Soil Erosion

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FORCES and RESISTANCE

FORCES

It is the interaction between objects, it can change the magnitude or direction of the speed of the object, and it can also change the shape of the object.

When we "push" or "pull" an object, we apply a force to it. Force includes magnitude and direction.

RESISTANCE

It is the force opposite to the direction of motion produced by the relative motion of an object in a fluid.

For instance, we stretch a rubber band when we apply the force to either end, The longer the rubber band is stretched, the greater the force required. However, if we continuously increase the forces, we will simultaneously experience the resistance exert to our fingers by the rubber band.

But there's no way that you can bend a pencil this way, because the pencil it self is stiffer than a rubber band.



This is a basic concept of general physics.

FORCES – RESISTANCE

↓

DISPLACEMENT

↓

MOTION

If we subtract the resistance from the forces that we apply to a material,then the force is greater than the resistance, then we will see a displacement on the material, and when you have displacement, you will have motion.

Watershed boundary

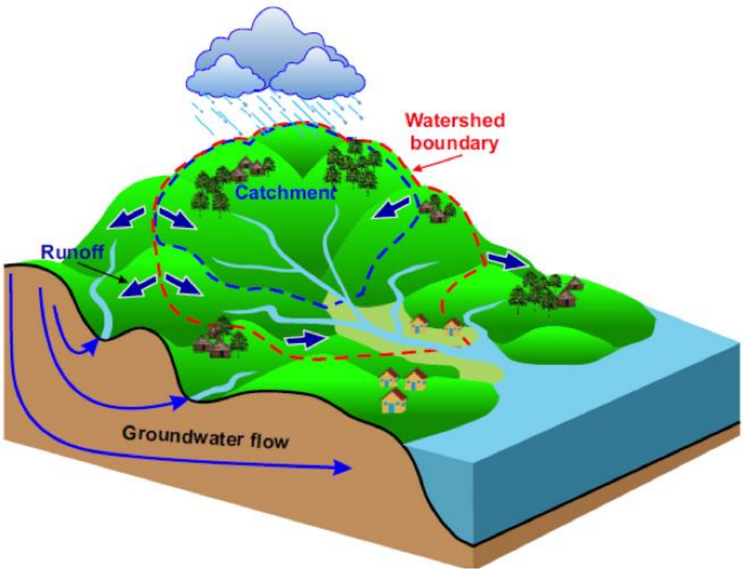
Catchment is an area that catch all the precipitation, including rain and snow.

So when rain falls within the watershed boundary, rainwater will be catched, so we will have surface run off, and some of the water will infiltrate into the soil and become part of the groundwater.

We have rivers, and water eventually reach to the coastline or a pond or a reservoir.

Watershed is an area of land that catches rain and snow and where water flows downward into a specific river, stream, lake, or aquifer.

All land is part of a watershed and we all live in a watershed.



Like a kitchen sink.

We have two kitchen sinks set one next to the other, if we turn on the tab, the water will fall into one catchment or one watershed.

We turn the tap from the left to theright, then the tap water will enter another catchment, another watershed, until the water fills up catchment. Then we was the overflow.

So watershed boundary defined the area that rainfalls into this region, there's no way a service runoff generated from one catchment will run over to another catchment, unless the rain is extremely heavy that the catchment can no longer carry the water downstream.

Gravitational force

When we have a material setting on the surface, on the sloping surface, the material it self received forces from the gravity.

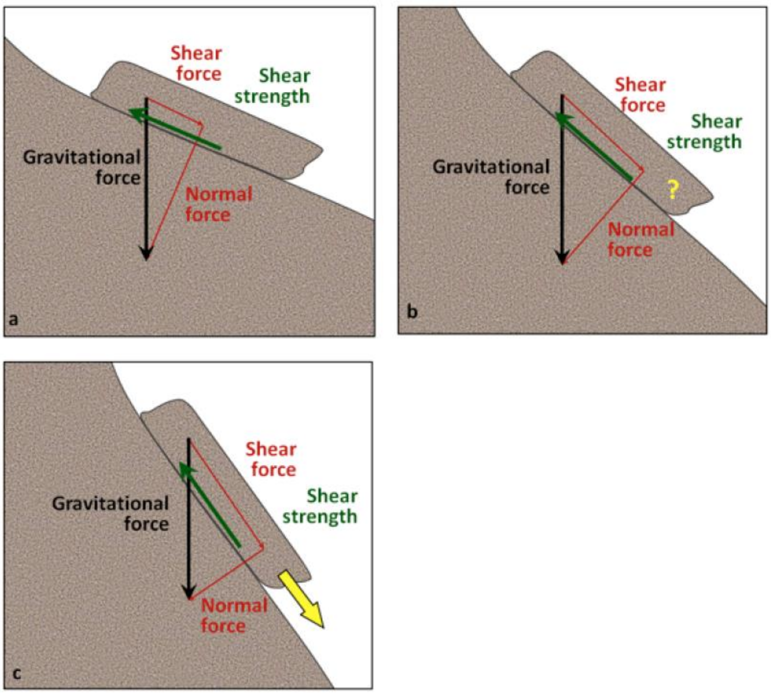
The bigger the material, the bigger the mass, then the bigger the gravitational force.

Shear force

Shear force refers to one of a pair of forces that cause shearing action with the same magnitude and opposite direction.

Shear strength

It refers to the strength of the material against shearing force, that is, the shearing strength of the material when it is subjected to shearing force.

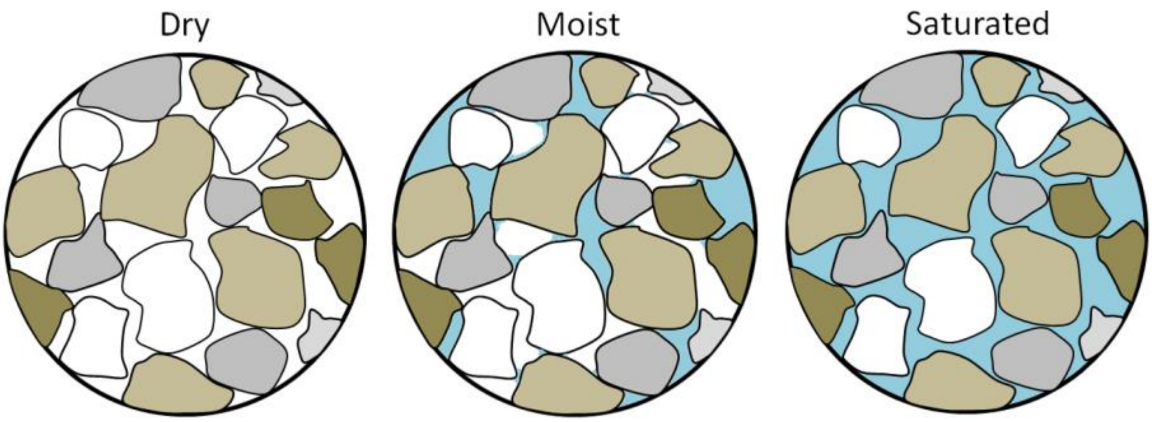


When the mass is dry, we see all the particles within this aggregates or particles we have voids, there's nothing except air fill the voids.

When the rain starts, rain falls on the surface, it will gradually infiltrate into the mass, then the rain water will occupy the void and become wet, we call moist condition.

When the more rainwater infiltrate and filled the gaps or fill the voids,Until you reach to the saturation, it will increase the mass or increase the weight of this mass, then the gravitational force will increase, we call moist saturated condition.

So when all the voids are filled with the rainwater, it also reduces the strength of this material, rainwater makes the mass unstable.

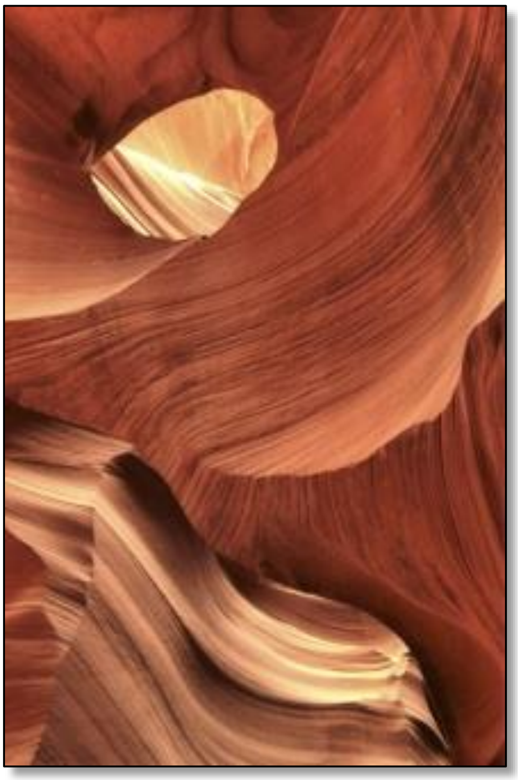


Erosion

Wind Erosion

It is the erosion caused by the wind.

Wind erosion is mainly carried out through two processes: one is abrasion, the other is deflation, Most common in deserts and coastal sand dunes and beaches.



Water Erosion

It is the erosion caused by the water.

Include splash erosion, sheet erosion, gully erosion, and streambank erosion.

Serious erosion can also cause damage to people and property.

Watershed

Headwater

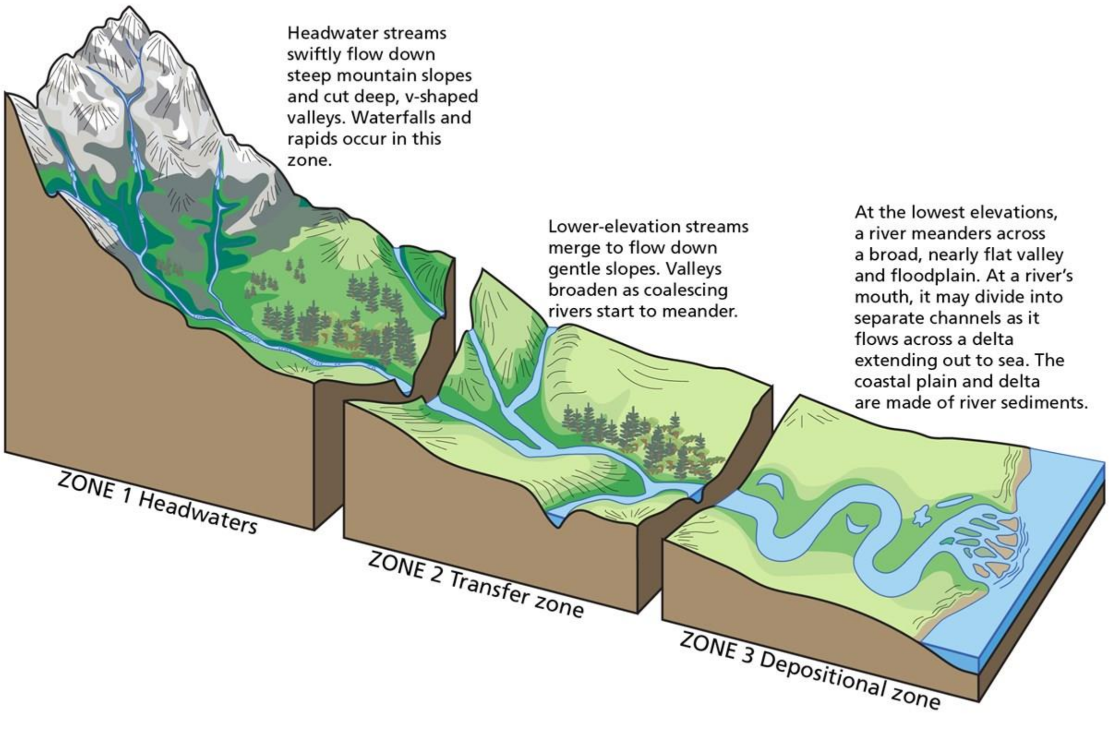
When start rainfall will runoff start to concentrate into transfer zone from this highest elevation location.

Transfer zone

Water forms surface runoff carries soil, sand and rock continues to be transported downstream in this lower elevation location.

deposition zone

The soil, sand and rock entrained by the water during the transportation stay at the lowest elevation location, and deposition in area.



Classifications of Mass Movement

Varnes proposed a classification of mass movement in 1978.

Type of Movement

Type of Movement is divided into fall, topples, slide, flow and complex.

Type of Material

Type of Material is divided into bed rock, predominately coarse soil and predominately fine Soil.

Type of Movement		Type of Material		
		Bed Rock	Predominately Coarse Soil	Predominately Fine Soil
Falls		Rock Fall	Debris Fall	Earth Fall
Topples		Rock Topple	Debris Topple	Earth Topple
Slide	Rotational	Rock Slump	Debris Slump	Earth Slump
	Translational	Rock Slide	Debris Slide	Earth Slide
Flow		Rock Flow (Deep Creep)	Debris Flow	Earth Flow
			(Soil Creep)	
Complex		Combination of 2 or more principal types of movement		

Erosion type

Look this picture we can know is erosion is everywhere.

Avalanche

Have rock place when rock falls from the high mountain our call rock avalanche, if include snow will change to snow avalanche.

Debris flow

Have enough water and debris this place will become to instability, and all material possible move down slope cause debris flow.

mudflow

Very fine material like clay, sand or lfilth, when they're saturated by water, it will become mud, so the movement of mud from the high mountain to the down slope, we call the mudflow.

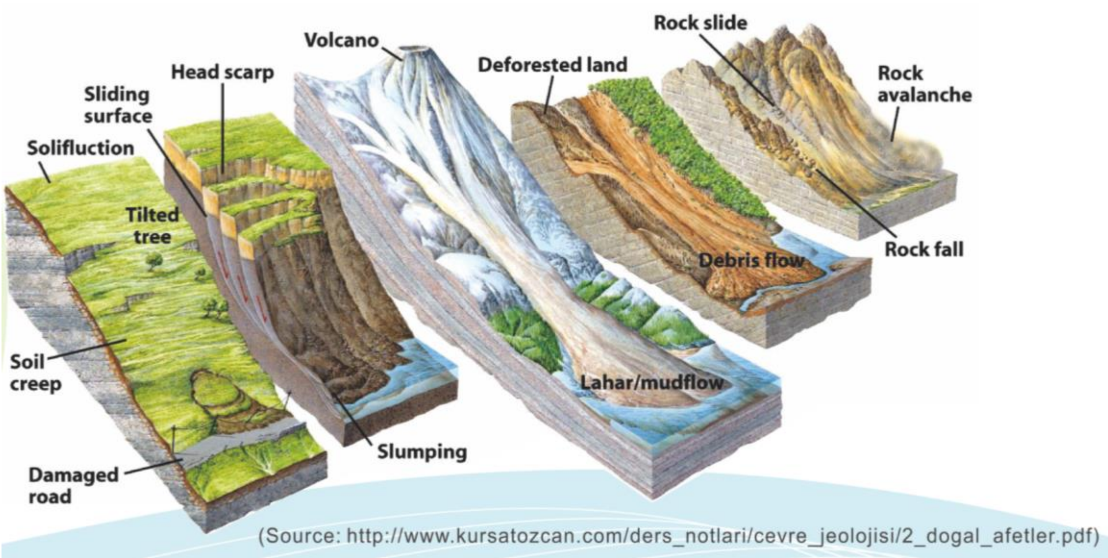
Slump

It mass move down slope from head scarp, we call the slump.

Creep

Creep is gradually moves down slow.

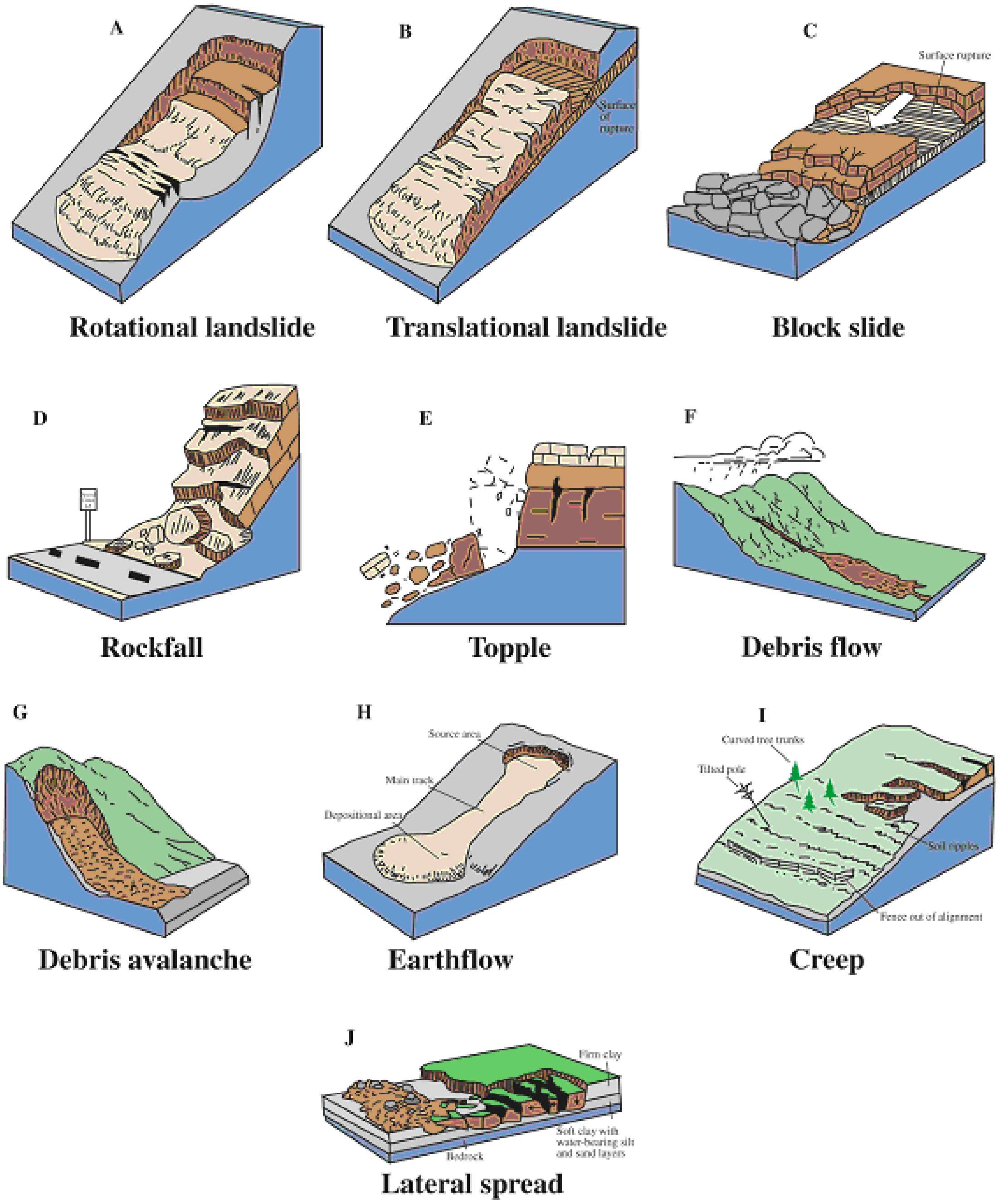
No way we can observe the motion of creep because it moves in a very slow speed.

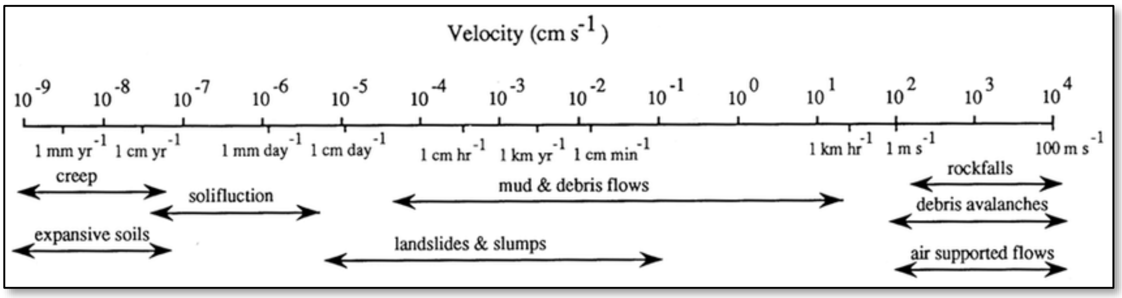


Those source were published by USGS in 2004, by Bryant in 1991 and by Finlayson & Statham in 1980

This is ten kind schematic of erosion type, and different terms of velocity at every erosion type.

Among rock falls, debris avalanches and air supported flow is fastest, cerrp and expansive soil is slowest.


A
Rotational landslide
B
Surface of rupture
Translational landslide
C
Surface rupture
Block slide
D
Rockfall
E
Topple
F
Debris flow
G
Debris avalanche
H
Source area
Main track
Depositional area
Earthflow
I
Curved tree trunks
Tilted pole
Soil ripples
Fence out of alignment
Creep
J
Firm clay
Soft clay with water-bearing silt and sand layers
Bedrock
Lateral spread


Velocity (cm s-1)
10-9 10-8 10-7 10-6 10-5 10-4 10-3 10-2 10-1 100 101 102 103 104
1 mm yr-1
1 cm yr-1
1 mm day-1
1 cm day-1
1 cm hr-1
1 km yr-1
1 cm min-1
1 km hr-1
1 m s-1
100 m s-1
creep
solifluction
mud & debris flows
rockfalls
debris avalanches
expansive soils
landslides & slumps
air supported flows

Erosion processes

When the rain force is greater than the soil resistance then the displacement occurs, and once the displacement occurs is motion initiates, motion processes will transportation soil, at the end, the particle in motion has stop at surface.

For the erosion processes, it three processes

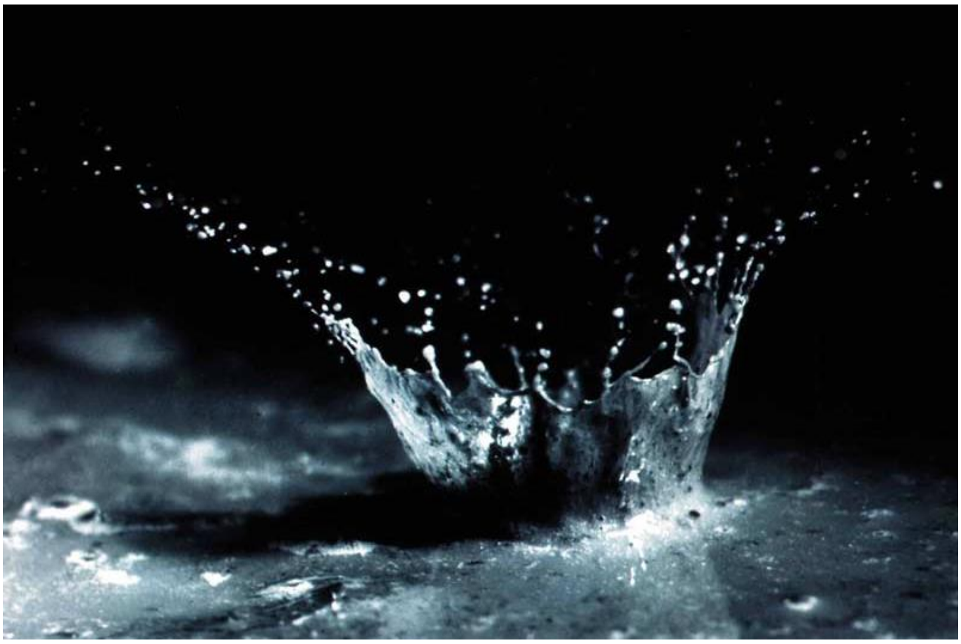
Detachment

↓

Transportation

↓

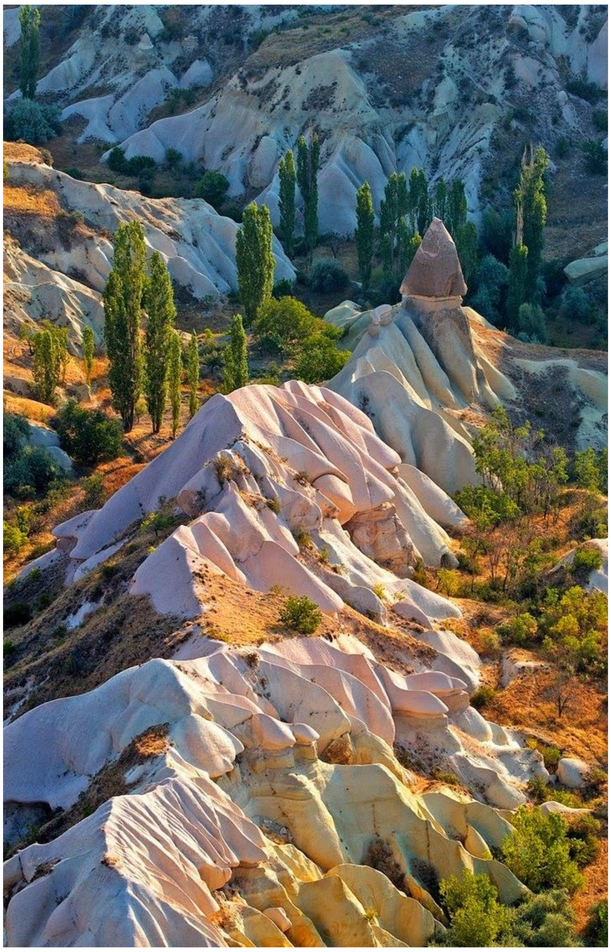
Deposition



Erosion generates very nice looking, very magnificent landscape, but the erosion also causes problems.

Losses due to the impact of erosion

1. Loss of soil fertility
2. Loss of crops productivity
3. Loss of life security
4. Increase in costs
5. Increase in sedimentation
6. Increase in hazard risks




Both erosivity and erodibility works together to create erosion.

Erosivity

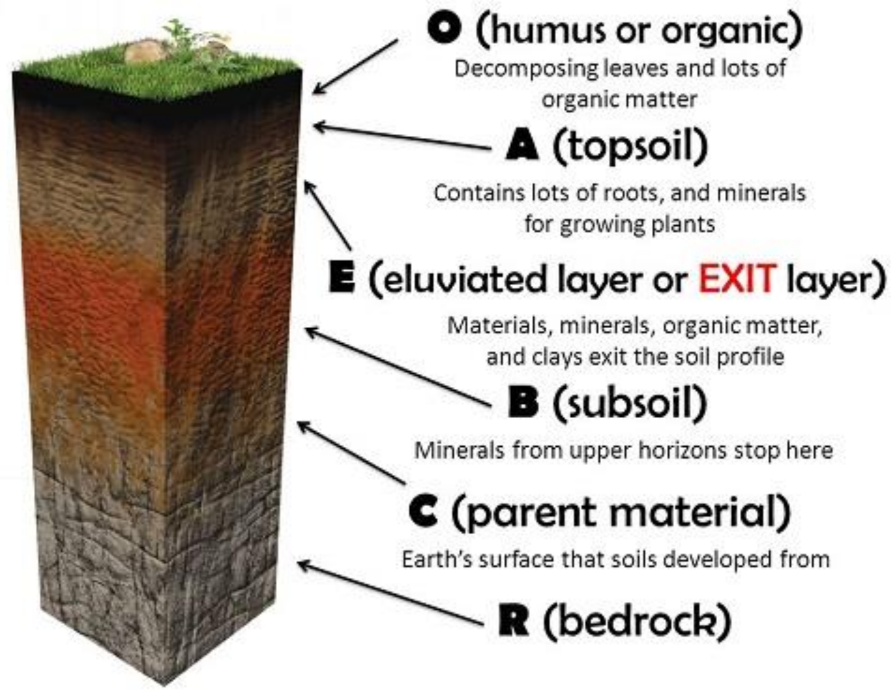
we need external forces to generate erosion.EX. raindrop impact, runoff from snowmelt, or water applied with an irrigation system.

Erodibility

We classify into two parts, one is the internal properties of the soil, another is external effects include slope, stiffness, length, land use.

Sometimes we develop our hill land based on our needs, so we cut the slope from a very relative flat slope into steep slope.

This is soil profile image



Food and Agriculture Organization of the United Nations (FAO) according to research need spent 1000 years to form 1 cm of soil

It's estimated that one billion tons of valuable nutrients in topsoil are lost to erosion every year.

Impacts of Soil Erosion

- A nation that destroys its soil destroys itself by Franklin D. Roosevelt.
- Every 5 seconds, the equivalent of one soccer field is lost due to soil erosion by FAO

  It is very severe problem, every 5 seconds every 5 seconds one soccer field is lost due to erosion. area of erosion covers almost one soccer field.
- In 2014 have statement made said that only 60 years of farming left if soil degradation continues, after then we will have no land to farm.

  If there's no land that we can farm, there's no land that we can grow our crops, raise our capitals, then food security will be a major problem.

REUTERS

SUSTAINABILITY

Only 60 Years of Farming Left If Soil Degradation Continues

Generating three centimeters of top soil takes 1,000 years, and if current rates of degradation continue all of the world's top soil could be gone within 60 years, a senior UN official said

December 5, 2014

Main Causes of Soil Erosion by Human

1. **Deforestation**

   ✧ The increasingly high demand of a growing population for agriculture.

2. **Overgrazing**

   ✧ It is caused by intensive cattle raising as plants don’t have the recovery period.

3. **Agrochemicals**

   ✧ The excessive use of phosphoric chemicals causes an imbalance of microorganisms in the soil.

4. **Tillage techniques**

   ✧ Tillage fractures soil structure and accelerates surface runoff and soil erosion.

5. **Construction and Recreational Activities**

Each country Causes of Soil Degradation

- **Europe**

  38% by deforestation, 23% by overgrazing, 29% by agricultural activities and 9% by industrialization.

- **Africa**

  24% by deforestation, 13% by overexploitation for fuelwoods, 49% by overgrazing and 14% by agricultural activities.

- **North America**

  4% by deforestation, 30% by overgrazing and 66% by agricultural activities.

- **Central America**

  22% by deforestation, 18% by overexploitation for fuelwoods, 15% by overgrazing and 45% by agricultural activities.

- **South America**

  41% by deforestation, 5% by overexploitation for fuelwoods, 28% by overgrazing and 26% by agricultural activities.

- **Oceania**

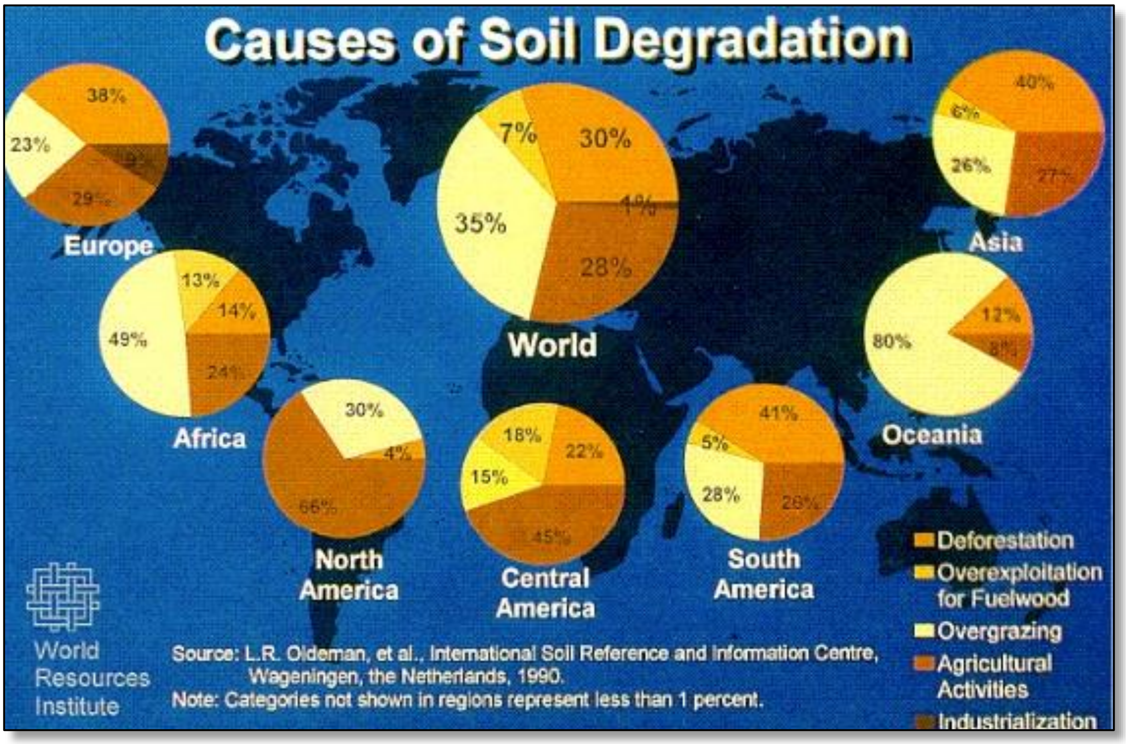
12% by deforestation, 80% by overgrazing and 8% by agricultural activities.

- **Asia**

  40% by deforestation, 6% by overexploitation for fuelwoods, 26% by overgrazing and 27% by agricultural activities.

- **Word**

  30% by deforestation, 7% by overexploitation for fueloods, 35% by overgrazing, 28% by agricultural activities and 1% by industrialization.

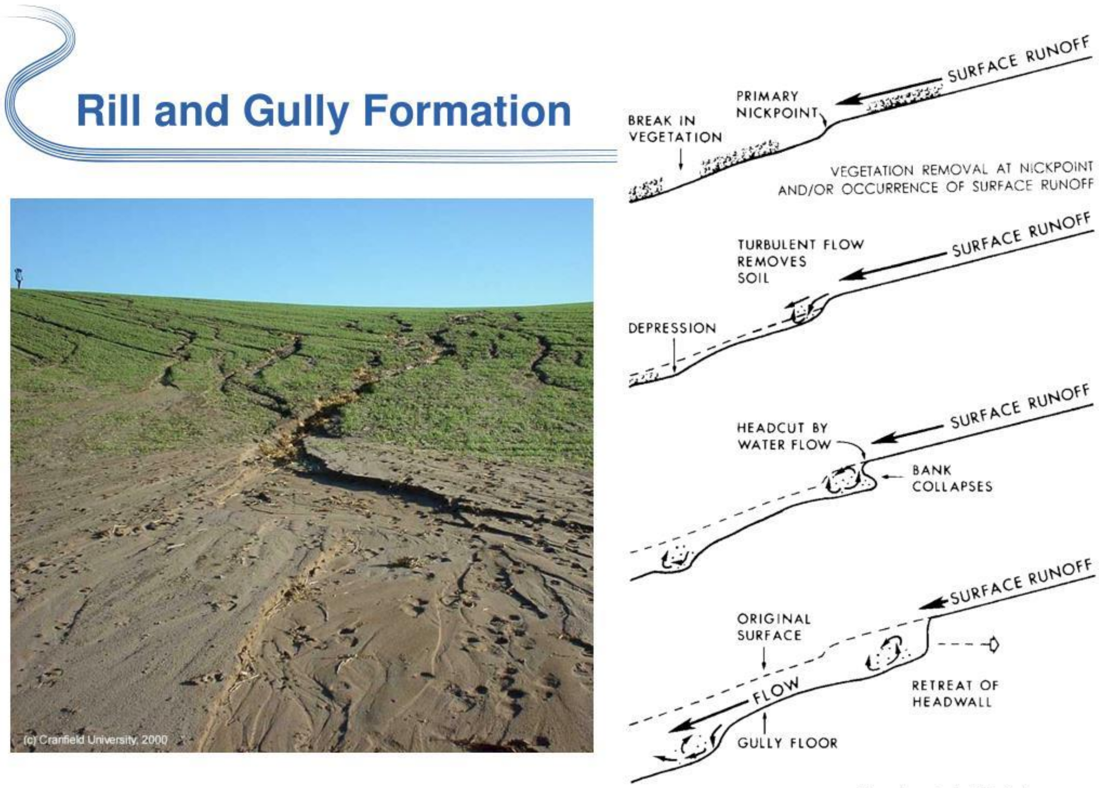


Rill and gully

Rill is caused by concentration of service runoff.

Rills are fairly easily visible when first incised, so they are often the first indication of an ongoing erosion problem.

Rills on regularly eroding areas may eventually develop into larger erosional features such as gullies or even (in semi-arid regions) into badlands.



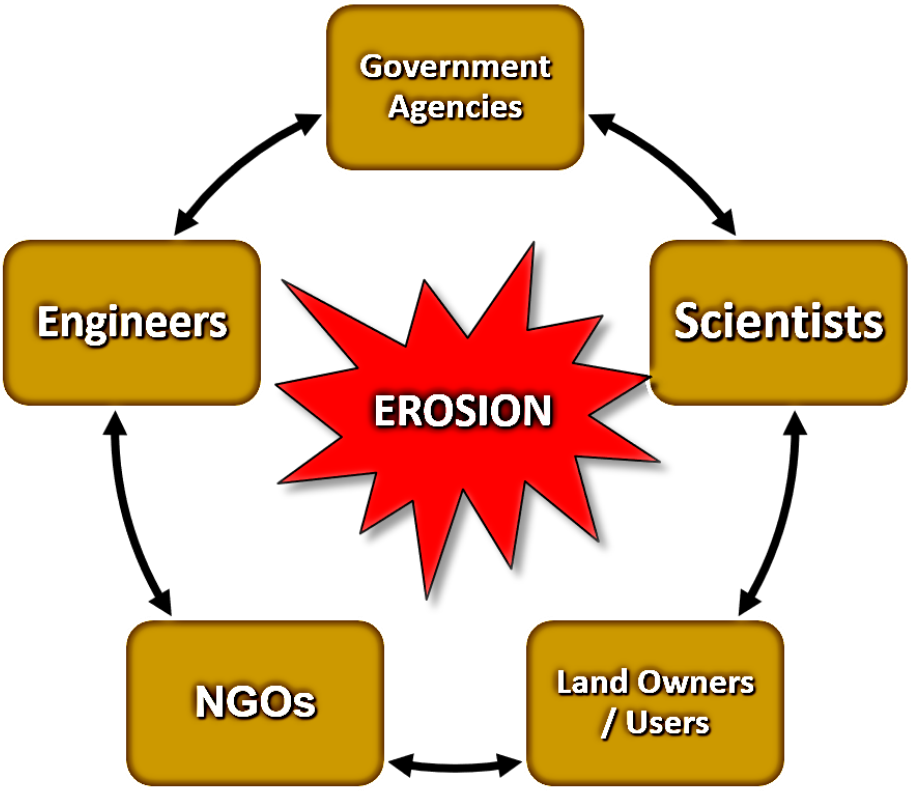
Brooks et al., Fig 8.1

Taiwan Experiences

Taiwan exercise the soil water conservation practices I would say probably back in 1958-1959, we learned this soil and water conservation concept from the United States.

Scientists to help they identify the problems and engineers follow the scientist finding and come up with the design to solve.

So in the past engineers, Scientists, Landowners, Land users works together with the government agencies, solve erosion problems together.



Central governments build 19 outdoor classrooms widespread from the north to the south in Taiwan.

Soil & Water Conservation

Farmlands

Slopelands

Land Development

Social-Economic Development

Handbook / Technical Regulations

Disaster Mitigation

Debris Flow

Fluvial Impact

Large-scale Landslide

Erosion Control

National Pingtung University of Science and Technology department of Soil and Water Conservation have creation of websites about erosion control method.Currently we have select twelve control measures and serve three languages, chinese, English and Thai language

1.Gravel-bag Slope Protection

2.Slope Protection using Recycle Tires

3.Used-tire Retaining Wall

4.Staking and Wattling

5.Turg Planting

6.Straw-mat Mulch

7.Hillside Ditch

8.Bench Terrace

9.Dry masonry Embankment

10.Farm pond

11.Composite Lining Drainage Ditch

12.Drainage Slump

http://sowactec.npust.edu.tw/?act=about

Farmland Soil and Water Conservation International Demonstration Park

In order to promote the technology exchange and cooperation with Southeast Asia countries, Soil and Water Conservation Bureau and NPUST worked together to establish the Soil and Water Conservation for Farmland International Demonstration Park. This integrated relevant domestic soil and water conservation technologies to achieve the goal of improving professional skills of soil and water conservation through technology exchange and information sharing.

The main conservation measures implemented in Demonstration Park are as follows :

Drainage methods :
Composite lining drainage ditch, drainage sump

Slope protection methods :
Bench terrace, hillside ditch, turf vegetation, straw-mat mulch, staking and wattling, dry masonry embankment, gravel-bag embankment, slope protection using recycle tires, used-tire retaining wall

Other farmland management and demonstration projects :
Farm pond, water storage system, irrigation system, contour farming and education implementation area

— Engineering Method —

Gravel Bag Slope Protection

Pebbles and gravels contained in soil are extracted and packed into gravel bags. This practice helps reduce farming difficulties and also services the purposes of soil and water conservation by fully utilizing its high permeability, mobility, and material security. When stacked at hill to e to form embankments, gravel bags may strengthen slope stability, decrease soil loss as well as increase land utilization.

Used-tire Retaining Wall

Tires are the necessary consumables for cars and motorcycles. They possess the characteristics of high strength, high toughness and durability. By recycling, used tires can be used for the protection of slope toe or gully sidewalls but tiers should not be stacked more than 2 meters high. In addition to providing soil and water conservation effects, recycling used tires also solves the waste management problem. Filling the cavities of stacked used tires with soil to form retaining walls can stabilize the slope and also help adjust the slope gradient. Hence, the retraining wall thus constructed serves the purposes of reducing soil erosion as well as increasing slopeland usability.

Slope Protection Using Recycle Tires

Motorcycles are one of the transportation tools for traveling in Taiwan. However, used motorcycle tires cause environment issue. This technique helps solve some of the environment problems by placing used tires on bare slopes to prevent soil erosion. Rebars are used to secure tires on the slope. Soil bags are then inserted into the tire cavity to facilitate vegetation growth if needed. Since tires are less difficult to work with, therefore, this technique can easily adapt to terrain changes.

— Vegetation Method —

Staking and Weaving

To make this barrier, timber, bamboo, or stems with sprouting capabilities can be used as stakes; whereas, bamboo strips or any netting materials can be interlaced or woven between the stakes to form the barrier as a means of preventing soil erosion. It is best to use local available materials. Staking and wattling can be used on areas prone to collapse, and it can be used for control and on areas with coastal wind erosion. This technique helps trapping eroded sediment. Manually back-filling the area behind the staking and wattling combined with sowing or hydro-seeding helps accelerate vegetation growth.

Current Emphasis

Currently Soil and Water Conservation Bureau emphasizes on these four categories

- Early-warning for Potential Debris-flow Torrents

  we already established debris flow early warning systems. Currently we have more than 1700 debris flow potential torrents under the early warning systems.

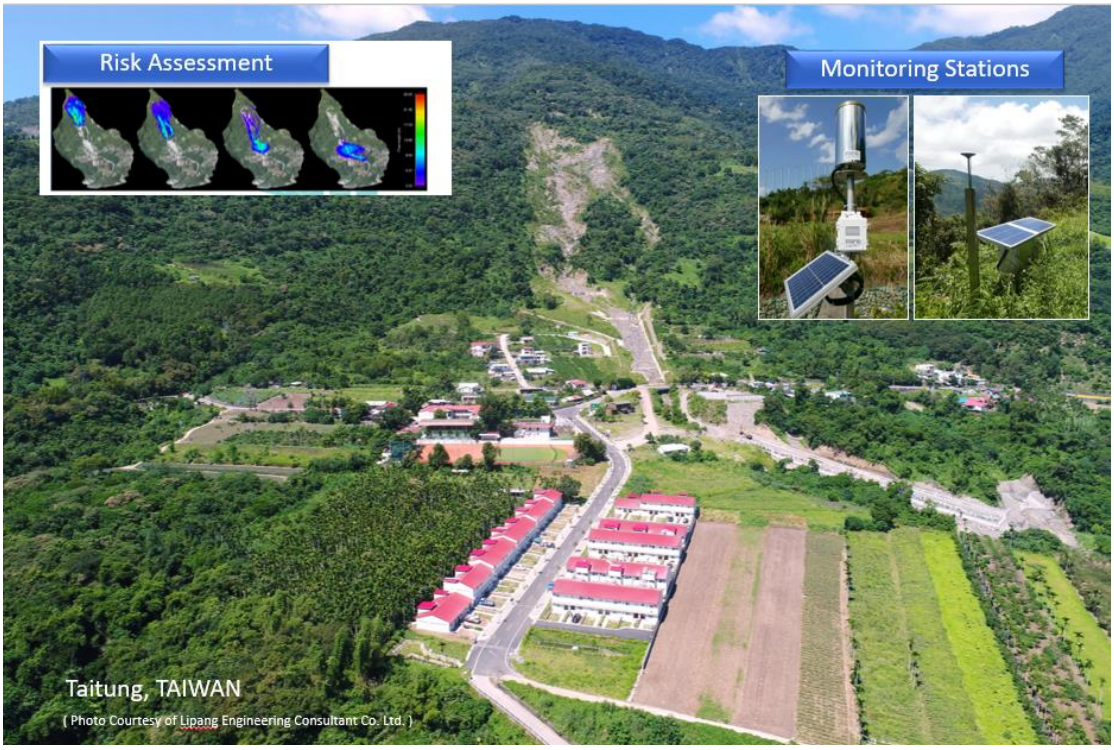
- Large-scale Landslides Online Monitoring

  Currently we have 34 large scale landslide sites identified under online monitoring.

- Restoration of Sediment-laden Streams
- Key Watersheds Management

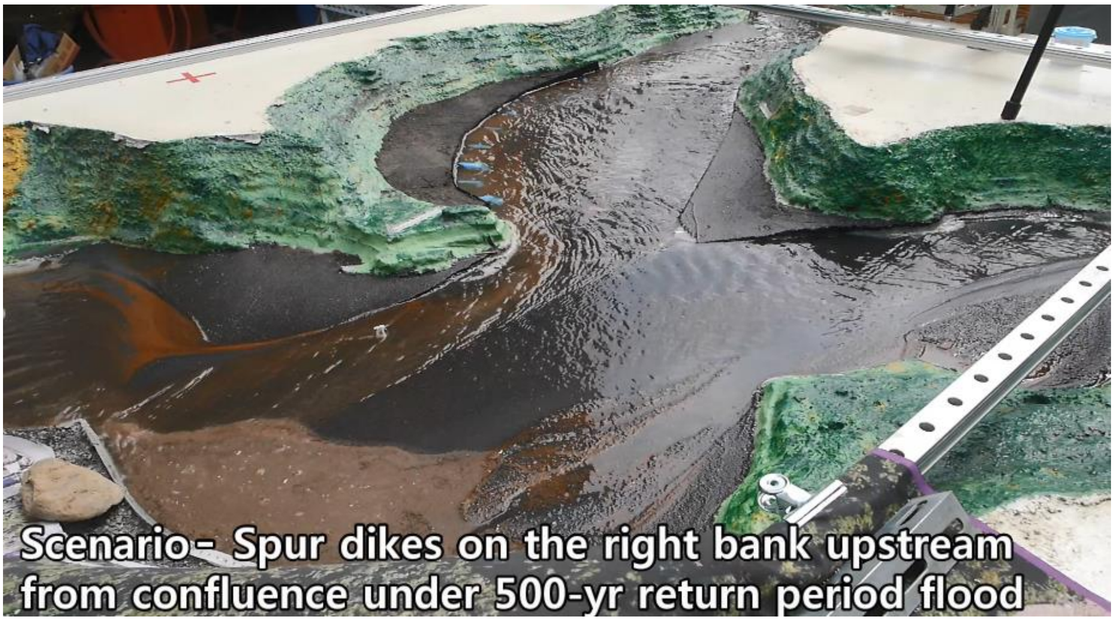
Here is an example of site located in Taitung County in Hong Yea.

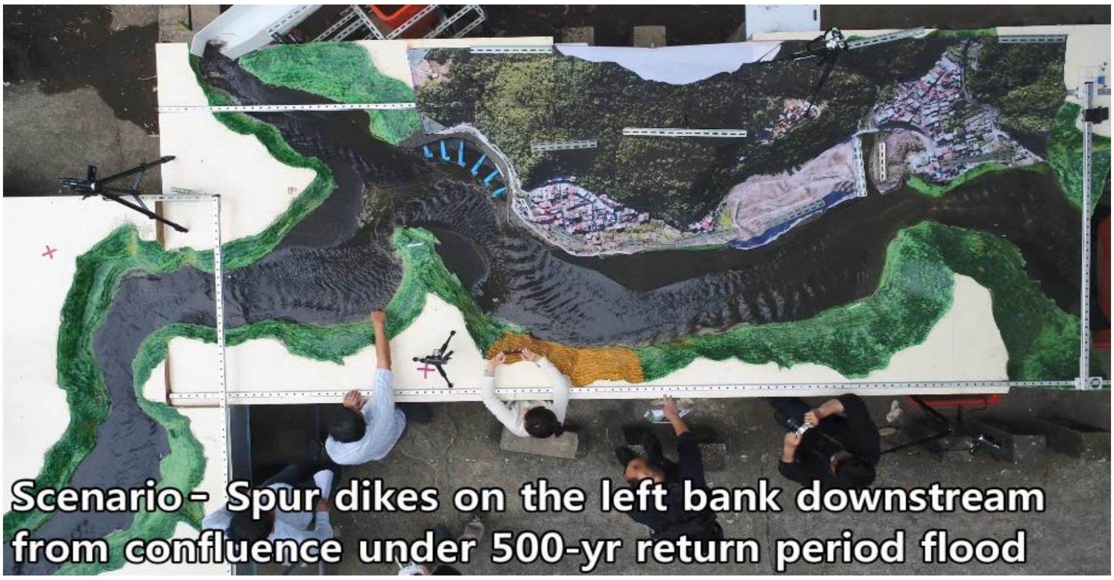
It's village there's a large sale landslide disaster occur in Hong Yea Village, all the material slides from the slope buried some of the houses.



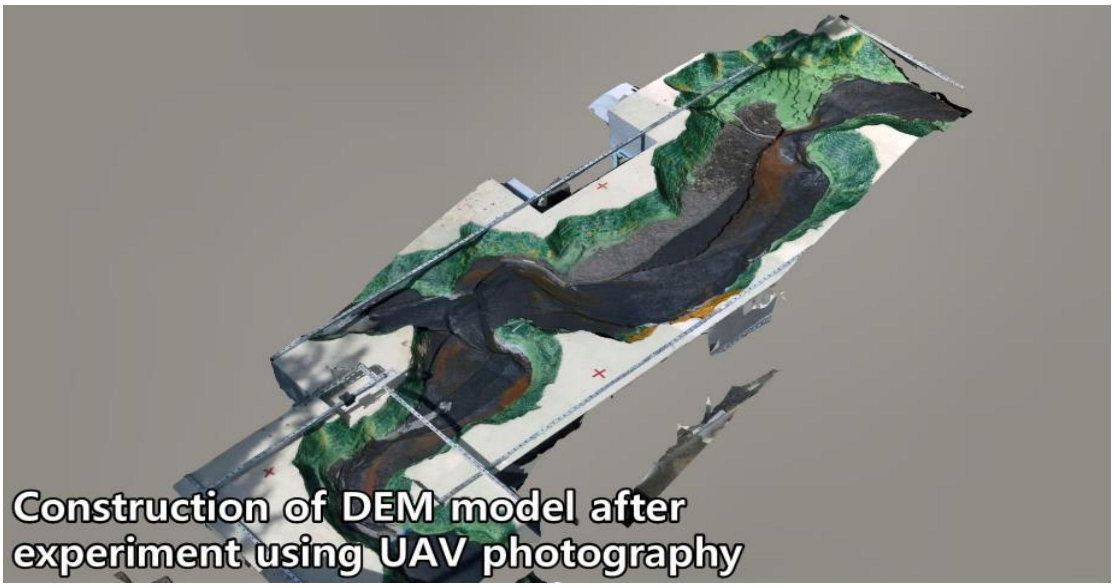
1:300-Scale Physical Model for Control Measures Assessment prior to Implementations – NPUST/SWC

This is 1 to 300 skill physical model of a stream sediment landed stream in Pingtung County





Scenario - Spur dikes on the left bank downstream from confluence under 500-yr return period flood



Construction of DEM model after experiment using UAV photography

Group efforts through exchange of ideas towards final outcomes