

Water Renovation in Ukraine
Project no. 22320101



Water Renovation in Ukraine

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The project is co-financed by the Governments of the Czechia, Hungary, Poland and Slovakia through Visegrad Grants from International Visegrad Fund. The mission of the fund is to advance ideas for sustainable regional cooperation in Central Europe.

Water Renovation in Ukraine
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Water erosion, erosion factors and erosion control measures

Slovak University of Agriculture in Nitra
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Content

- 1) What is soil erosion?
- 2) What are the agents of soil erosion?
- 3) Intensity of soil erosion
- 4) What are the consequences of soil erosion?
- 5) What are the main factors affecting the erosion process?
- 6) How can we measure / estimate the erosion intensity?
- 7) How can we fight the soil erosion and retain water in the landscape?

- Visegrad Fund



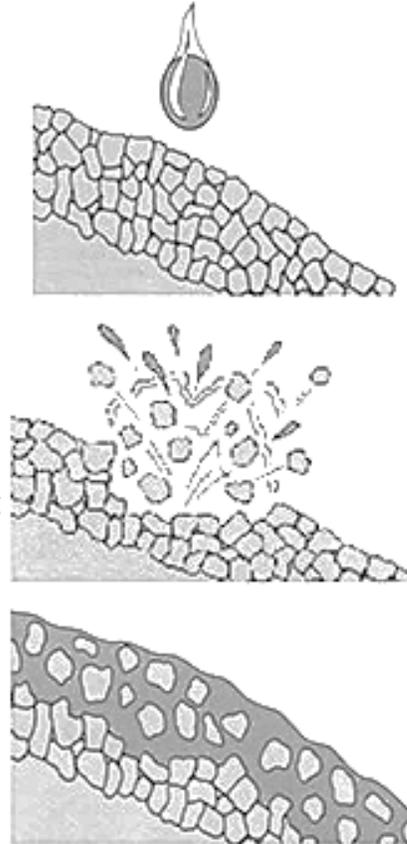
Aydin, 2018

Weathering vs. erosion



https://simple.m.wikipedia.org/wiki/File:Weathering_freeze_thaw_action_iceland.jpg

Weathering is the breaking or disintegrating of rocks into smaller pieces or chemical alternation of the rocks in situ.



<https://extension.okstate.edu/fact-sheets/print-publications/pss/raindrops-and-bomb-the-aerosion-process-pss-2252.pdf>

- Visegrad Fund

- Particles detachment
- Transport
- Deposition (sedimentation)



Erosion agents



human

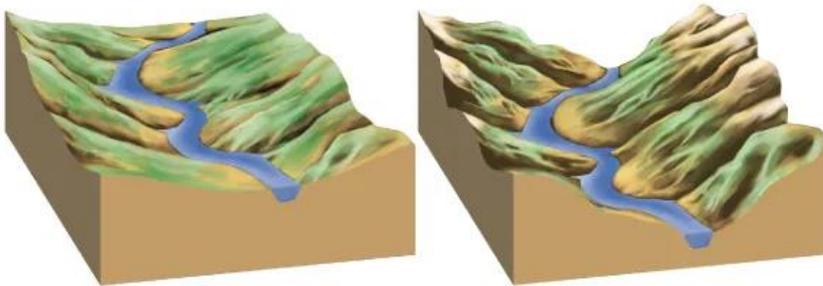
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- Visegrad Fund
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Source: Kaletová

water

gravitation

Types of Erosion

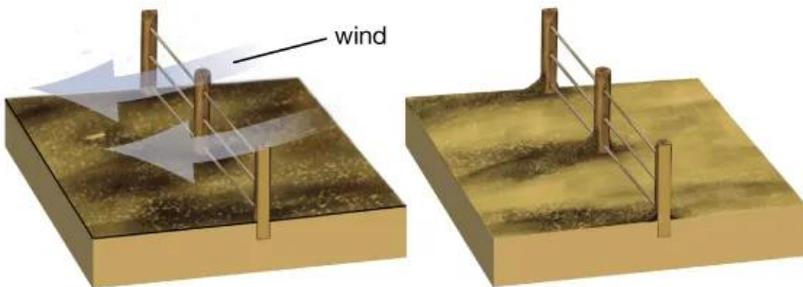


river carving a valley

waves cutting back cliffs

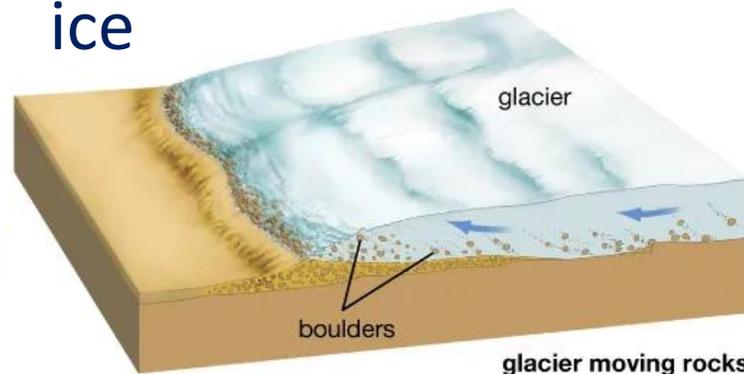
wind

ice



wind blowing topsoil

landslide



glacier moving rocks



Erosion intensity

Q1: Which images show accelerated erosion?

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- Visegrad Fund
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- geologic erosion (natural)

1 cm of soil is being formed in 80 – 200 years

(0.125 – 0.05 mm of soil per year)

- accelerated erosion (human-induced)



John Leys, https://apdim.unescap.org/sites/default/files/2021-09/APDIM-Leys-final_LowRes.pdf



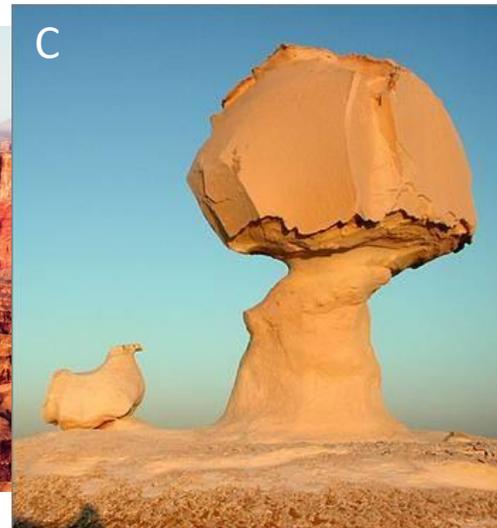
Kaletová



<https://top10a.ru>



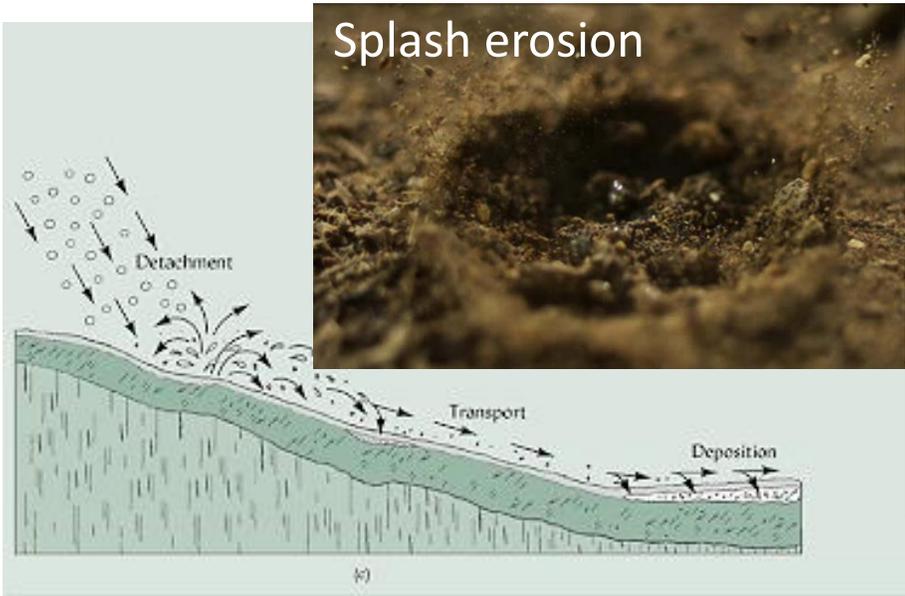
<https://foundtheworld.com/grand-canyon-national-park-arizona/>



www.codingtag.com

Types of water erosion

- Visegrad Fund



Type	Width (cm)	Depth (cm)
Splash erosion	<2	
Rill erosion	2–10	
Furrow erosion	10–30	<30
Ridge erosion	30–100	30–100
Gully erosion	>100	>100 (150)



<https://restoringutopia.blogspot.com/2010/07/like-hollow-point-bullets-from-sky.html>

<http://www.omafr.gov.on.ca/english/engineer/facts/12-053.htm>

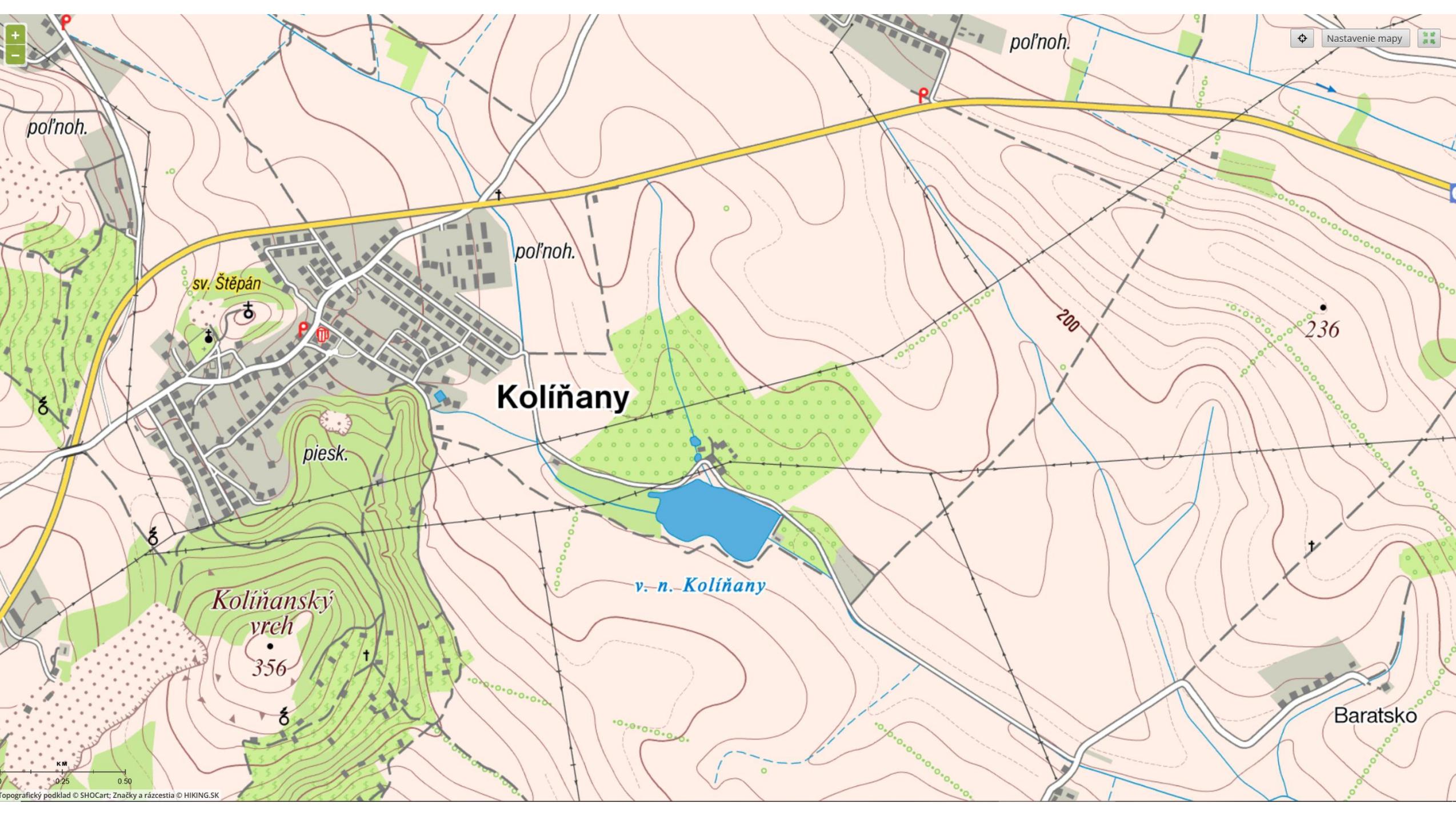


<http://www.omafr.gov.on.ca/english/engineer/facts/12-053.htm>

Aydin, 2019

Aydin, 2007

Aydin, 2013



poľnoh.

poľnoh.

Nastavenie mapy

sv. Štěpán

poľnoh.

Koliňany

piesk.

200

236

v. n. Koliňany

Koliňanský
vreh

356

Baratsko

0.25 0.50

KOLÍŇANY



Gully erosion



Sheet / rill erosion



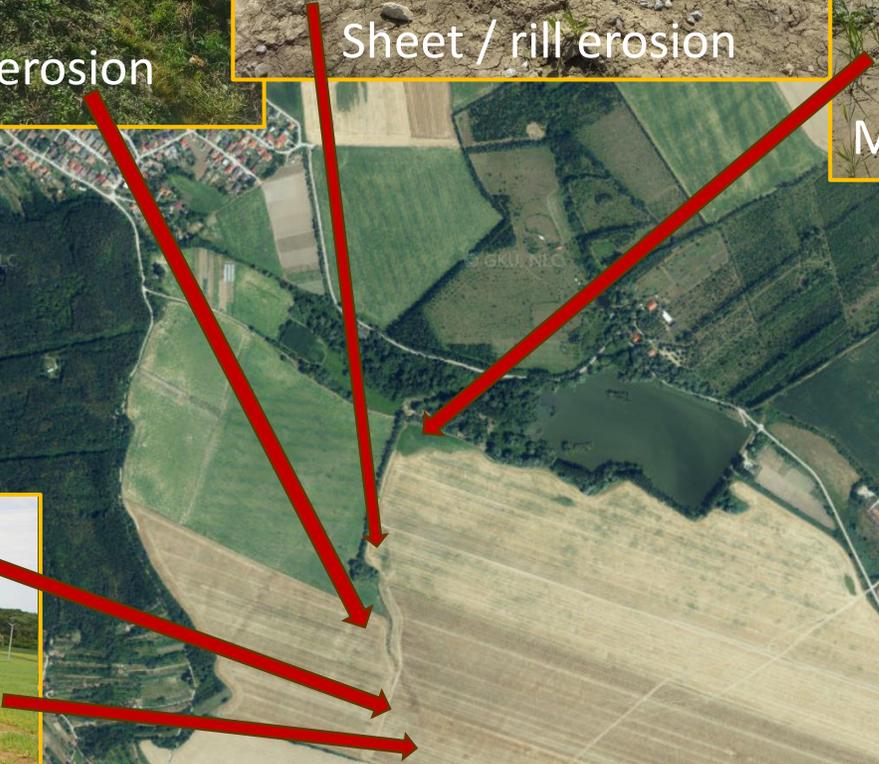
Material deposition



Furrow erosion



Rill erosion



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- Visegrad Fund
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2017 – 2019

<https://zbgis.skgeodesy.sk>



Aydin, 2020



1950

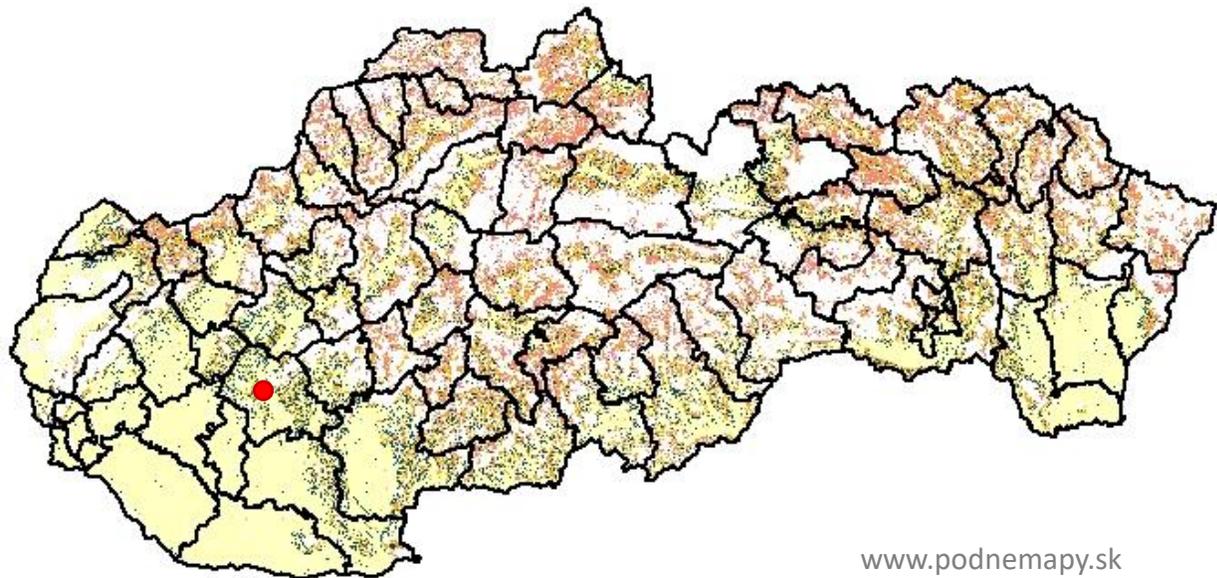
Historická ortofotomapa © GEODIS SLOVAKIA, s.r.o.; Historické LMS © Topografický ústav Banská Bystrica; Ortofotomapa © EUROSENSE, s.r.o. a GEODIS SLOVAKIA, s.r.o.; Mapové podklady © TOPÚ Banská Bystrica; Katastrálna mapa WMS, Mapa určeného operátu WMS © ÚGKK SR, r. 2015; ZBGIS © GKÚ Bratislava, r. 2017; Ortofotomozaika © GKÚ, NLC, r. 2017

<http://mapy.tuzvo.sk/HOFM/>

Potential erosion risk across agricultural soils of Slovakia

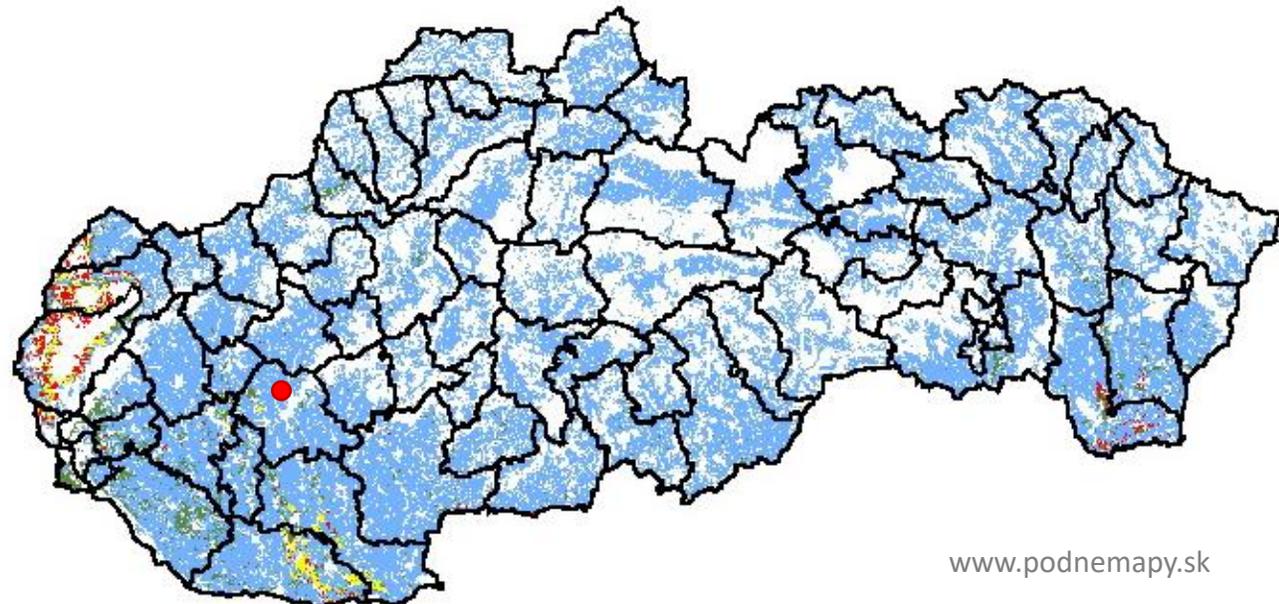
• Visegrad Fund

water erosion



www.podnemapy.sk

wind erosion



www.podnemapy.sk

	Soil loss (t/ha/yr)	Area in ha	% of agric. soil
1	none or mild (up to 4)	1 357 390	56
2	medium (4 – 10)	230 473	9
3	high (10 – 30)	354 555	15
4	extreme (above 40)	481 060	20
SUM		2 423 478	100

	Soil loss (t/ha/yr)	Area in ha	% of agric. soil
1	none or mild (0,7)	2 273 421	94
2	medium (0,7 – 22)	73 186	3
3	high (22 – 75)	45 753	2
4	extreme (above 75)	31 118	1
SUM		2 423 478	100

The effects of water erosion

- Loss of topsoil and nutrients from the agricultural land
- Siltation of road ditches



Source: Aydin, 2007



Source: Aydin, 2019

- A decrease of crop yield

- Visegrad Fund

- 1) Problems at the place of origin
- 2) Problems on the way
- 3) Problems at the place of accumulation



Source: Kaletová

- Algal bloom as a result of eutrophication

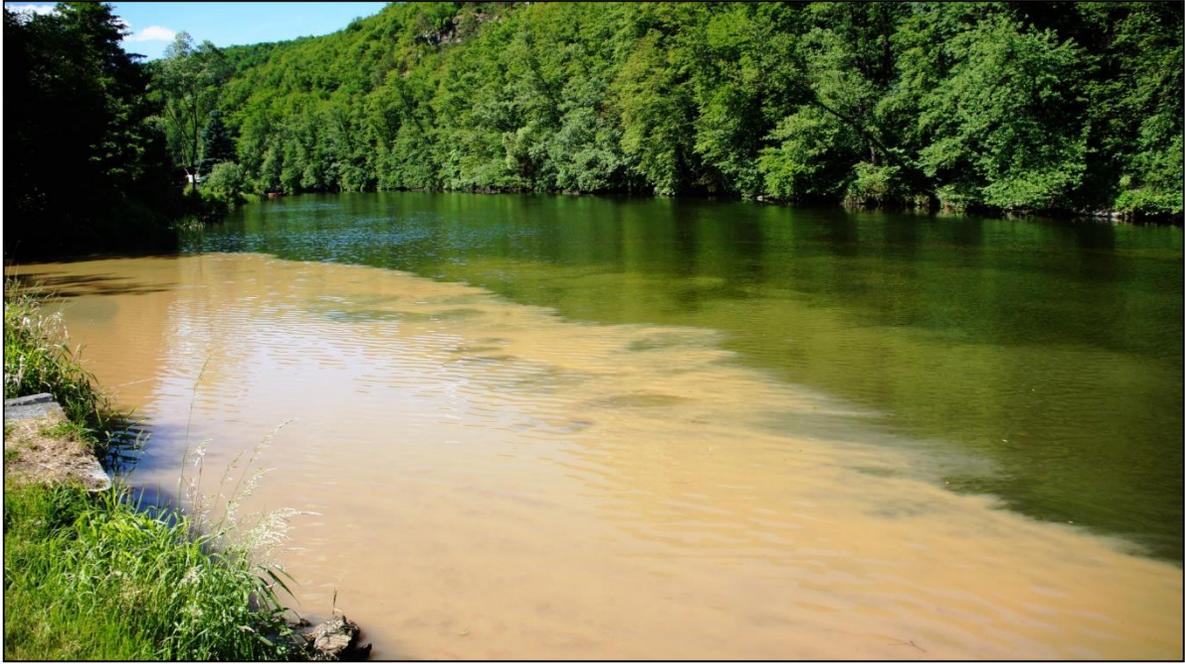
The effects of water erosion

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- River bank, river bed and coastline instability



[https://en.wikipedia.org/wiki/File:Kirkby_Brook_near_Valley_Road_\(Merseyside\).jpg](https://en.wikipedia.org/wiki/File:Kirkby_Brook_near_Valley_Road_(Merseyside).jpg)



Source: Aydin, 2017

- A decrease of water quality

- Sedimentation of water reservoirs



https://www.barrages-cfbr.eu/IMG/pdf/colloque_tsmr-cfbr_2022__s._wieprecht.pdf

Soil erosion factors

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- Visegrad Fund
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	Water erosion	Wind erosion
Climate	Rainfall or irrigation intensity, their distribution	Wind speed, distribution, direction
Soil properties	Soil texture, structure, water content, infiltration rate, organic matter content	Soil texture, structure, surface roughness, organic matter content, water content
Terrain properties	Slope length, gradient, slope forms, exposition	Slope length, gradient
Vegetation cover	Crop type, density, duration of the vegetation period	Crop type, density, duration of the vegetation period
Soil management	Landuse, crop rotation, tillage practices, machinery used, erosion control measures	Landuse, crop rotation, tillage, machinery used, erosion control measures



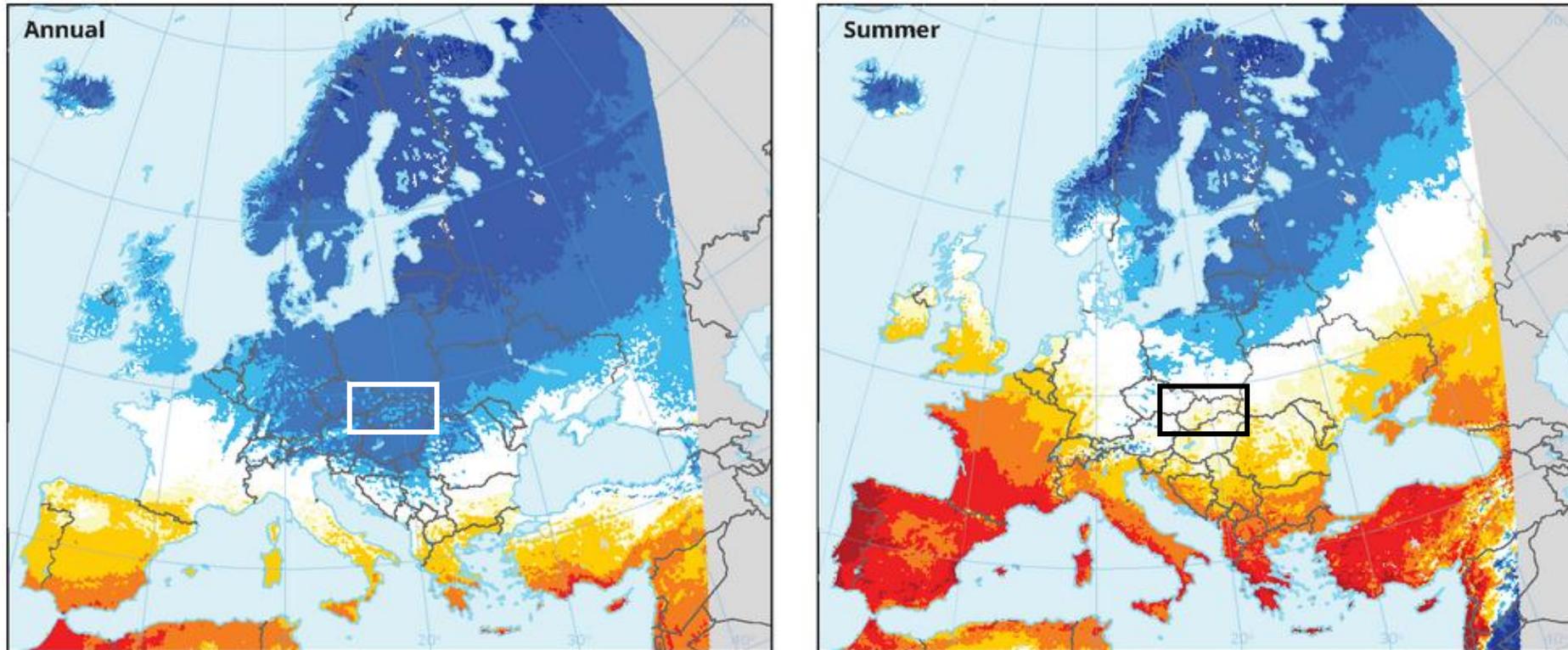
Climate factor and climate change

Projected changes in annual and summer precipitation (%) in the period 2071–2100 compared to the base period 1971–2000

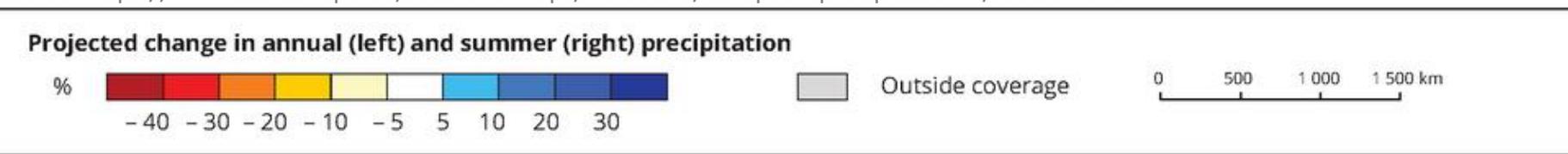
Impact on Slovakia:

+5 up to +20 % ↑

↓ 0 up to -20 %



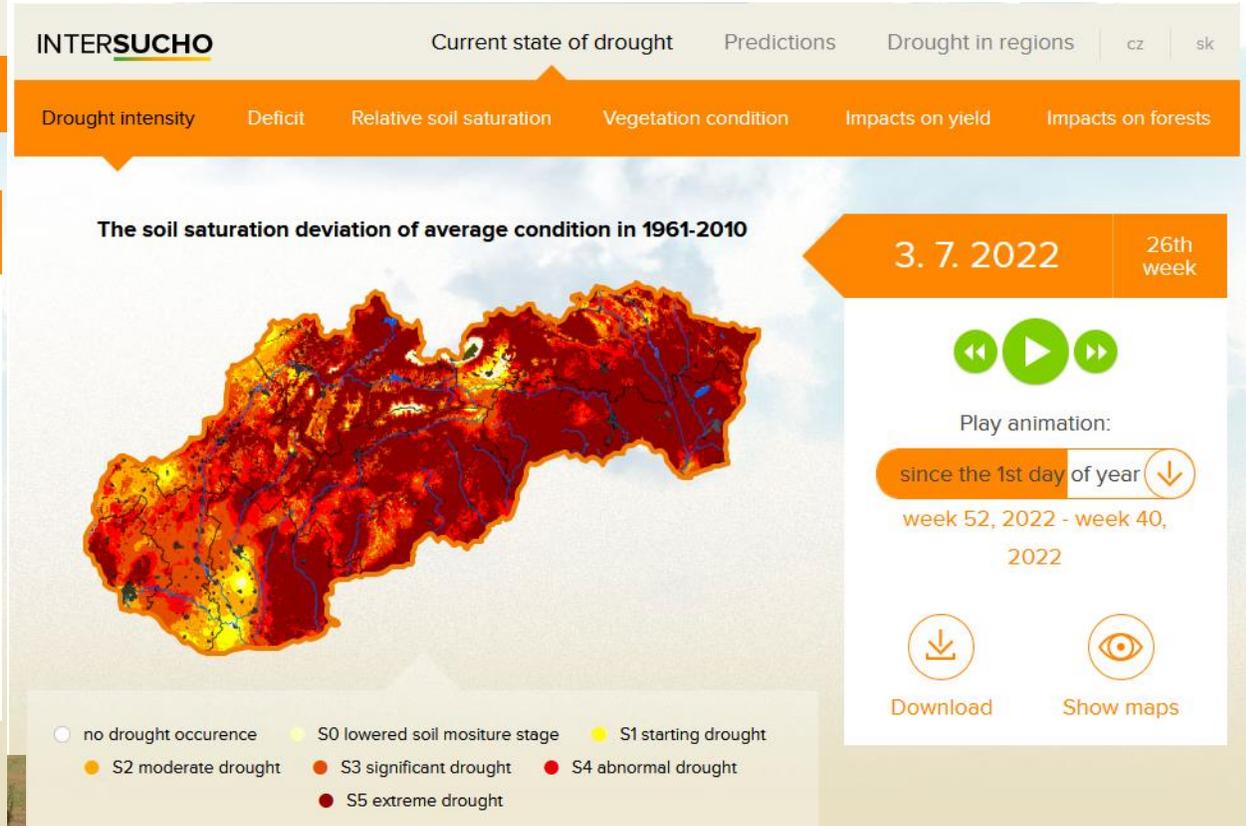
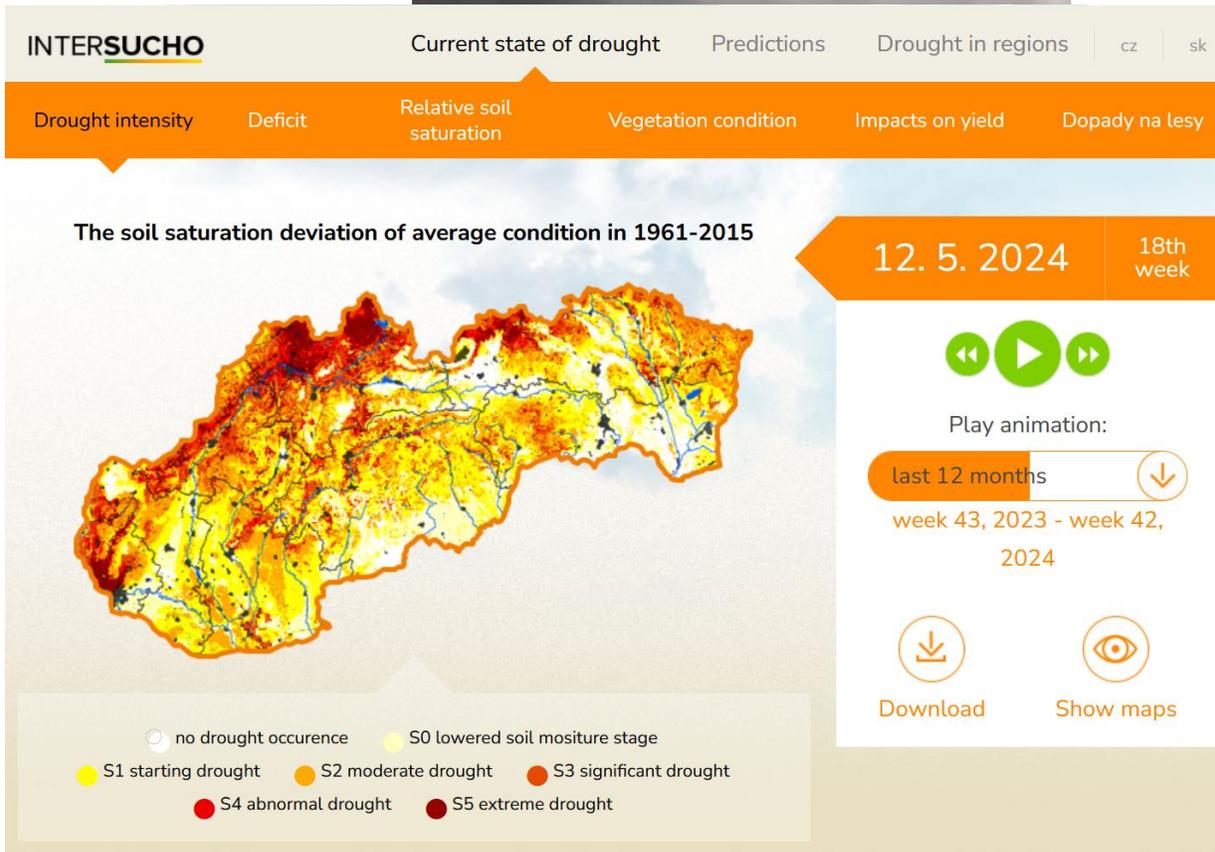
Source: <https://www.eea.europa.eu/data-and-maps/indicators/european-precipitation-2/assessment>



- Visegrad Fund

- change in the redistribution of precipitation
- 50 % more summer storms
- soil drought
- tornadoes

Monitoring of soil drought intensity



Source: https://www.shmu.sk/sk/?page=1&id=monitoring_sucha

Downpour → surface runoff → water erosion

No rain → soil drought → wind erosion



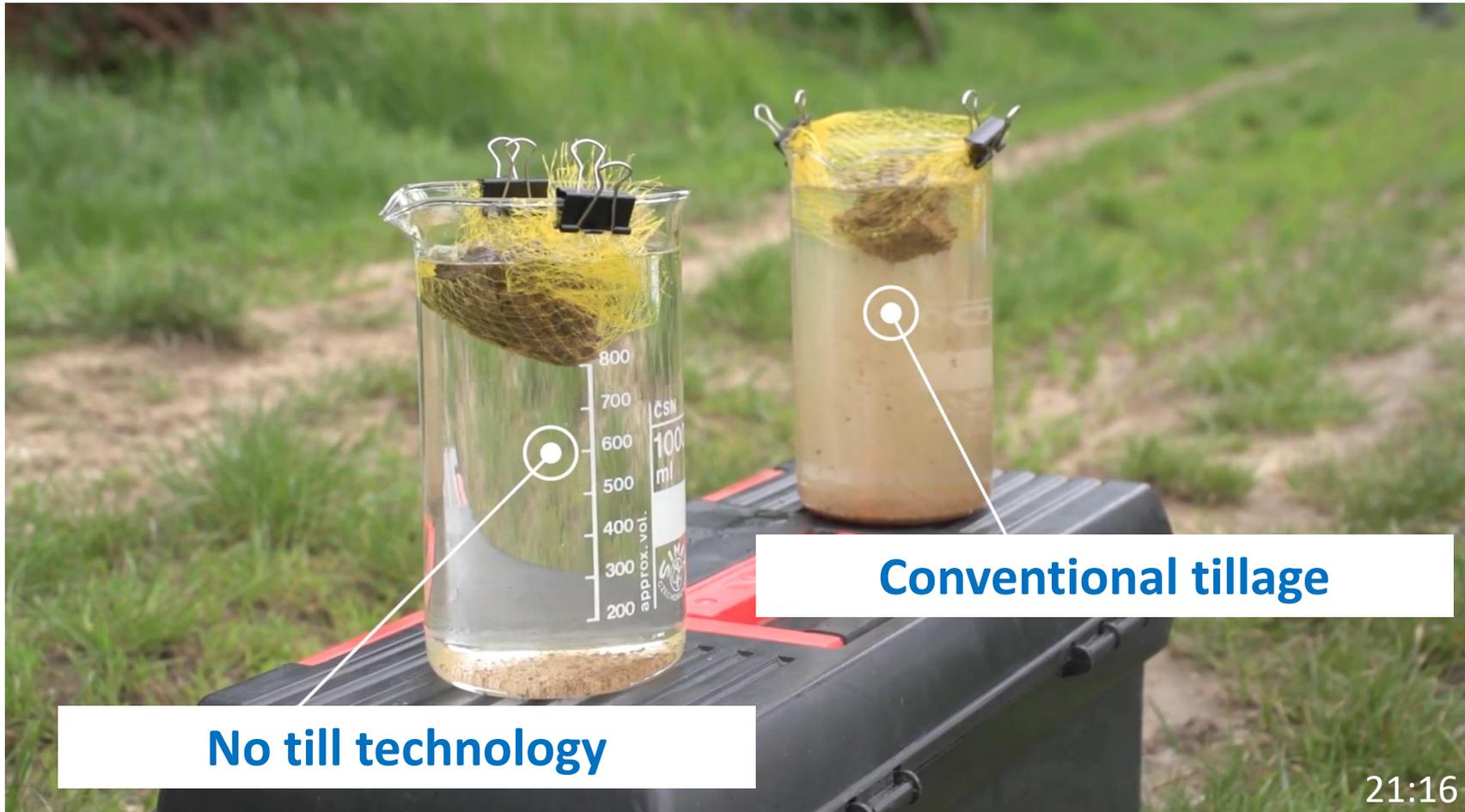
Zákopčie, SVK, 2018 (source: SITA/Prezídium HaZZ)

Trenčín, SVK, 2018 (source: Tregión TV)

Soil factor

Simple aggregate stability test
- immersing dry soil aggregate in water

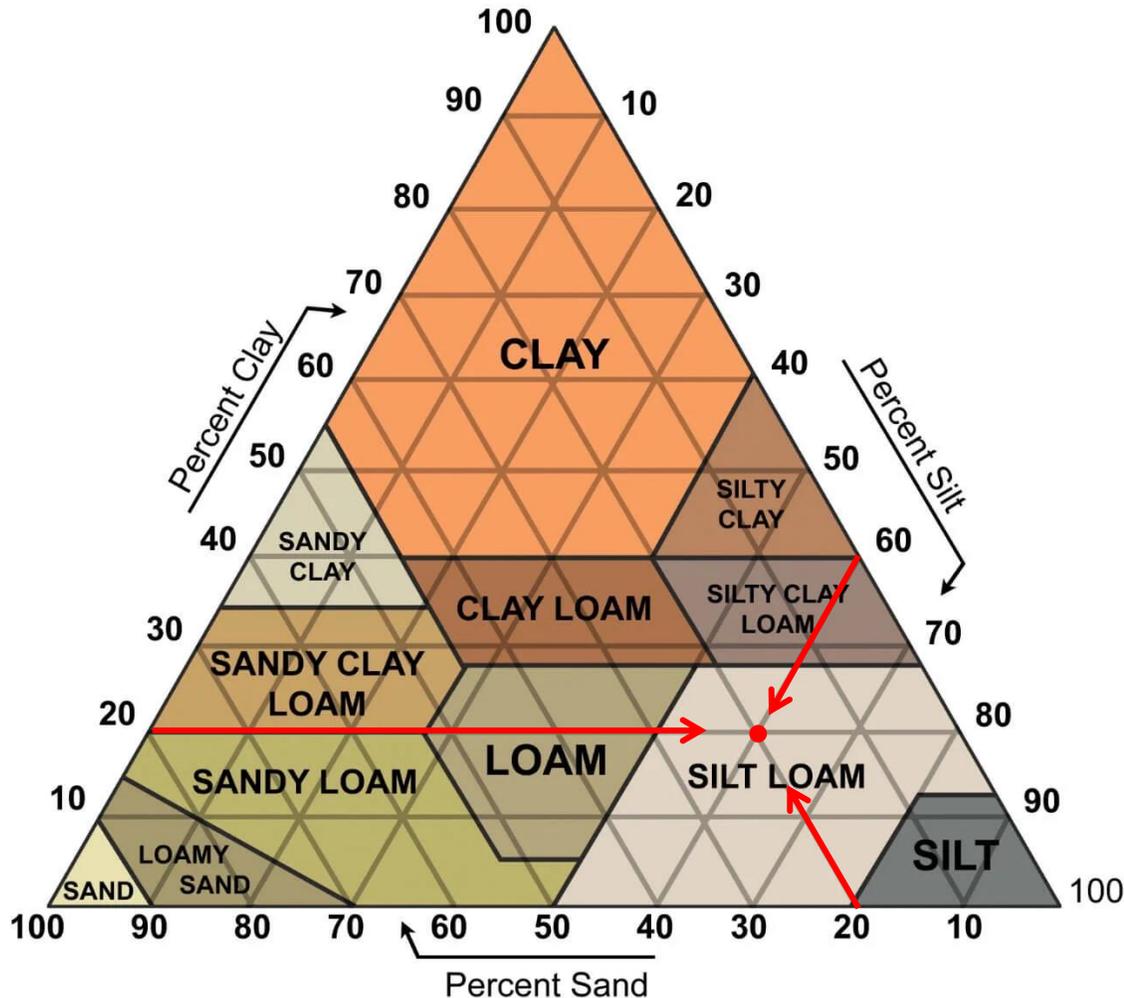
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- Visegrad Fund
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Exkurzia Kolíňany: <https://youtu.be/0yNy-4wMWil?feature=shared&t=1268>

Soil factor

Soil type determination using textural triangle



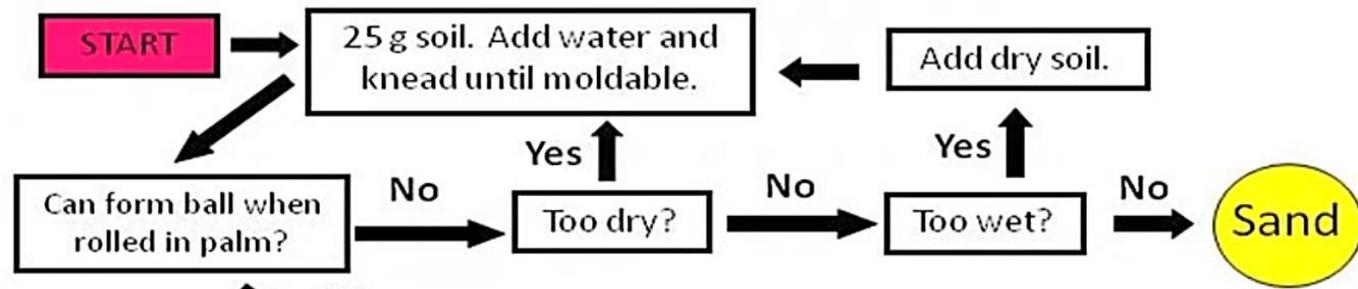
Sand: 20%
Silt: 60%
Clay: 20%
Total: 100%

Soil type: SILT LOAM

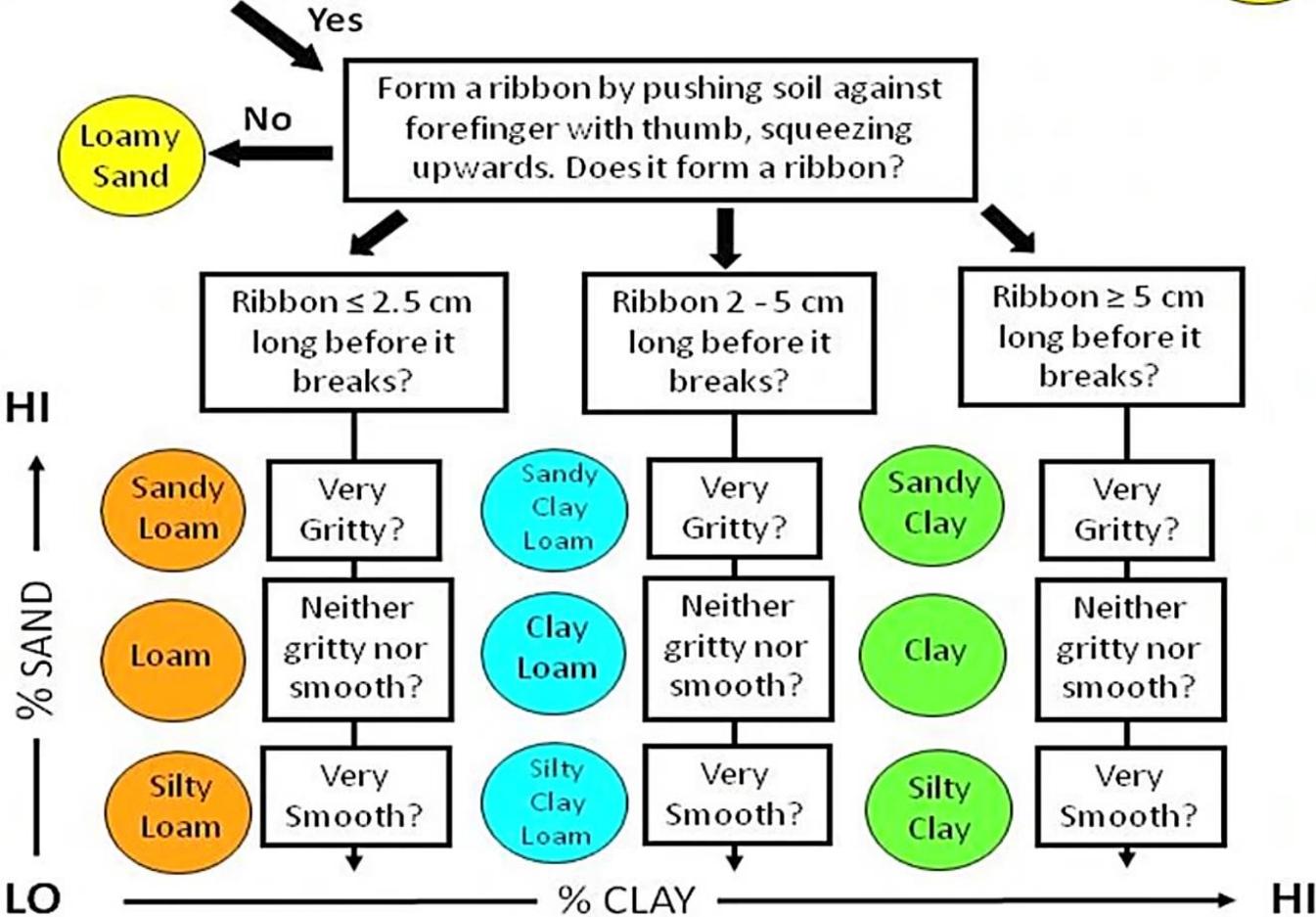
Q2: Determine the soil type:

Sand: 75%
Silt: 15%
Clay: 10%

Soil type:



Visegrad Fund



A soil with...

- **Sand** feels **gritty**
- **Silt** feels **soft** and **silky** like dry flour
- **Clay** feels **sticky** (when moist) and is **hard** to squeeze.

Adapted from Thien, S. 1979. A flow diagram for teaching texture-by-feel analysis. J. Agr. Edu. 8: 54-55.



Soil texture determination by feel

Soil pores

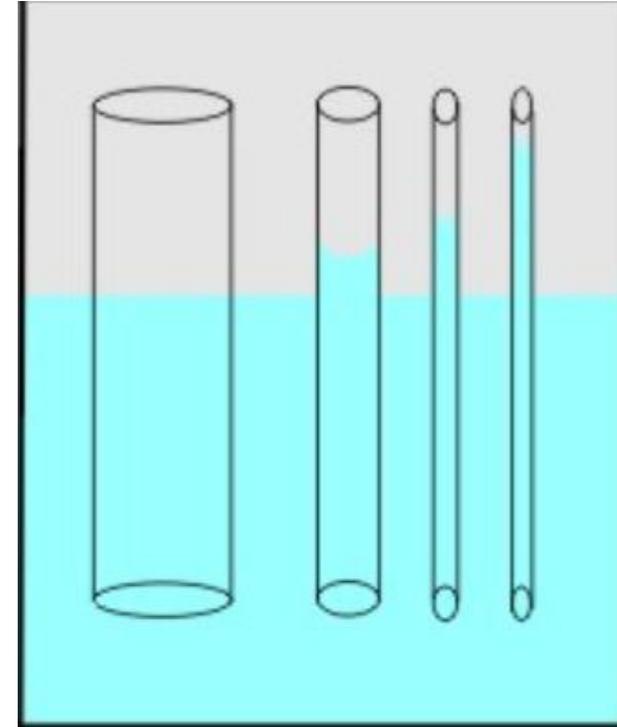
Non-cappillary pores (macro-pores)

They allow top-down movement due to the prevailing forces of the Earth's gravity. They allow the exchange of air between the soil and the atmosphere. They are virtually tension-free pores.

Semicapillary pores (both gravitational and capillary forces are applied)

Capillary forces determine the maintenance and movement of water in **capillary pores**. These are pores with tension. They reduce the action of the Earth's gravity when water moves upwards. The penetration of air and its movement are limited. These pores are penetrated by the plant roots, which find the necessary nutrients in the soil solution. Most chemical, physico-chemical and biochemical reactions take place in these pores.

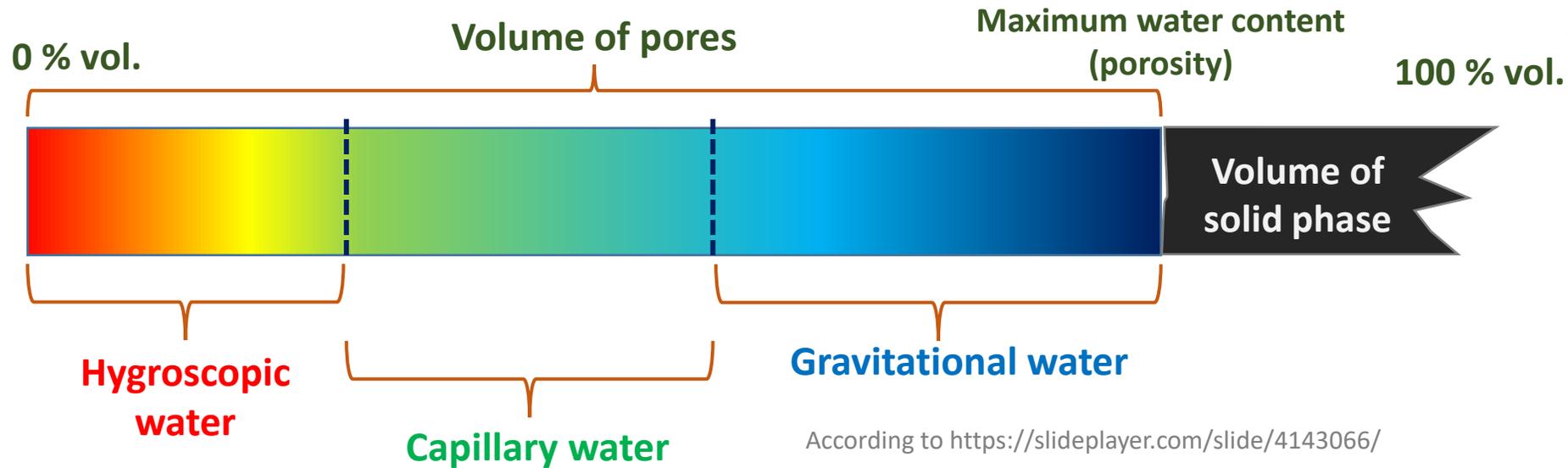
- Visegrad Fund



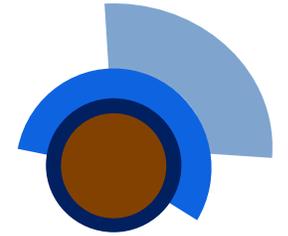
https://wocatpedia.net/wiki/Soil_and_soil_water

Capillary rise depends on the diameter of the tube (soil pore)

Categories of soil water



• Visegrad Fund

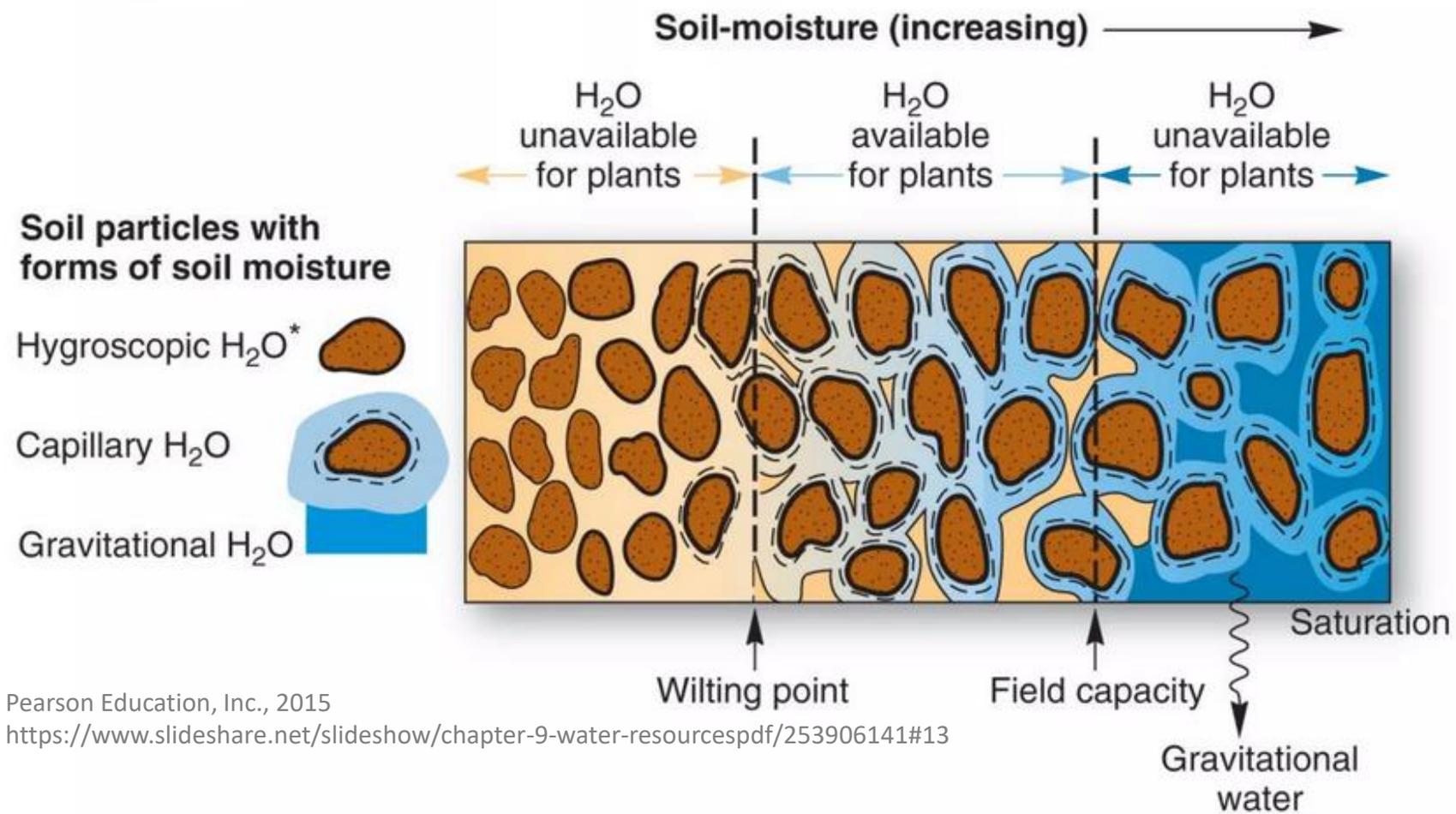


Soil particle and categories of soil water

Hygroscopic (residual) soil water - It is the water held tightly to the surface of soil particles by adsorption forces in thin films of 4 – 5 milli microns thickness. It is essentially non-liquid and moves primarily in the vapour form. This water is unavailable to the plants as huge pressure force would be needed to extract it.

Capillary soil water - water held in the capillary pores. Capillary water is retained on the soil particles by surface forces, adhesion, cohesion and surface tension phenomena. Adhesion is a process of the attraction of solid surface for water molecules and forms a very thin film of water at solid-liquid interface. On the other hand, cohesion is attraction of water molecules for each other. However, the water within the capillary range is not equally available (readily available water / not available for plant use).

Gravitational soil water - moves downward freely under the influence of gravity to the water table. It is also referred to as free water. Gravitational water is of no use to plants as it drains out due to gravity. It reduces aeration in the soil and hence, its removal from soil is necessary for optimum plant growth.

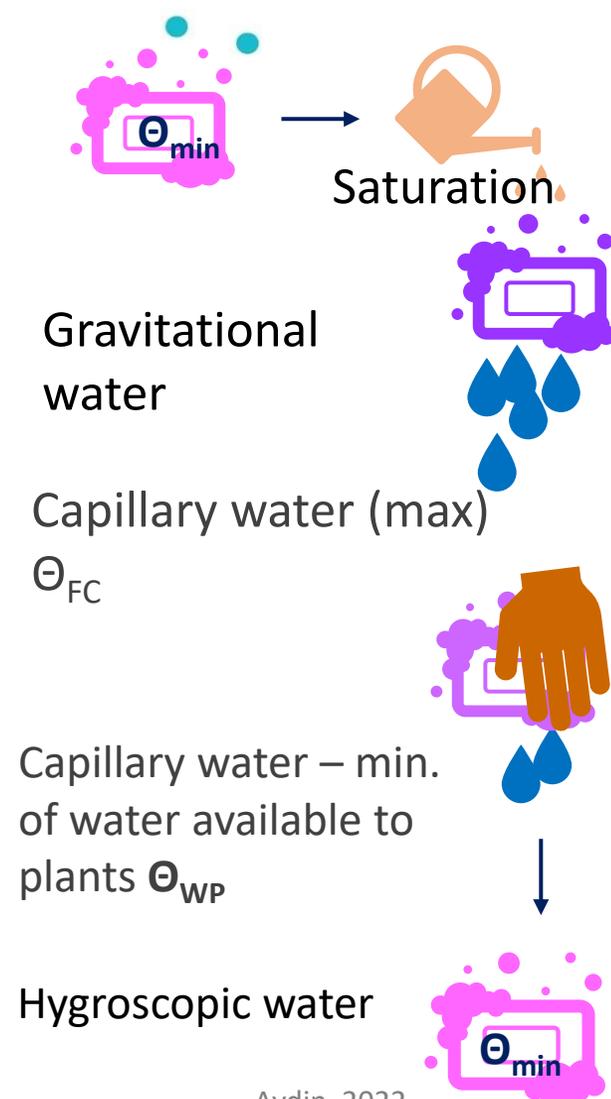


Pearson Education, Inc., 2015
<https://www.slideshare.net/slideshow/chapter-9-water-resourcespdf/253906141#13>

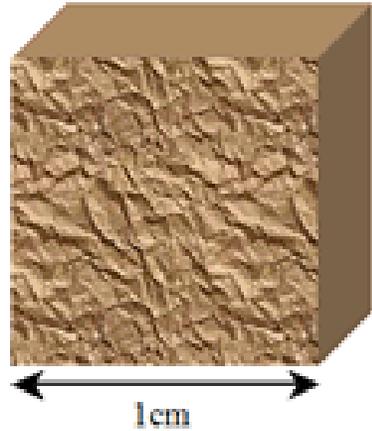
(a) Hygroscopic water bound to soil particles and gravitational water draining through the soil moisture zone are not available to plant roots.

*Note: Some capillary water is bound to hygroscopic water on soil particles and is also unavailable.

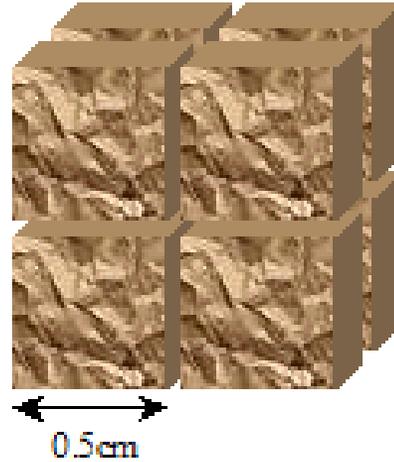
• Visegrad Fund



Cubic with 1 cm



Surface area $S=6\text{cm}^2$



Surface area $S=12\text{cm}^2$

<https://www.winner-psa.com/technical-articles/bet-specific-surface.html>

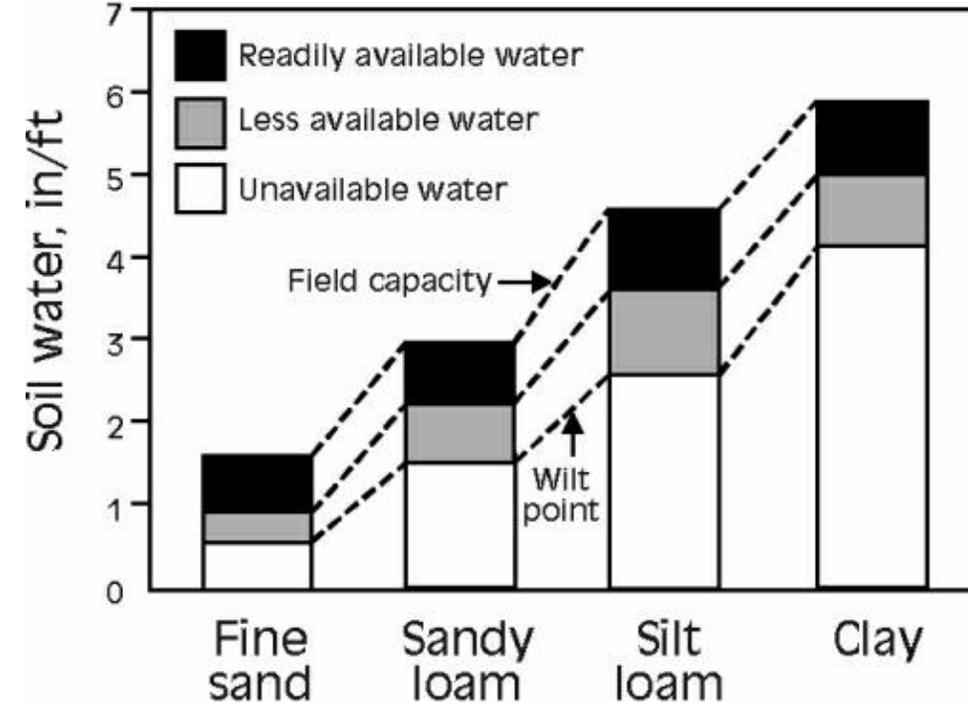
The **specific surface area** of particles is a measure of the activity of physical and chemical processes.

Clay particles $150 - 250 \text{ m}^2 \cdot \text{g}^{-1}$

Sand particles $<10 \text{ m}^2 \cdot \text{g}^{-1}$



Soil water available to plants



<https://passel2.unl.edu/view/lesson/bda727eb8a5a/3>

Soil factor

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Soil type

https://www.lodigrowers.com/download/water_management/USDA_IWM_1998.pdf

Infiltration rate:

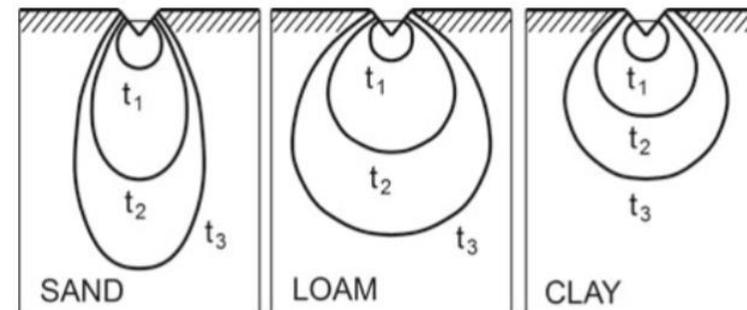
Cohesiveness:

Water holding capacity:



Soil erodibility - water erosion

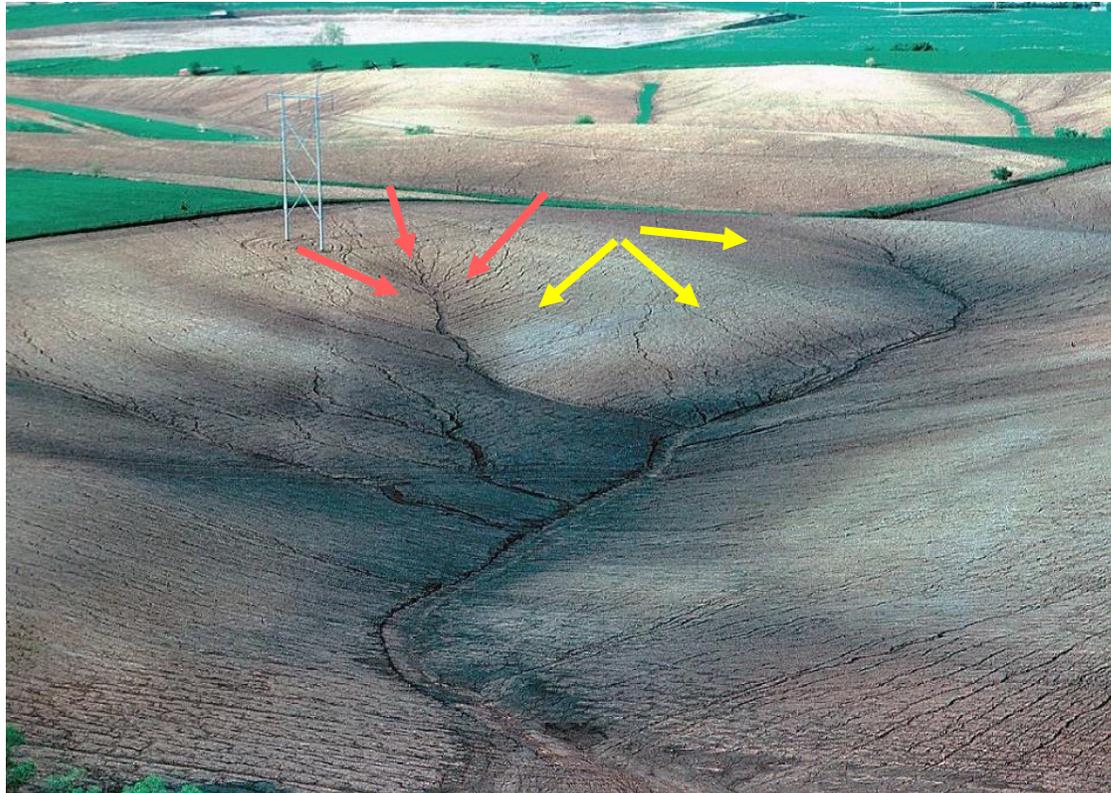
- medium-textured soils (most prone)
- fine-textured soils
- coarse textured soils (least prone)



Wetting front movement as a function of soil type

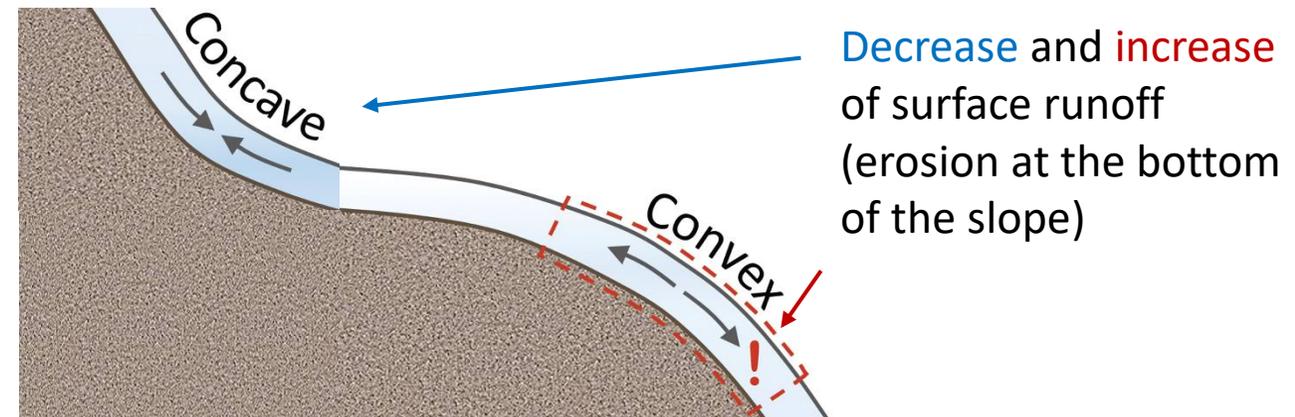
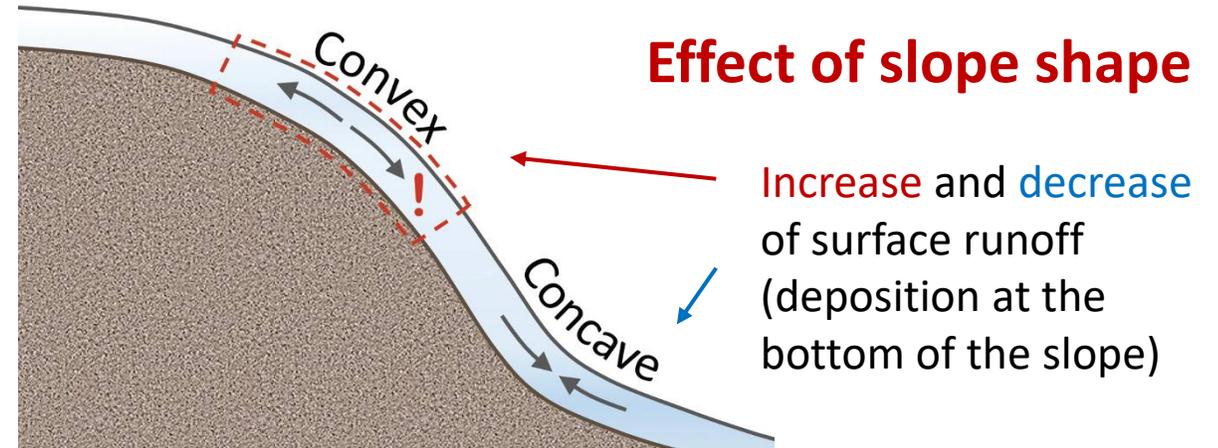
Fig. 10.13 Schematic positions of infiltration fronts during furrow infiltration, for three time intervals from the infiltration onset ($t_1 < t_2 < t_3$) and three soil types: sandy, loamy and clayey soil

Slope gradient, slope length, slope forms



Lynn Betts, USDA National Resources Conservation Service
<https://nap.nationalacademies.org/read/11820/chapter/10#238>

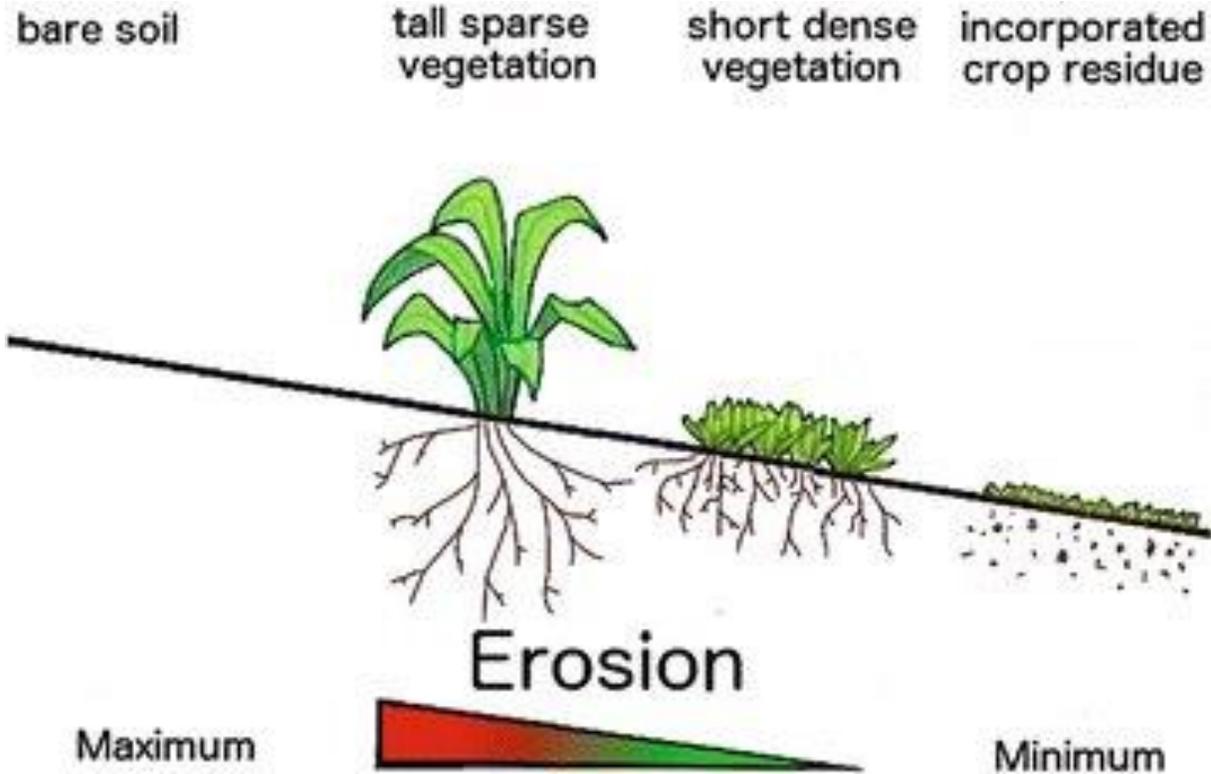
Concentrating and **diverting** of surface runoff



<https://avysavvy.avalanche.ca/en-ca/slope-size-and-shape>

Vegetation cover

- Crop types (wide / narrow rows)
- Timing
- Canopy density



Small, Finlay & Raizada, Manish. (2017). Mitigating dry season food insecurity in the subtropics by prospecting drought-tolerant, nitrogen-fixing weeds. *Agriculture & Food Security*. 6. 23. 10.1186/s40066-017-0096-6.

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- Visegrad Fund
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Pezibear, <https://pixabay.com/photos/silver-coat-leaf-plant-529225/>



Jdblack, <https://pixabay.com/photos/spring-crops-green-planting-4202968/>

Risk of water erosion increases at areas with:



Aydin, 2020

• Visegrad Fund

- Intense precipitation
- Medium-textured soils
- Steep slope gradient
- Long slope
- No / bad vegetation cover
- Wrong management such as rows parallel with the slope gradient (and direction of the surface runoff)

Risk of wind erosion increases at areas with:

Ridges in the topsoil created by changing the plowing direction



<http://inhabitat.com/australian-farmer-fights-erosion-with-a-patchwork-of-geometric-designs/brian-fischer-erosion-control-art/>

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- Visegrad Fund
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- Strong winds
- Coarse soils
- Dry soils
- Flat, smooth terrain
- Large, long plots
- Without vegetation cover



<http://thediaexpress.com/2016/07/30/wind-erosion-control/>

Determination of water erosion intensity

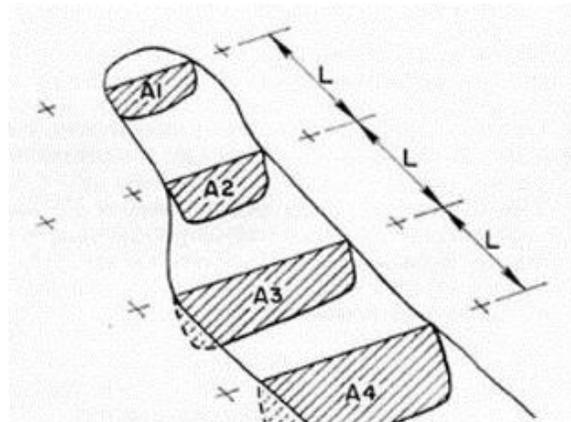
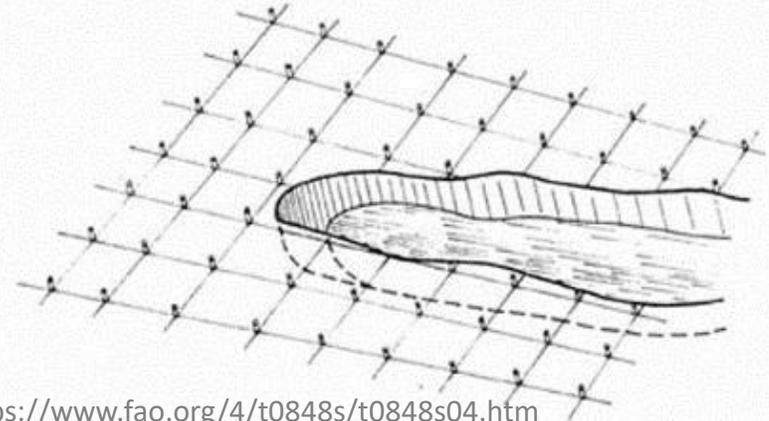
Field methods

- Changes in the soil depth



Antal, 1990

- Changes in the shape and volume of erosion forms



<https://www.fao.org/4/t0848s/t0848s04.htm>

- Photogrammetry (UAV and laser scanning)



Aydin, 2017

Determination of water erosion intensity

- Rainfall simulations



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- Visegrad Fund
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- Surface runoff and sediment trapping



<https://www.youtube.com/watch?v=okPtNdcc2W4>



Determination of soil erosion intensity

- Remote sensing

- Visegrad Fund



<https://www.google.com/maps/>



Masria A, Nadaoka K, Negm A, Iskander M. Detection of Shoreline and Land Cover Changes around Rosetta Promontory, Egypt, Based on Remote Sensing Analysis. *Land*. 2015; 4(1):216-230. <https://doi.org/10.3390/land4010216>

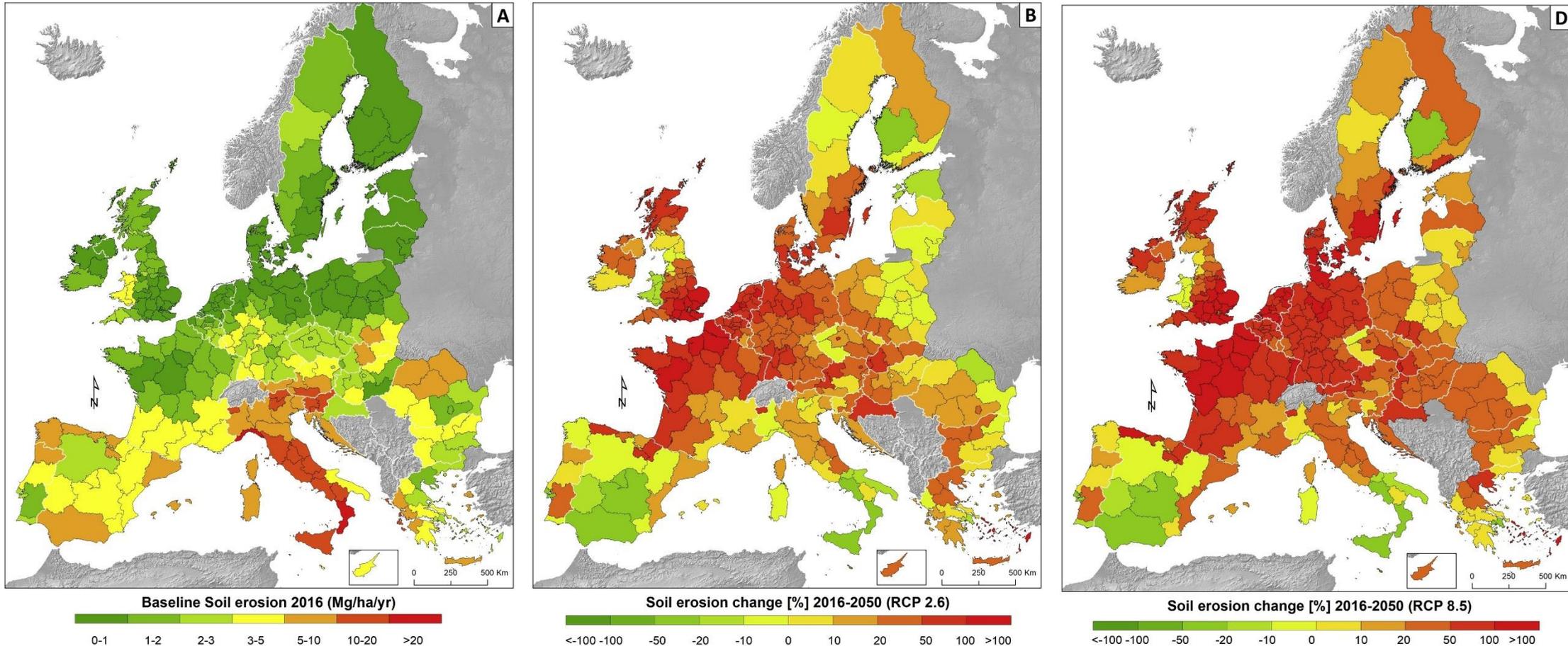
Modelling of erosion processes in GIS

wind erosion: WEQ (Wind Erosion Equation) <https://www.ars.usda.gov/ARSUserFiles/30200525/897%20A%20wind%20erosion%20equation.pdf>

water erosion: USLE (Universal Soil Loss Equation) https://www.ars.usda.gov/ARSUserFiles/50201000/USLEDatabase/AH_537.pdf



Prediction of soil loss by water erosion by 2050 (Panagos et al., 2021) in RUSLE



Erosion control

Aim:

- Protecting soil from impact of wind and rain drops
- Increasing water retention and infiltration into the soil
- Increasing of organic matter content in the soil
- Increasing soil roughness
- Cutting down the slope length
- Retaining the surface runoff
- Safe redirection and slowing down the surface runoff



Source: Aydin, 2021

Water erosion control measures

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Mulching



Image credit: hybridveggies
<https://eng.kisanofindia.com/latest-news/eco-friendly-mulching-why-is-organic-mulch-beneficial-for-crops>



Konstantin Zhdanov,
https://commons.wikimedia.org/wiki/Commons:Wiki_Loves_Earth_Czechia_2024#/media/File:Moravsk%C3%A1_Zebra.jpg

Creating ridges
perpendicular to
flow direction



https://stock.adobe.com/cz/search?k=furrow+agriculture&asset_id=354053514

Water erosion control measures



<https://bucksccd.org/home/agricultural-best-management-practices-bmps/>

No till farming
Conservation farming (crop residues)



<https://unsplash.com/photos/herd-of-sheep-on-meadow-W1SoHm5gn6M>

Grazing management to protect the
vegetation cover

Water erosion control measures

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- Visegrad Fund
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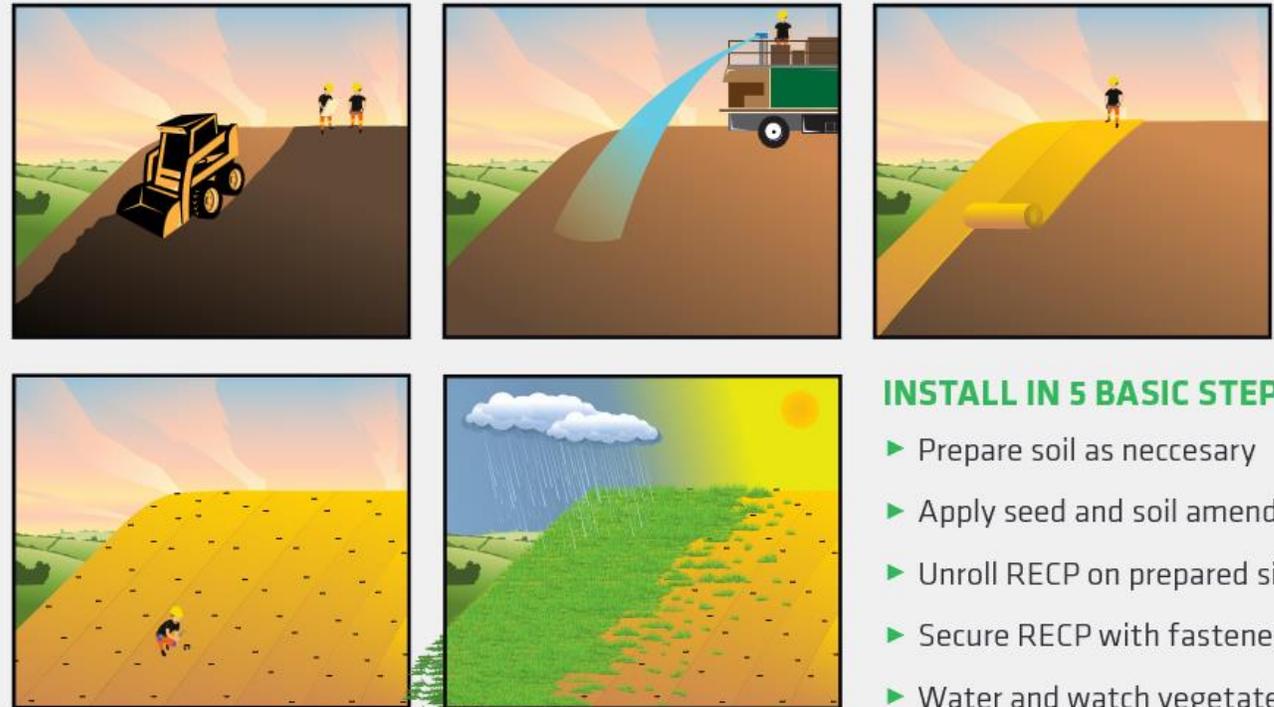
Terrace farming



http://soilwater.okstate.edu/CCA/StudyGuide%20pdfs/BMP_Terraces.pdf

Biodegradable erosion control blankets

BASICS OF INSTALLATION



INSTALL IN 5 BASIC STEPS

- ▶ Prepare soil as necessary
- ▶ Apply seed and soil amendments
- ▶ Unroll RECP on prepared site
- ▶ Secure RECP with fasteners
- ▶ Water and watch vegetate

https://nagreen.com/sites/default/files/2022-06/GEN_EC_BRO_4.22.pdf

Water erosion control measures

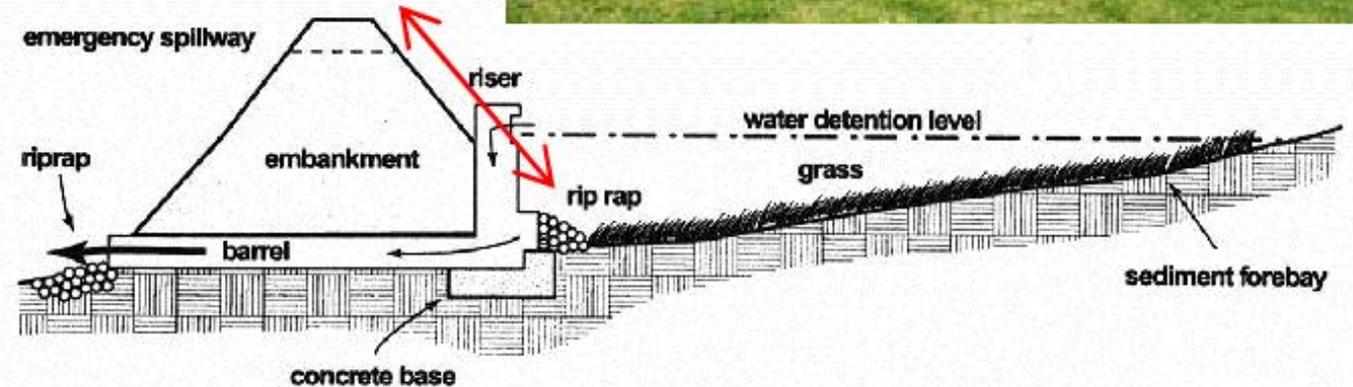
- Visegrad Fund



Check dams

<https://megamannual.geosyntec.com/npsmanual/checkdams.aspx>

(Dry) detention ponds



https://www.researchgate.net/publication/302435141_Water_Sensitive_Urban_Design_in_Existing_Urban_Settings_Case_Study_of_Dry_Detention_Pond_in_Kuching_City



Source: Aydin, 2021

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- Visegrad Fund
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Thank you for your attention

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Source: Aydin, 2024

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