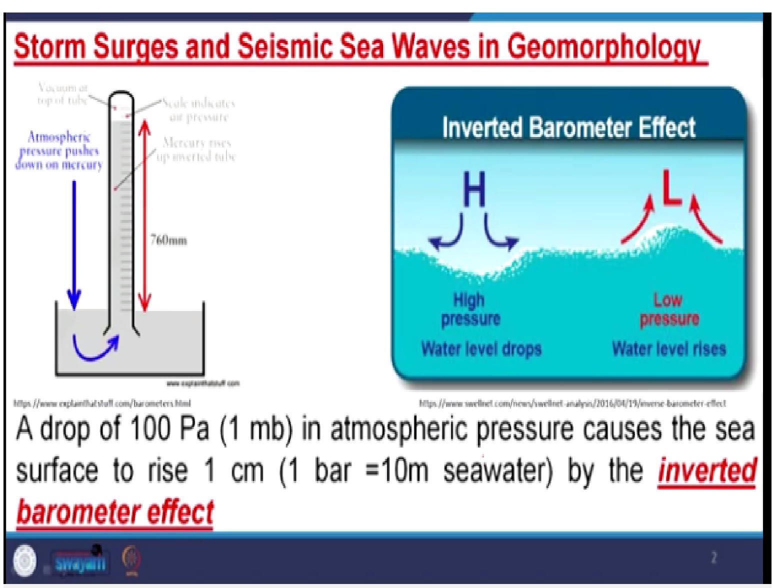

So that means, if the atmospheric pressure is high, so that means, we are lowering the sea level, so if the atmospheric pressure is low, we are elevating or lifting the sea level up, so this type of activities, this type of interrelationship, it is called inverted barometric effect, so the inverted barometric effect either it will decrease the sea level or increase the sea level, sometimes you might have heard the news, that there is the low pressure occurring at the Bay of Bengal or the high pressure occurring somewhere else.

So, this high pressure and low pressure means, if it is low pressure that means this wave or this ozone surface is swelling up and the ozone surface once it is swells up, so that means, water level increases and that increased water level it affects the coast, so water will encroach, the shore line will move forward towards the land and water level will increase, so that means, directly it is affecting the coastal geomorphic systems; coastal geomorphic processes.

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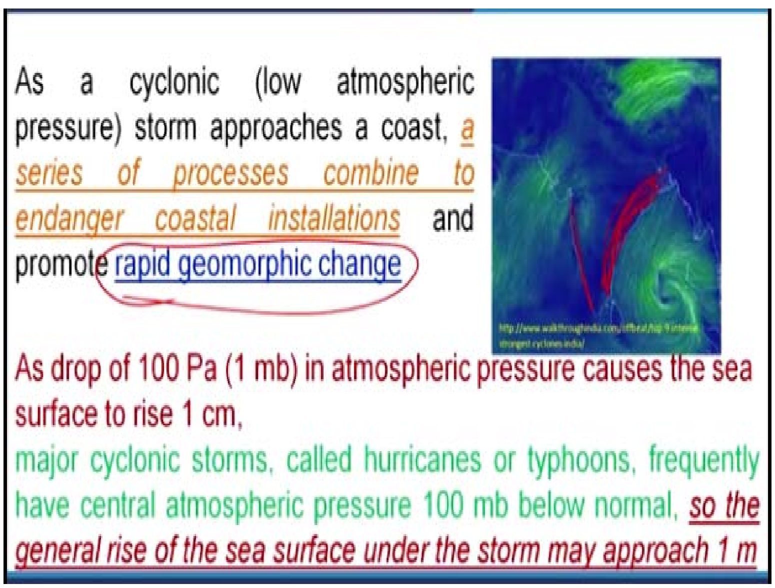

Then as a cyclonic storm approaches to coast, a series of processes, combine to endanger coastal installations and promote rapid geomorphic changes, this is important to understand here, these type of cyclonic effect, sudden increase of sea level and hitting the coast that rapid geomorphic changes occurs here; rapid geomorphic changes means, when we talk about this coastal processes, we say this the coast is constantly being modified by the wave action.

It is the permanent process but once there is an event of storm activity, there is an event of sea level rise; sudden sea level rise and this water will encroach to the coast, so that will rapidly modify this process however, though it is rapidly modified but those modified geomorphic system, will not sustain forever, it is a very limited time period it will be there and finally, it will be modified or peneplained by the other processes.

So, during cyclonic storms whatever this changes takes place along this coast, it is in a rapid form, so you know if the drop of 1 milli-bar pressure in the atmospheric pressure which drops 1 milli-bar, it increases the water level of 1 centimetre, so major cyclonic storms either it is hurricanes, the typhoons, cyclones whatever may be it name, these are the name depending upon this areas, so however, it is the same cyclone, it is called cyclone, it is called typhoons, it is called hurricanes like that depending upon the region, okay.

So, during this cyclonic storm, so this typhoons frequently have central atmospheric pressure that is 100 milli-bar below normal, so that the general rise of the sea surface under the storm approaches to 1 meter, so that means, either it is 1 meter drop or 1 meter rise, so that 1 meter that affects a lot along the coastal zone because the coastal, it is close to the mean sea level and this contours are sparse.

So, this area is relatively gentle, it is gentle slope, if it is gentle slope but sometimes this coastal plain is not gentle for example, if you compare our Indian west coast and east coast, you know. The east coast mostly, it is a gentle slope, plain area, cultivated land like that but the west coast, the steep phase of the western ghat is there. So that means, if that 1 meter rise occurs, 100 milli -bar pressure drops and 1 meter rise of this sea level, rises 1 meter.

That 1 meter rise may affect this much area of the system however, that 1 meter rise will hardly affect this part because the stiffness of the slope, so lower slope region like the coastal plains that 1 meter rise or fall that affect loss, 100's of square kilometre will affect or 1000's of square kilometre will be affect. So that means, those geomorphic processes which were genetically related, they will shift their respective positions by this shift by this drop of 1 meter of sea level.

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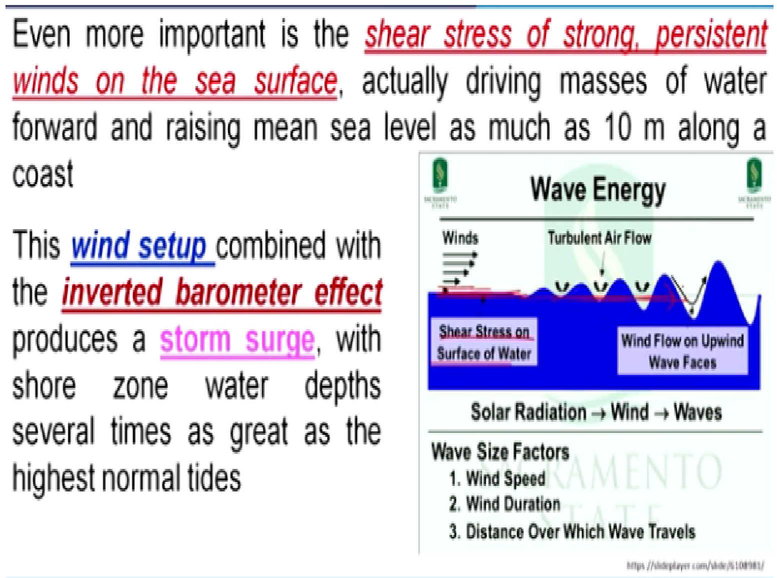

Even more important is the shear stress of strong persistent wind on the sea surface actually, driving mass of water forward and raising mean sea level by 10 meters along this coast. So, during the cyclone and due to this shearing action of these high speed winds, so if you see here, this is the water surface or ocean surface and wind is blowing here, this is the shear stress on the surface of water.

And finally, we know that gradually, the ripples will form, then ripple will converted to mega ripple and again, this mega ripple will converted to waves of high amplitude and higher size, so that means, gradually this persistence wind due to the shearing effect of the wind on the water surface, it creates these type of waves, so that means, we have the atmospheric pressure which can up and down this water surface, we have wind which can up and down the water surface and compel the water to move.

So, if this 2 factors combine together, that means, wind set up is combined with inverted barometer effect, so this combination effect product is the storm surge. So, storm surge with shore zone water depths, several times greater as the highest normal tides, so now you imagine, whenever we are talking about 1 meter rise of; fall of sea level, 1 meter rise of water level, it is affecting 100's of square kilometre.

So, if several tens of meters rise of the sea level and the whole water is pushing forcefully towards the land, so that means there is a major damage to this coastal installations, so geomorphology changes, this coastal set up changes, this deposition, erosion, whatever the geomorphic processes, whatever the relict land form of the present land forms that are affected.

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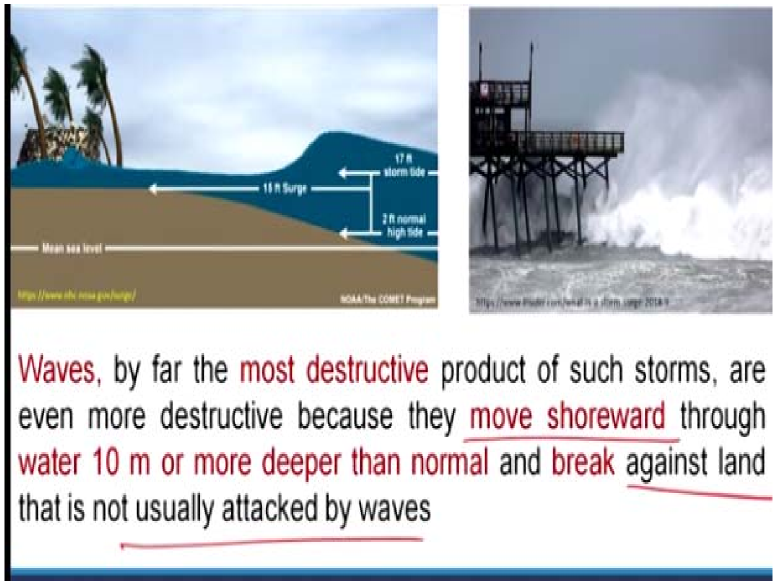

Waves by far most destructive product of storm surge are even more destructive because they move shoreward through water 10’s of meter or more deeper than the normal and break against land, it is not usually attacked by the wave, here it is understand. So, you see, when we are talking something about the normal sea level, we have decided in an area, we have confined area which is known as breaker zone.

So, breakerzone, it breaks the waves, so breaks the wave means, the wave height increases, the amplitude increases, the wave length decreases and those waves they are very destructive one, so now we have increased the sea level of 10’s of meter and the whole water were carrying towards the land and once this whole water, the 10’s of meter of water is going towards the land, so it is creating the breaker zone, were usually water cannot reach, so that means, mass inside the land, it is creating the breaker zone.

And once the breaker zone is there, this wave breaks up, breaks apart, it is creating a high water level, high amplitude waves and the low wave length and they are most destructive one, so major damage inside the land surface, it is created due to this type of breaking of this high waves, so that means, due to this storm surge, due to increase of water level, that water is moving inside the land and it is breaking against those areas were usually, not reached by normal sea level.

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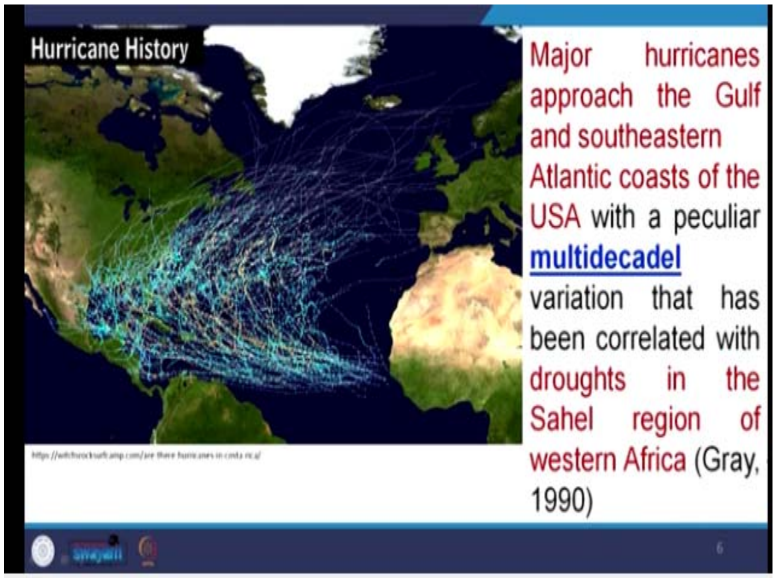

And hence major damage causes, so if it is in a world example is given here, major hurricanes approach the Gulf of south-eastern Atlantic coast of the USA with a particular multi-decadel range, variation that has been correlated with drought in the Sahel region of western Africa.

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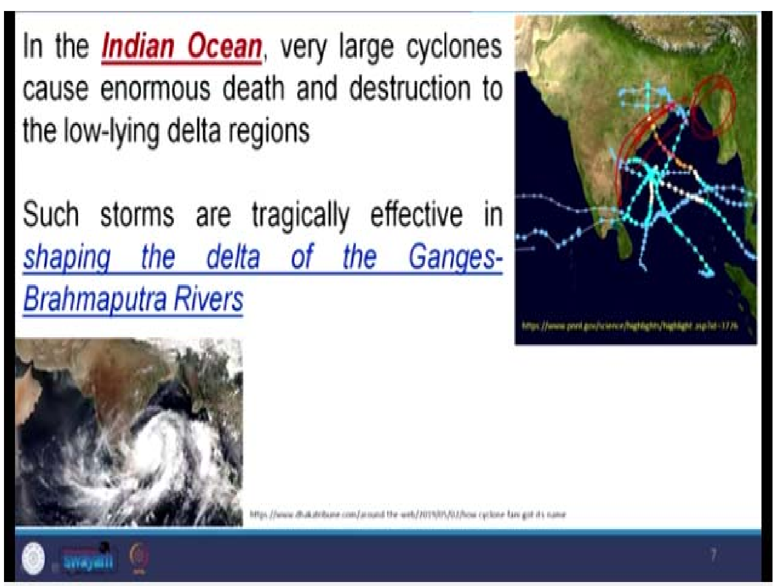

Similarly, in Indian Ocean also, in Indian examples, you; every year we can say, this cyclone, naming the cyclone, cyclone naming that they are occurring and finally, most affect occurs along the east coast of India and in the Bangladesh, so this Indian coast, very large cyclone cause enormous death and destruction of the low-lying delta regions, even it changes geomorphology, the Ganga, Brahmaputra delta, major changes in its geomorphology that occurs during the time of a cyclones.

So, such storms not only the deltaic part which is affect, this coastal plain from starting from the South to North, the whole coastal plain is affected but the most affect occurs where it hits to the surface because this is the breaker zone, so the breaker zones are mostly, damaged.

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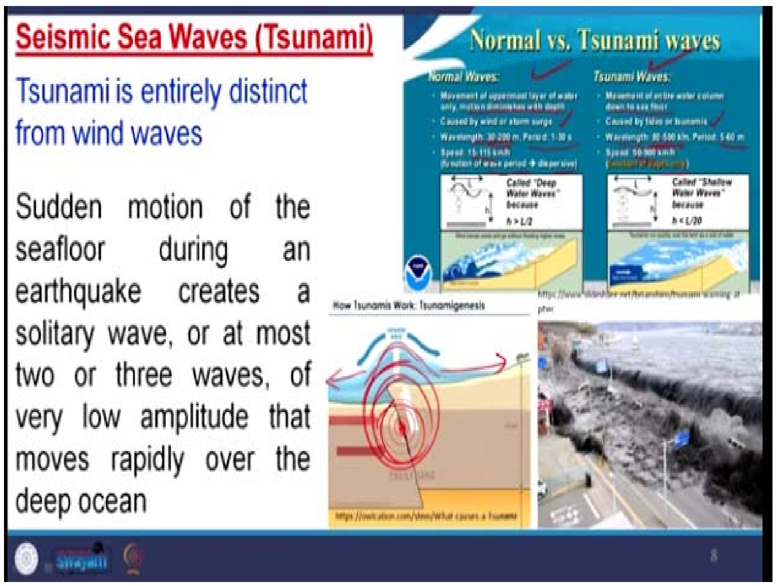

Then another reason or another way of generation of wave, it is the Tsunami waves, so Tsunami it is related to submarine earthquakes. So, if you see here this is a diagrammatic representation if you are creating an earthquake here, from the earthquakes, waves are moving upward and finally, it is swelling of this ocean water here and the wave it migrates this direction and this direction and hits the continental region.

But here, we have to very cautious about distinguishing what whether this wave generated or wave interacting at the coast zone, it is due to Tsunami wave or it is due to storm wave or it is the normal wave, so that can be distinguished by careful observations. For example, if you see here there is comparison given with tsunami waves and normal waves. Normal waves; movement of upper most layer of water only, motion diminishes with depth.

But tsunami waves; movement of entire water column down to the sea flow with whole water column is moving, causes by wind or storm surge, causes by tides or tsunamis or earthquakes, submarine earthquakes, wave length is 30 to 200 meter, period is 1 to 30 second, period here is it is called frequency and wavelength if you compare this tsunami waves, it is 80 to 500 kilometre, here 30 to 200 meter, but here 80 to 500 kilometre wavelength.

And period is 5 to 60 minute, so speed is 15 to 115 kilometre, 50 to 900 kilometre per hour, so function of depth only, it is a function of wave period and dispersion only, so that means, by careful observation of this nature of this wave, we can distinguish which type of wave is coming from the tsunami and which type of wave is coming from this normal storm surge and normal level of sea of due to wind frictions.

So, as this tsunami wave moves from submarine condition towards the coast, sudden motion of sea floor during the earthquake creates a solitary waves of the most 2 or 3 waves of the very low amplitude that moves rapidly over the deep ocean, that rapid movement that is 50 to 500 kilometre wavelength and it is 50 to 900 kilometre per hour that sudden hit along this coastal zone, its damage more.

So, there are historic evidences, there are geological evidences of tsunami waves, they are recorded along this coastal sediments okay, so that means, there are tsunami waves, there are storm waves, due to change in water pressure in the waves, so that means, there are many regions through which we can generate waves in the ocean surface and that waves they are gradually or suddenly it is coming and interacting along the coast zone.

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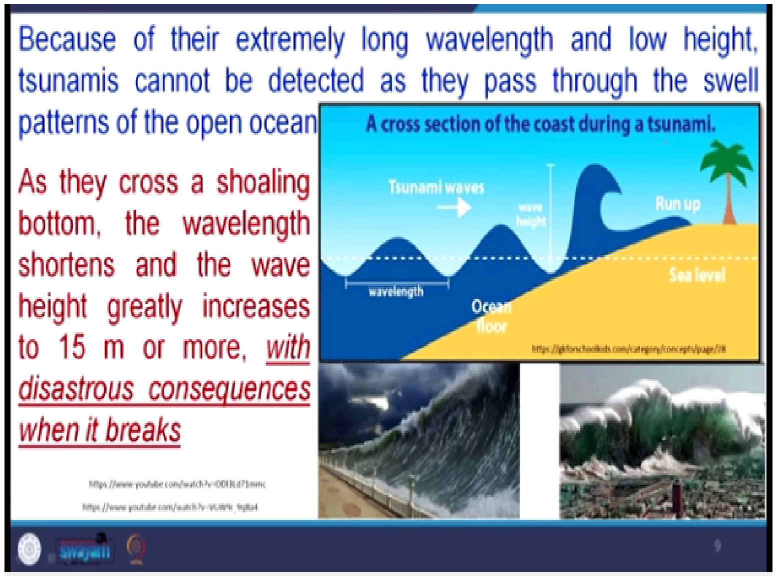

And finally, these are changing the geomorphic process along this coastal region because of their extremely long wavelength and low heights, tsunamis cannot be detected as they passed through the swell pattern of the ocean flow, as they cross the swelling bottom, the wavelengths shortens and the wave height greatly increases up to 15 meter or more with disastrous consequence when it breaks.

So, a 15 meter wave, when it is breaking, so its height increases and those height of wave, it is more than the normal height of these buildings, so that will damage more as compared to other types of waves.

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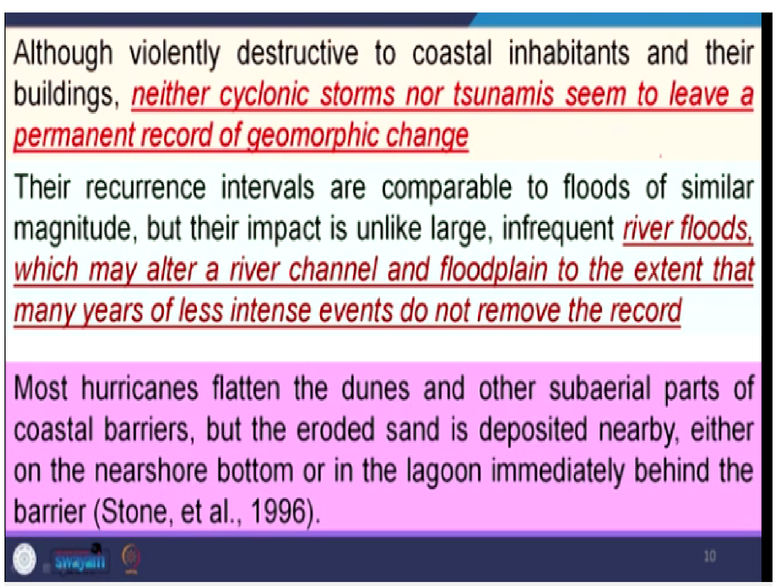

Although, violently destructive to coastal inhabitants and their buildings, neither cyclonic storm not tsunamis seem to leave a permanent record of geomorphic changes, so it is has to be understood here, that means though they are occurring, they are going far beyond their normal level but whatever the record they leaves, that record is not a permanent record because they can easily modified by the other processes.

However, those records which are let by the normal waves along the coast zone, they remain relatively permanent as compared to the tsunamis but tsunami record, they are recorded within the sediments but their geomorphic changes, they are not permanent but if we compare this geomorphic changes of floods, the tsunamis, and the other processes, the flood geomorphic changes are more permanent as compared to the tsunami geomorphic changes.

So, the recurrence interval are comparable to floods of similar magnitude but their impact is unlike large in frequent, river floods which may alter a river channel and flood plains to extent that many years of less intense events, do not remove the record. So, that means I want to say that the tsunami record or tsunami record of geomorphic changes, not the tsunami record of sedimentation, tsunami records of the geomorphic changes is not permanent as compared to the river changes.

Most hurricanes flatten the dunes and other sub aerial pattern parts of coastal barriers but the eroded sand is deposited nearby, either on the near shore bottom or in the lagoons immediately, so those sands, those waves are removed or eroded from this coast that is transported to a little distance and deposits there. Similarly, during high tide that material again transported towards coast again, deposits somewhere here.

So, that is why the coastal geomorphic process it is dynamic, the coastal geomorphic changes is dynamic, like this wind system; wind system it is a dynamic geomorphic process, every time that means, in the morning wind and this evening wind that will change the position of the dunes. Similarly, this sand dunes or the representatives or whatever the geomorphic processes involved along this coast region.

They also frequently change their positions, this is a depositional process, the depositional land forms, they frequently change their positions, so that is why it is the coast zone, it is mostly, it is a vibrant geomorphic region where these frequency of, changes of the geomorphic process is relatively more rapidly as compared to other processes or other regions. So, in addition to waves either it is tsunami waves, it is storm waves or the waves which is created by this atmospherics changes.

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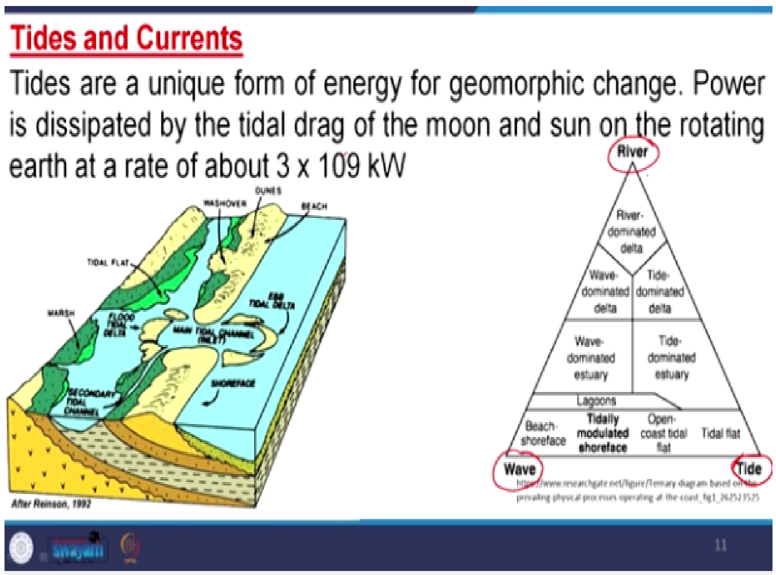

So, in addition to the waves, tides and currents also plays their role changing the geomorphology along the coast. Tides are unique form of energy of geomorphic change, power is dissipated by the tidal drag of the Moon and Sun of the rotating earth, at the rate of about 3×10^9, it will be 10^9 kilo watt. So, here are 3 processes; one is river process, one is wave process, another is tide process.

So, 3 processes combinedly working along the coastal zone to change the coastal geomorphology, if you see here each process they have their region of dominance, so if you see here, it is where river process is more active as compared to this wave and tide, we are getting river dominated delta, if it is wave is more active, that it means, beach shore face, then it is tide is active, we are getting tidal flat.

Similarly, depending upon the degree of dominance, we are getting tide dominated delta, tide dominated estuaries, wave dominated delta, wave dominated estuary and here we are getting lagoons, models it is wave dominated and near to the beach and tide does not affect or hardly it affects to this and do not affect this lagoons, so that means I want to say depending upon their geographic domains, depending upon the dominance of different agents, so landforms either erosional or depositional land forms, they form accordingly.

Similarly, if you see here, these are this sis opens sea and this is; this tidal delta it is tide dominated, this is the mass land and finally, this is the secondary channels, this is main tide channel, so the land forms here either it is marsh, it is tidal flat, it is deltas or whatever the landforms, those landforms they are dominated by particular type of processes or they are equally dominated, equally influenced by number of processes involved.

Similarly, the geomorphic changes or the geomorphic process of a particular land form, may be combined of many of this geomorphic agents or may be dominated by a particular geomorphic agents, depending upon their positions. So, if it is isolated, then only towards the land, river will be more dominated, if it is towards sea that is wave will be more dominated, in between tide waves and rivers, they will be equally dominated or reciprocally dominated, okay.

So that means, coastal geomorphology is a combination of many of these processes they are acting together.

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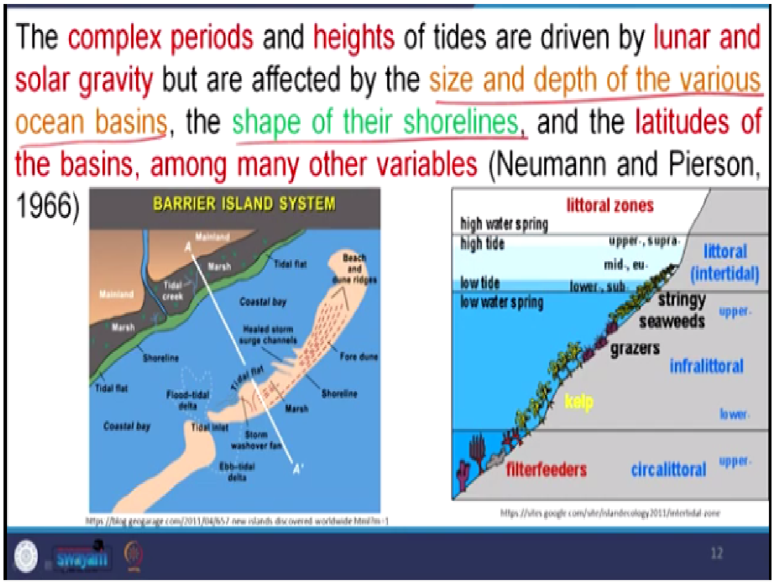

The complex period and the height of tides are driven by lunar and solar activity or solar gravity but are affected by size and depth of various ocean basin, here size and depth of various ocean basin, the shallow ocean that will affect differently as compared to the different part of the ocean. The shape of the shoreline, this also matters, the shape of the shoreline either, it is a straight shoreline, it is an undulating shoreline, along the shoreline, it is dominated by hard rock; hard and compact rock.

It is shore line, it is semi-consolidated or consolidated sediment or it is loose sediment line, latitude of the basins geographic position that means, either it is a low latitude or it is in the higher latitudes, the warm water current is there or the cold water current is there. Among many variables, these variables like the size and depth of various ocean basin, shape of the shoreline, latitude of the basin and type of a rock exposed, all those parameters influence differently to decide what should be the coastal geomorphic processes active there.

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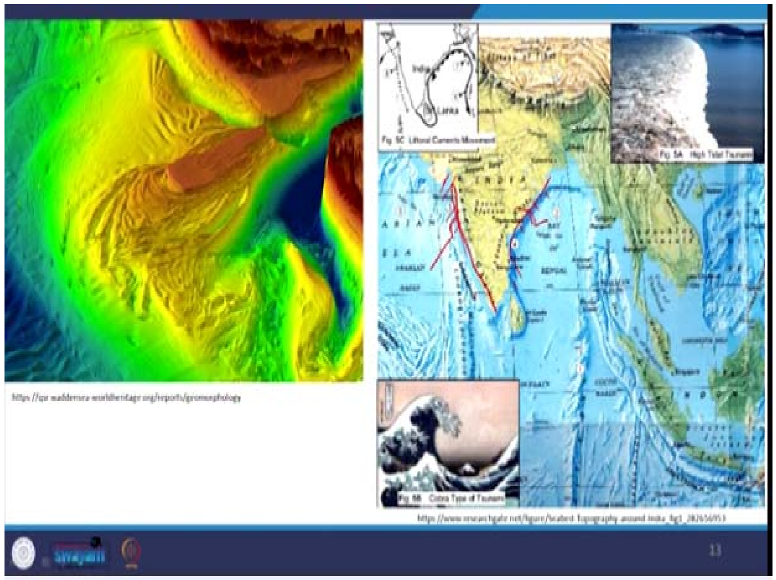

What should be the coastal landforms will produce there, okay, so if you see here, we have the Indian coast and the; if you compare this coastal regions of west and the coastal regions of the east, this is the digital elevation model diagram which is artistic diagram, you see there is a sudden change, there is a sudden change in topography but here there is a gradual change and then there will be a sudden change.

So, that means, if the same level of water increase or decrease, that will affect here differently as compared to here, so that means, what type of rock; for example, in the western ghat, the whole western ghat in the western coast is lying as a wall, a hard rock is there; hard compact rock however, if you compare there, this is mostly alluvial; coastal alluvial, cover with coastal alluvial, so the rate of the geomorphic changes along the East coast will be more as compared to the west coast, okay.

Similarly, that is why there are different agents, different processes like here discussed, so all those factors they combinedly decide what should be the geomorphic process, what should be the geomorphic landforms that will produce along this coastal plains.

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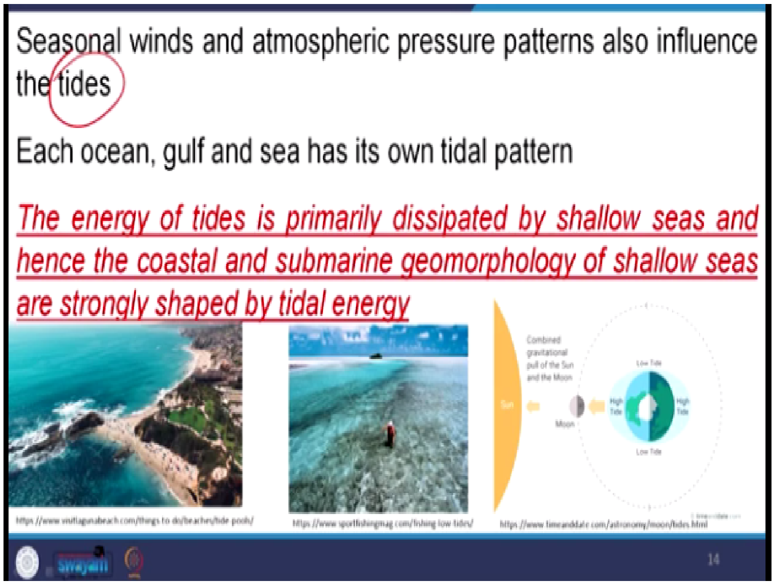

Seasonal wind and atmospheric pressure pattern also influence the tides, here tide also it is coming into effect, so not only wave, the tides, there are high tides, there are low tides, some places there, 4 times a tide is affected, some places it is 6 times tide will be affect, some places it will be less than 4, so that means, this geographic position also decide what type of landforms we are going to get.

So, tide also influencing the coastal landform of reciprocal manner, each ocean, gulf and sea has its own tidal pattern, the energy of tide is primarily dissipated by the shallow sea and hence the coastal and submarine geomorphological processes of the shallow seas are strongly shaped by this tidal energy, so that is why this tide plays important role along with waves to shape the geomorphology of the coast.

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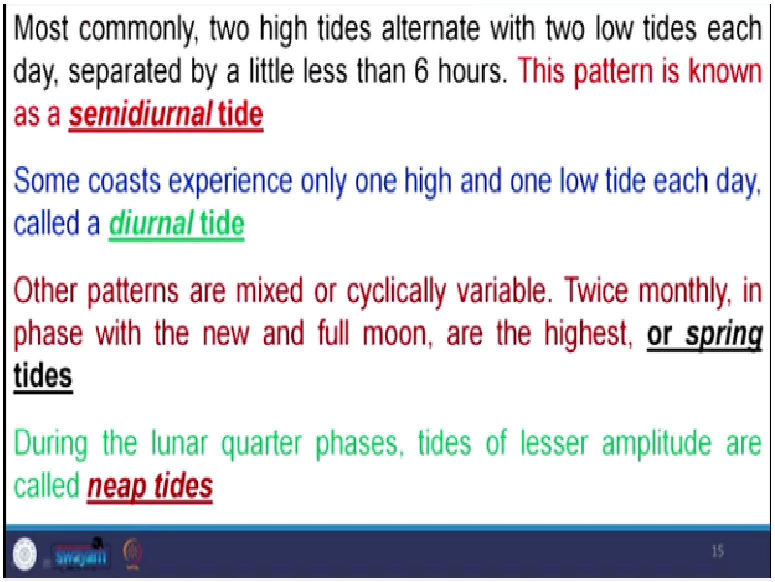

Most commonly, 2 high tides alternate with 2 low tides each day, separated by a little less than 6 hours, this pattern is known as semidiurnal tide and some coast experience only 1 high tide and 1 low tide is there, it is called diurnal tide. Other patterns are mixed or cyclic variable, twice monthly in phase with the new and full moon are these highest or spring tides, which is called. Similarly, during lunar equator phase, tides of less amplitude are called neap tides.

So, tides have also different patterns, so some areas there is a experience of more tide, some area it is experience less tide and somewhere frequent tide activity is there, somewhere less frequent tide activity is there. So, depending up on this that also changes the geomorphology that also changes what type of geomorphic land forms will occur there.

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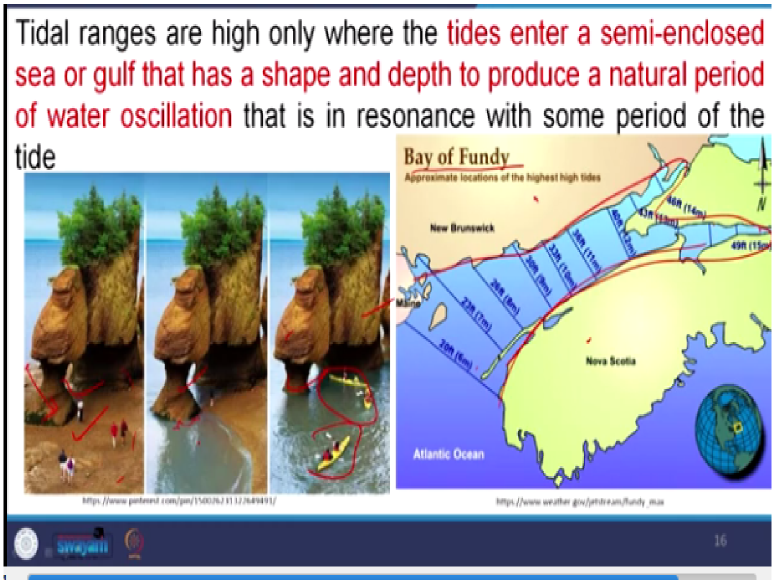

Tidal range are high only where the tide enters semi enclosed sea or gulf that has a shape and depth to produce natural period of water oscillation, that is the region with some period of the tide, so here very important and example of world example is there, this is the Bay of Fundy, if you see here, there is tide range, tidal range is here 6 meter and here it is 15 meter and somewhere it is 16 meter.

So that means, 16 meter of increase of water level a day, if you see here, this 3 consequent photograph is there, at once upon a time in a day, you will find this is totally dry region and water level is here and during tide, you see, this water level is increasing that means, water level increased from here to here and similarly, with another photograph you see, the people are enjoying with boats.

So, that means, here this is a particular place in Canada, here 16 meter increase and decrease of sea level a day, so that means, water is lifted 16 meter is that means, it is 3 stair building or so, so that means, after that level, water is increasing and decreasing, so that means, this increment and decrease of this water level that is creating some geomorphic changes and if you see here, this geomorphic changes or that erosion and erosion is there.

So that means, this tidal ranges are high, where tide enters to a semi enclosed sea, semi enclosed here if you see here, this type of sea it is entering here, both sides are confined by land, is this type of geographic setup is there, tide will affect more as compared to open sea.

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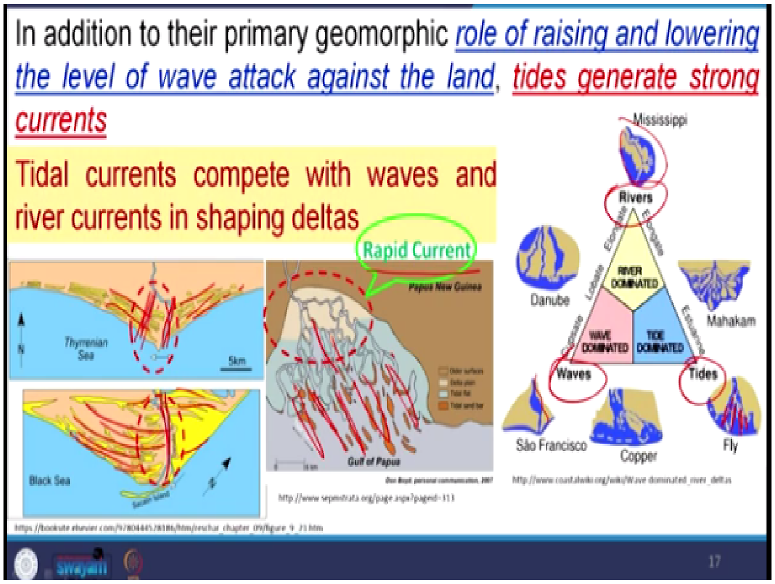

In addition to their primary geomorphic role of raising and lowering this level of wave attack against the land, tides generate strong currents; tidal currents compete with waves and river currents to shaping the delta. Here, not only this tides act as a lift of; lifting this water level or the wave level from here to here because in the low tide level, wave is acting at this level, at high tide level, wave is acting at that level.

So, tide is acting as a lift to uplift the wave level or to decrease the wave level, similarly the wave level is this much, so erosion only occur in this level, so at low tide, wave is acting at this level, so erosion only occur in this level, so that means, there is a drastic variation; drastic variation of water level, the erosional level from this level to that level. Tidal current compete with waves and river currents in shaping deltas.

So, how much tide will affect, how much wave will affect, so that is why the delta are shaped accordingly, so here we have 2 types of photographs; one is wave dominated delta, one is tide dominated delta. If you see the alignment of this depositional system, here this tide dominated delta, it is elongated according to this tide but here the wave dominated delta, the depositional systems, they are elongated according to this wave system.

So, this is a funnel shaped system or funnel shaped conduit through which the tide can move, so rapid currents they are moving along this during tide; high tide or low tide, these conduits or this river valves they, through which rapid currents are moving to and fro and once there are rapid movement of currents, they changes the river level, they changes the river and that is the river base level.

And finally, it is changing the geomorphic system, so that is why this river dominated delta or tide dominated delta or there will be a combination of that, if you see here which is river, then wave, then tides here, this shape of this delta you see, this is; if it is river dominated delta, where it is Mississippi delta, which is called bird foot delta and similarly, tide dominated delta we are getting some of these landforms you see, they are parallel to this tide.

And wave dominated delta, it is due to wave dominated like this, so according to this dominance of a process, either it will be river dominated or there will be a tide dominated that defines, similarly, the landforms changes. So, I think we should stop here and we will meet in the next class, thank you.