GREEN RESTORATION PROGRAM FOR THE KOŠICE REGION OF SLOVAKIA: LANDSCAPE AND WATERSHED RECOVERY

2021 -2030

KOŠICE
SELF-GOVERNING
REGION

PROGRAM GOALS

Green Restoration Program for the Košice Region of Slovakia aims to restore the land and revitalize water resources and watersheds, resulting in the region's economic recovery. The integrated watershed restoration plan will ensure water, food, environmental, and climate security at the regional level within ten years.

Figure 1. Map of Europe. Inset map: Košice Region of Slovakia

This paper is an abbreviated version of an original 117-page document published in the Slovak language. The original record can be accessed here: https://dz2fe.vucke.sk/Home/ZasadnutiaDetailBod?id_session=155&id_replicate=8922
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INTRODUCTION

Water supplies in the Košice Region of Slovakia are currently limited and insufficient for its long-term needs. Land alterations and changes to the landscape structure have damaged the hydrological functions of ecosystems and urban landscapes. Especially in the Eastern Slovak Lowlands (Abov, Gemer, and Spiš), there is a documented temporal and spatial change in precipitation distribution. Such precipitation changes exhibit increased heavy rainfall and prolonged dry rain-free seasons, forming large thermal islands. Local torrential rains result in flooding, whereas rain-free periods cause drought. Droughts have been prevalent in the spring and autumn. Severe thunderstorms and extreme torrential rains occur several times from May to late summer and throughout the years, harming nature and human activities, causing significant economic damages.

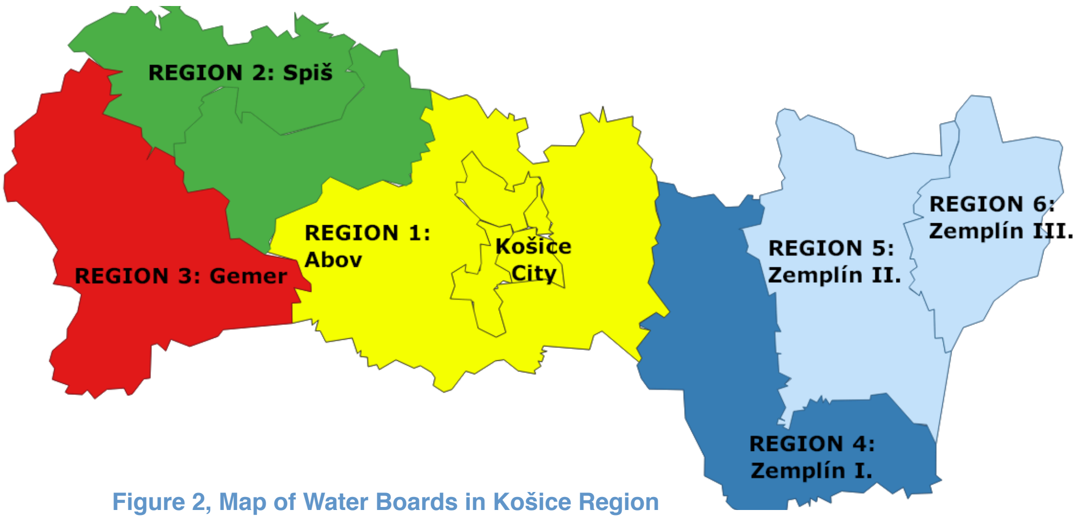


Figure 2, Map of Water Boards in Košice Region

	District 1:	Abov	(Košice city and vincinity)
	District 2:	Gemer	(Rožňava county)
	District 3:	Spiš	(Spišská Nová Ves county and Gelnica county)
	District 4:	Zemplín I	(Trebišov county)
	District 5:	Zemplín II.	(Poondavie - Michalovce county West)
	District 6:	Zemplín III.	(Michalovce & Sobrance counties)

Increased risk of droughts requires immediate attention. The Košice Region's challenge is to respond flexibly by optimally utilizing both urban and rural landscapes. The most effective solution is the ecosystem restoration of water supply in the damaged and dehydrated landscape, retaining rainwater, slowing down its drainage and infiltration, and, consequently, recharging aquifers and preventing floods.

It is essential to understand the hydrological cycles and recognize the need to retain the rainwater where it falls and slow the runoff down. This is different than the existing approach to stormwater management. The current water infrastructure affects the aquifers, altering the water cycles, causing inadequate and erratic rainfall, which poses a significant restriction challenge for agriculture and urban life and signifies a water supply shortage in watersheds. Floods and droughts are becoming a new normal.

According to the new water paradigm shift, integrated water-and-land restoration management will provide adequate water supply and storage, improve water quality and resilience, sequester carbon, increase crop productivity, reduce heat islands and improve the climate.

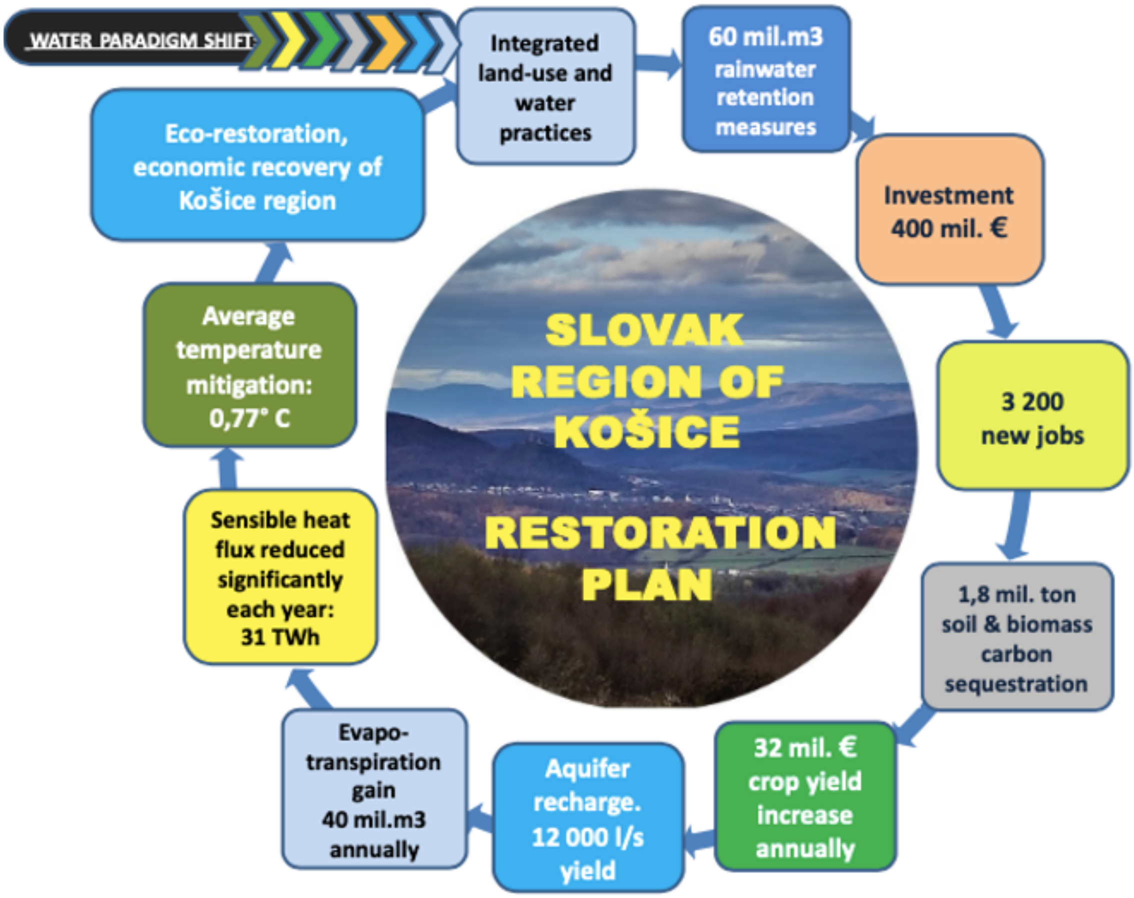


Figure 3 Restoration Plan Benefits

Groundwater recharge will increase water supply and offer a cost-effective way of raising the water table. We expect to install sixty million cubic meters of rainwater-retaining measures and groundwater recharge projects on 1.7 million acres of land. Our cost estimate is approximately 400 million EUR within the next decade. The recharge projects will create 3,200 new green jobs. The entire region will arrive closer to its carbon neutrality goals, as the retention project will add annually 1,8 million tons of carbon in soil and biomass carbon sequestration. Replenishing the aquifers will augment water yield by 12,000 liters per second, returning moisture to the short water cycles (small water cycles). Soil fertility will naturally rise with more water in the landscape, generating an additional crop yield, estimated at 32 million EUR annually. Annual evapotranspiration gain will return 40 million m3 water vapor to the atmosphere. A reduction of the sensible heat will moderate the local climate and lower the temperatures by an average of 0.77 degrees Celsius.

Green Restoration Program for the Košice Region of Slovakia Proposal (Košice Protocol) was initially approved on October 22, 2018. Following the proposal approval, the governor, county and municipality mayors, farmers, foresters, state administration representatives, volunteers, and activists convened. In 2019, the meetings led to establishing the Water and Land Restoration Advisory Boards (abbreviated: Water Boards) for six separate territories, respecting each area's unique geographic properties and history. Each independent Water Advisory Board oversees its domain. It has a task to prepare an action plan, provide sound stewardship of their assigned landscape, natural lands, urban and rural forests, agricultural fields, pastures and permanent grasslands, urban areas, including municipal and private real estate property. See Figure 2 for the Water Board boundaries. From November 2019 to December 2020, twenty-six individual water advisory board meetings took place and drafted action plans for integrated land and water management. The final plan was approved in February 2021.

COLLABORATIVE LANDSCAPE AND WATERSHED RESTORATION PLAN

Water is essential for the recovery of the climate. A new green recovery plan is contingent upon watershed restoration as a starting point, providing the economic recovery roadmap.

The Košice protocol made a historic commitment several years ago. At present, it is further motivated by United Nations Resolution 73/284, which declared 2021-2030 the Decade of Ecosystem Restoration, intensifying the fight against desertification and adding to the "Water for Sustainable Development," Decade 2018–2028.This resolution, signed by the Slovak Republic and 70 other countries on March 1, 2019, calls for the promotion and increase of efforts to prevent, halt and reverse the degradation of ecosystems, and raise awareness of the importance of river basin and soil restoration. The state departments, municipalities, NGOs, and businesses are called to collaborate in their restoration efforts as one of the strategic pathways for achieving these resolution objectives.

In October 2020, the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Framework for Climate Change again issued a call for increased efforts to restore and rehabilitate the landscape and forests. Among other things, FAO emphasizes the importance of wetlands in the revitalization of the landscape. The global extent of wetlands is estimated to have declined by between 64% and 71% in the 20th century (Davidson, 2014). Peatlands, for example, store nearly 30% of global soil carbon and twice as much carbon as forests, according to FAO.

According to the UN Framework Convention on Climate Change, wetlands are disappearing three times faster than forests. However, these land areas promote biodiversity and the return of investment in nature. Directly or indirectly, they provide almost all of the world's freshwater.

Complex and integrated solutions are a pathway that can bring about systemic changes in the use, protection, and restoration of natural resources. Integrated water and land-use management will increase the country's water supply, which improves the soil. Rehabilitation of water storage is a key to restoring degraded soil, mitigates the risks of floods and droughts, and improves crop productivity.

The fundamental elements on which each community and country exist are water, land, and energy. With these resources in ample supply, humankind in various parts of the world could survive even in the worst of times. Worsening of natural resources: loss of soil fertility, extreme weather events, and deteriorating environmental security are risks that are a challenge to address but also are pushing our coping mechanisms to the limit. For this reason, this action plan is geared towards comprehensive and integrated management of natural resources, which can systemically restore the results of wrong decisions in the past. We will be successful if we can methodically restore three fundamental pillars in the management of native resources: WATER, ENERGY, FOOD.

The connection between water (W) – energy (E) – food (F) attracts much attention from economists and researchers worldwide as a challenge to address related economic growth problems. In 2011, the World Economic Forum published a report titled "Water-Security: The Water-Food-Energy-Climate Nexus," which stresses that an integrated approach to water, energy, and food can increase resource security, efficiency, poverty reduction, and better resource management in all sectors. To achieve a sustainable water-energy-food (WEF) nexus, all-natural, human, and social scientists and businesses must combine their efforts in solving problems.

It is essential to apply the research into practice and put it to work in real life.

The Košice Region of Slovakia Landscape and Watershed Restoration plan intends to address these topics with an integrated policy approach. The program proposes to connect the dots between water, energy, and food and between weather, climate change, and biodiversity. Comprehensive solutions to the WEF approach need to be sought, as climate change itself concerns many aspects, such as water, soil fertility, extreme heat, and the increase of natural disasters.

All the above conclusions and recommendations reveal one more important link. Integration policies for water, energy, food, and biodiversity need to be defined and enforced at any public policy level.

It is these commodities that will be limiting factors for any development and subsistence cycle. This collaborative approach will extend public policy beyond the water, energy, and food sectors. Such a strategy will allow solving the climate and socio-economic difficulties in the Košice Region.

The further challenge is to include health, the environment, trade, biodiversity, and international cooperation, further providing a higher level of integration and a sound basis for strategic decision-making. The Action Plan of the Košice Region (interchanged with the term Košice Green Recovery Plan in this report) focuses on the sustainable management of natural resources.

This green recovery plan has developed a concept of watershed regeneration methods in damaged landscape structures to increase the intensity of photosynthesis. Consequent plant growth and the sequestration of carbon into biomass and soil promote the region's production growth potential.

This strategy first appeared in Slovakia in implementing the SIM4NEXUS project (www.sim4nexus.eu). This project calculated the opportunities to revitalize and strengthen natural resources in the context of ongoing climate change, based on data from the Košice region.

The water security of the region, soil fertility, biodiversity, and economic resiliency can be achieved by understanding the natural hydrological cycles and the value of the precipitation recharging the groundwater and the ecosystems. Retaining the rainwater where it falls, or in close proximity, preserves natural resources, by restoring ecosystems in forest, agricultural and urban landscapes, strengthening the country's water reserves across the board, increasing soil moisture and fertility.

Rainfall reaching the land surface follows one of several trajectories. Precipitation may flow over the land surface as a surface runoff, or percolate through the soil to recharge groundwater, or soak up the soil to provide moisture to plant roots and subsequent transpiration through leaf pores. Rainfall accumulated directly on plant leaves will also evaporate back to the atmosphere. Soil water retention capacity is vital for optimal water capture, seepage, storage, and evapo-transpiration.

Plants, crops, and forests depend not only on precipitation but also on the soil's capacity to absorb and store water. In times of drought, plant roots can draw water from soil water reserves as they need. Experimental research has confirmed that the meadow ecosystem can store up to 18 tons of carbon per hectare per year when enough moisture is present (Pokorný, 2018). Based on this and similar research, rainwater runoff calculations were performed for each municipal land register in the Košice region.

Each Water Advisory Boards obtained data such as:

- the rainwater runoff (volume of water that is draining from precipitation)
- the volume of avoidable runoff (how much rainwater can be sustainably harvested),
- the soil carbon potential (how many tons of CO2 can be sequestered in the soil)

Individual Water Advisory Boards prepare the action and recovery plan for their respective territory based on this data. The Košice action plan will provide a policy comprising a blend of strategic incentives, building code compliance proposals, stormwater regulations, etc. The Košice Parliament and Water Advisory Board policy resolutions will stimulate the new water paradigm shift transition to a more sustainable path for people, water, and nature. The significance of supporting the existing wetlands and augmenting present rainwater storage in the landscape's revitalization is the key to recovery.

GEOGRAPHIC CHARACTERISTICS OF REGIONS AND WATER RESTORATION ADVISORY BOARDS

Košice region by the numbers:

Size:	1.7 million acres (comparison: the area of Rhode Island and Delaware combined)
Population:	800, 000

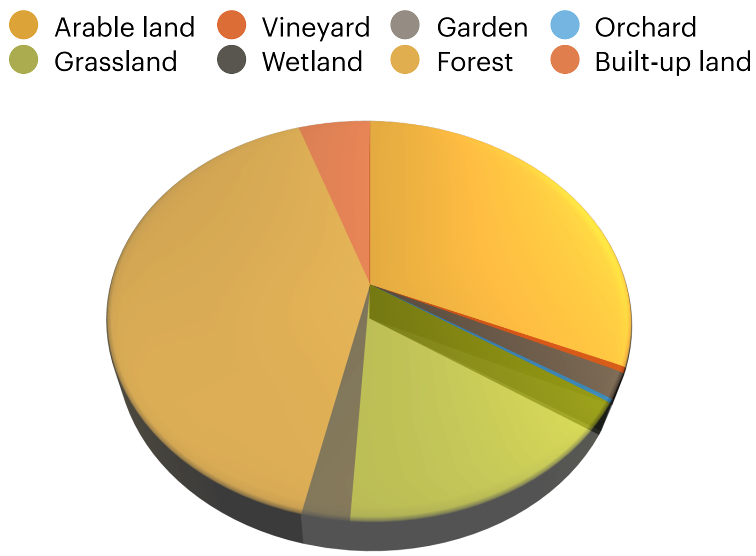


Figure 4 - KOŠICE REGION LAND USE

The Košice region of 6,754 km2 (1,668,950 acres) is located in the southeast of the Slovak Republic and occupies 14"% of its territory. The community is the second most populated within Slovakia and the fourth largest region. It borders the Republic of Hungary and Ukraine along with two other Slovak regions: Prešov and Banská Bystrica Regions.

Forests cover two-fifths of the surface. Gelnica is in the most wooded district of Slovakia, forested up to three quarters. Woodlands are found mainly in the mountain and foothill areas in the northern and southwestern parts of the region. In the southeast of the territory, there are floodplain forests. The eastern and southern parts have a lowland character, with hills peppering the countryside as well. The whole region used to enjoy a temperate climate, averaging annually around 10 °Celsius (50 Fahrenheit). According to Slovak Hydro Meteorological Institute, the latest data point to a temperature increase by 2 °Celsius in recent years, compared to 70 years ago.

The region's highest point is Stolica, at 1,476 m (4,843 ft). The lowest point is 94 m above sea level at the mouth of the Bodrog River. Watercourses include lowland, highland, and mid-mountain rivers.

The largest river is Bodrog, which, together with its tributaries, drains the region's easternmost part. Two basins Hornádska kotlina and Košická kotlina are drained by Hornád river with its tributaries.

The Slaná river flows through the western part of the region, and the Tisa river passes the southeastern area. Zemplínska šírava, Ružín and Palcmanská Maša are among the largest and most important water reservoirs.

The Košice Basin is one of the most promising areas in terms of the use of geothermal energy.

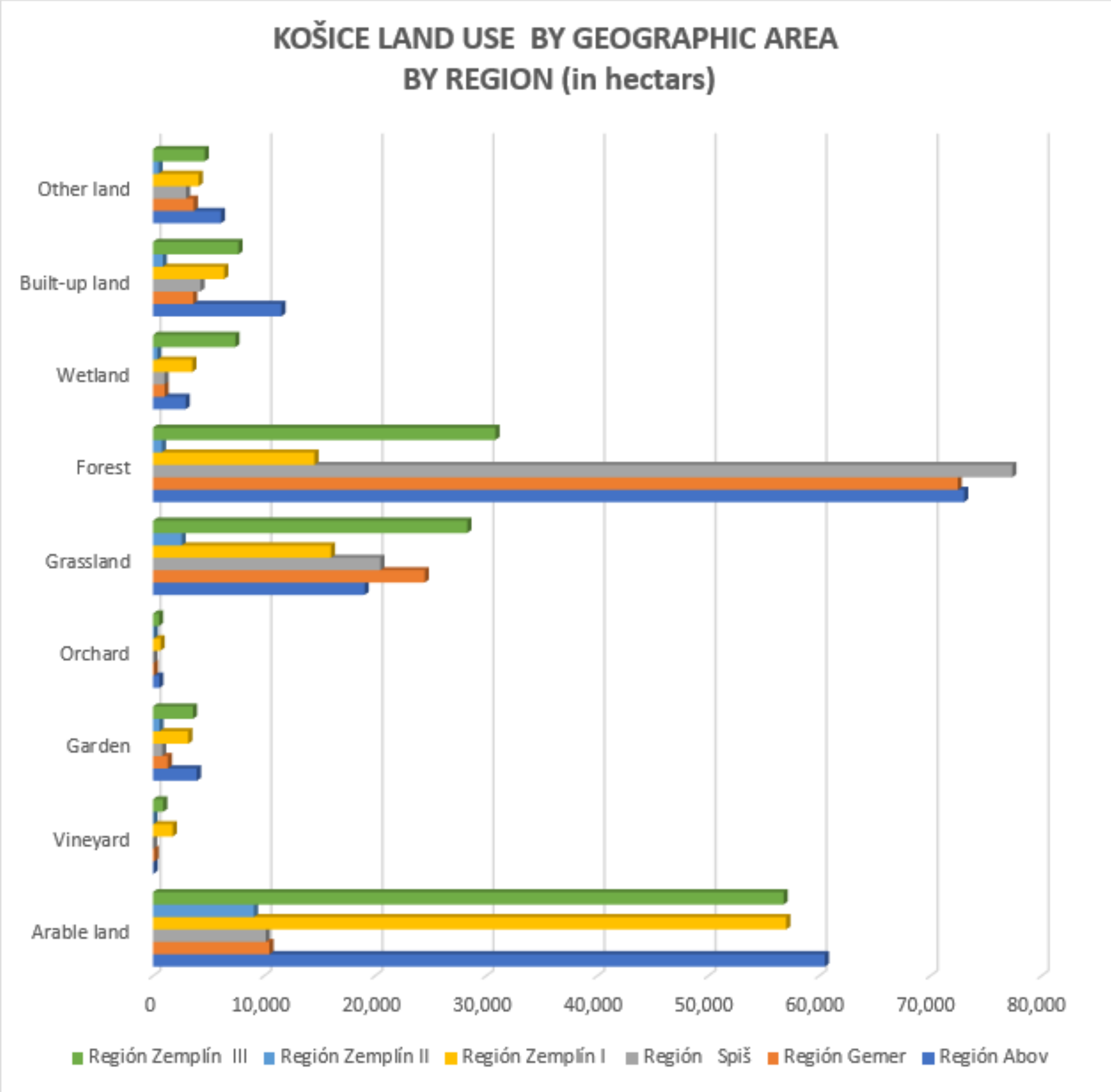


Figure 5 Notes:
Source: The Statistical Office of Slovak Republic

- Total acreage: 6,754 square kilometers or 1,669,026 acres (675,431 hectares)
- Wetland refers to a body of water. According to U.N. and the RAMSAR Convention, wetlands include: “all lakes and rivers, underground aquifers, swamps and marshes, wet grasslands, peatlands, oases, estuaries, deltas , and coastal areas, and all human-made sites such as fish ponds, rice paddies, reservoirs and salt pans.”
- Rural Landscape includes agrarian cultivated fields, forests, pastures, etc.
- Grasslands include the entire category of perennial grasslands, pastures, meadows, etc.
- Built-up and related land, in land use and agriculture statistics, comprises residential land, industrial land, quarries, pits and mines, commercial land, land used by public services, land of mixed-use, recreational, and other open lands. Scattered farm buildings, yards, and annexes are excluded. Build-up land is a human altered land.
- Other land includes mostly roads and land used for transport and communications and technical infrastructure.

Rapid drainage of stormwater from the forest, agricultural, and urbanized landscapes often results in torrential rains and flash floods, which are becoming a frequent reality. Floodwaters carry away the soil and the soil nutrients with it. Flash floods take everything in their path, including debris and fertilization, polluting the watersheds. Rain-free periods of abnormally dry weather are getting longer. Consequently, one of the largest water reservoirs in the area, the Ružín dam, frequently dries up, destroying fish farming in the Hornád river and ending its recreational opportunities.

Rill erosion. High intensity rainfalls carry away soil nutrients and sediments. Trebejov, 2016.

Erosion and land degradation. Regular roads give way to fast-flowing streams amid torrential rains. Flood and road hazard at Trebejov, 2016


Left: High flood risk level, Ružín dam, October 2020. Right: Dam breach, October 2020.


Left photo: Ružín dam filled with debris after the floods in 2005 and 2020. Right: Harmful algae bloom covers the waters behind Ružín dam, which recede or dry up during the arid years.


Left: High flood risk level Ružín dam breach, October 2020. Right: Destroyed crops translate to agricultural revenue loss.


Submerged residences experience property and financial losses. Hornad River, October 2020.


Medzev - Počkaj, Bodva, March 2016

Floodwaters carry debris and pollute waterways, endangering the aquatic life and creating a public health hazard.

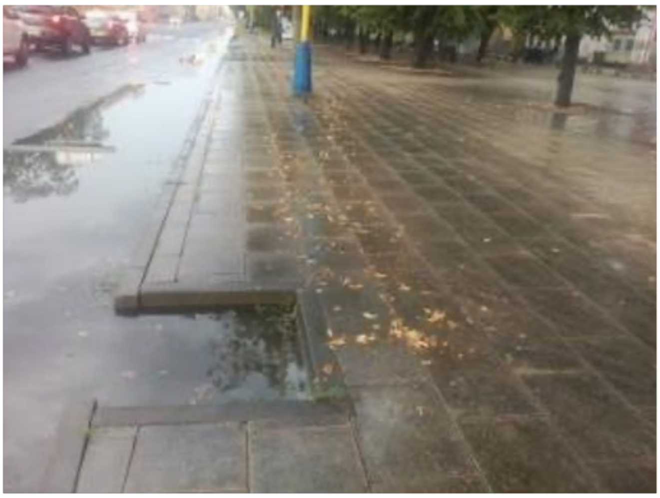
The flood & rill erosion at Košice forest 2010.

Flood ruined the crops and erosion destroyed topsoil. Košicke Oľšany, 2016

Left: Budimír, Torysa river basin, after the floods in 2010.

Right: Barrier restoration of a ravine at Turovce district, Torysa River basin. The photo was taken in 2019, nine years after restoration.

Photo on the left: Inadequate rainwater management drains runoff out and away from the Kavečany town. Middle: Olšava flood, 2010. Right: Flawed rainwater management at Spiš.



***Left*: Stormwater runoff is treated as a nuisance in Košice city, drained out to the nearest river, polluting it, and leaving the city dry during rainless periods. Picture shows that the tree roots cannot access moisture, while during rain, puddles collect on the road. *Right*: Roads in Košice city flood after heavy rains. Impervious paved roads give the rainwater no room to seep into the ground and nourish the vegetation. Urban bioretention methods would slow the rainwater down and prevent floods.**

After the flood, waters carried the sediment away, depositing it downstream, eroding the road.

Farmland not tilled on contour encourages avoidable runoff. Topsoil nutrients are washed away.

Left: Inadequate rainwater management drains runoff out and away. Kvačany. *Middle:* Olšava flood, 2010. Stormwater runoff washes out pollutants to the streams. *Right:* Flawed stormwater management.

Left: An impermeable asphalted pavement and road allow the rainwaters to rush down faster, forming a flooded trail, stopped by a berm temporarily.

Michaľany (Trebišov). Flood damage.

Draining rainwater in the township of Zemplínsky Klečenov (Trebišov). Concrete stream channel. Culvert. Unsustainable channelization and inadequate stream crossings alter hydrology and destroy aquatic life.



The old water paradigm at Kazimír, Malá Tŕňa (Trebišov district). The borough is discharging rainwater as an unnecessary resource. Impermeable surfaces seal the soil, reducing water infiltration, further dwindling groundwater supply.


Michaľany (Trebišov district).

Outdated rainwater paradigm. Rainwater is collected as a waste product, instead as a valuable resource.A vital creek was channeled into a straight concrete canal. Groundwater does not have a chance to recharge, and insufficient riparian buffer does not provide shade and bank stability. The channelized stream ran dry.

The existing inadequate rainwater management in urban areas of towns and villages contributes to the culmination of flood situations, drought, overheating of urban areas, creating urban heat islands, and air pollution development. Insufficient utilization of precipitation reduces natural water infiltration, worsening water quality and water supply.

Vineyards provide a typical distinctive character to the Southern Zemplín countryside. Rainwater management in connection with transport infrastructure directs runoff rapidly to the storm sewers. The river basins and soils have been drained dry for wineries and agriculture, causing water scarcity for vineyards or farmers. Moreover, biodiversity loss ensues.


Vineyards at Malá Tŕňa (Trebišov district)


Loss of moisture causes desertification. Soil loses nutrients and becomes lifeless dirt. Kazimír (Trebišov)

With the progressing quantity of impervious pavements, roofs, and industrial development, water runs off the land and travels on the surface towards the streams. The runoff then journeys to the rivers with an increased speed, collecting pollutants. On the other hand, infiltrating and slowing down stormwater runoff restrains flooding and enhances the water quality, effectively improving public health.

In many ways, healthy watersheds essentially affect the local microclimate and the air quality as well. Please see Figure 6 for the air quality report.

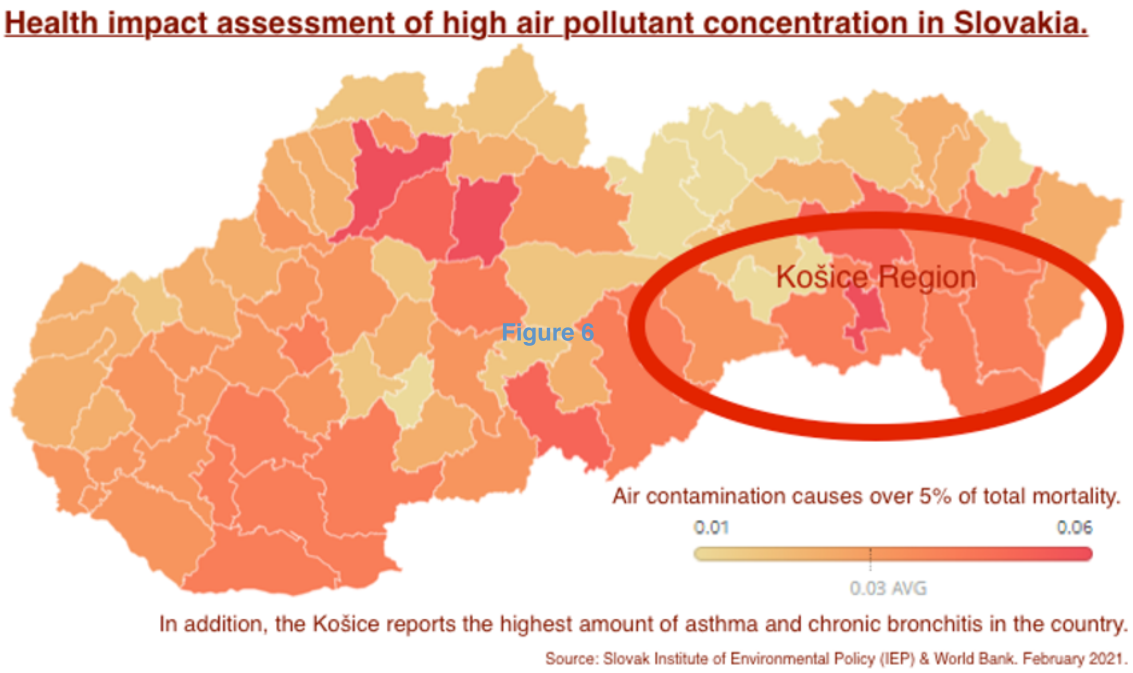


Figure 6

As of February 2021, Slovakia recorded the third highest air pollution levels in Europe.

Public health impacts cannot be overstated. Košice maintains a public record of one of the highest incidences of asthma and chronic bronchitis in Slovakia. Air pollution produces premature deaths, reduced activity and lost workdays, on top of a higher incidence of respiratory disease. Improving air quality in the Košice region will therefore have the most significant impact on improving public health.

The water-retaining methods will sustain trees and green vegetation and influence air quality by increasing humidity and absorbing toxic air particles and contaminants.

THE GREEN RESTORATION PROGRAM GOALS AND RESOURCES

The Restoration Program aims to implement sixty million cubic meters of water-retaining measures appropriate in various landscape settings, such as forest, agricultural and urban landscapes, and more.

These structures and projects will cyclically collect rainwater and return it to small water cycles to replenish soil and groundwater reserves, feed the springs, and reduce erosion activity. The measures implemented will harvest and retain rainwater to restore biodiversity processes, increase soil fertility, create water resources, and rehabilitate the climate.

The purpose is to slow down rainwater surface runoff from the catchment to reduce soil and nutrient removal from the land by the force of water erosion. Slowing down stormwater reduces erosion and allows for clean water streams instead of muddy watercourses, even in times of heavy rains and floods. Decreasing stormwater flow and creating water infiltration structures help the fish population during flood conditions and reduce fish mortality, benefiting recreational fishing.

Harvested rainwater resources are a mostly untapped asset, readily available. Last century rainwater management methods disregarded avoidable runoff. An International Journal of Water review confirms that the new water paradigm is likely to increase ecosystems' capacity to deal with stress, which is a crucial sustainability objective (Ziegler, Varga 2010). It can promote social goals associated with strong sustainability and improve the recovery and the growth of the economy.

The Restoration Program proposes an integrated land and water management for each municipality, including local stakeholders (forestry, farmers, land, and property owners) in their respective lands. Implementing area-wide measures in optimal spatial distribution will benefit all stakeholders.

The land-and-water measures will apply the latest technologies and practices, respecting the existing human-made landscapes.

The political will is necessitated to carry these solutions to scale—and fast, within a decade.

SWOT ANALYSIS OF KOŠICE REGION

Water and climate parameters are defined in strengths, weaknesses, opportunities and threats (SWOT) analysis on the example of Abov and Zemplín regions.

Strengths	Weaknesses
the topographical nature of the landscape	decreased precipitation (comparing to prior years)
the rural character of the population	heavy rains and flash floods in the Roňava watershed
relative low population density	few water-holding elements
availablility of land lots for the water-holding (water-harvesting) elements	administrative burden
sufficient precipitation	historical drainage of the territory
a network of river tributaries (Chlmec, Roňava)	high air pollution in Kosice region (See Map below, Figure 6)
quality topsoil	lack of funding, the insufficient support of the State Department
the existing pond in one of the villages (Zbehňov)	low water management or restoration awareness of the population
suitable location of some towns – slightly sloped terrain – natural water gradient	lack of land for building water management measures
municipal water supply from local wells	occupying arable land for construction
	large monocultural crops– wind erosion
	pollution of water streams and canals/ human-made watercourses
	groundwater pollution — non-existent sewerage system
	few green areas in the villages and towns,
	construction of stone-wood dams,
	the methods of logging and timber harvesting, deforestation
	large-scale farming methods
	the arrival of heavy equipment when the soil is wet causes soil disturbance, both in the forest or farm fields

Opportunity	Threat
the flood prevention measures,	flooding prevention nor sufficient
the cooperation of mayors and councils with project implementation,	time is running out
favorable tourism opportunities	droughts
the attractiveness of the region,	complete drainage of the territory; water table decreased
natural irrigation fed by tributaries,	flash flooding; erratic and torrential rains,
food self-sufficiency – fruit and vegetable growing opportunities,	depopulation of the territory,
a desire of the municipalities to participate in solving the water problems,	the existing environmental damages,
improving the quality of life of the population,	poor awareness, inadequate information access
the rural character of the countryside,	a passive approach of the political leaders– slow deterioration,
employment opportunities,	lack of funding,
publicly funded projects, job offers to the unemployed,	inadequate watershed management
building small waterworks or bioretention projects	economic crisis,
a multitude of small local projects accomplishment and support	pandemic, social unrest,
	lack of responsibility and cooperation,
	inadequate current water management measures,
	neglected existing waterways (water streams filled with sediments, taken over by vegetation),
	inadequate maintenance of water streams.

KOŠICE REGION WATER RETENTION MEASURES, IMPLEMENTED TO DATE

Košice landscape and watershed restoration proposes urban green infrastructure practices that address stormwater runoff. Stormwater is a valuable asset, a sustainable resource. Green infrastructure methods are low-impact development practices that include various water-retention measures, infiltration structures, infiltration trenches and basins, bioretention basins, rain and bio-climatic gardens, vegetated swales, dry wells, cisterns, permeable paving, highly permeable soil amendments, green roofs and green walls, etc.
There are many other methods applicable in the countryside, farmland or forests. These practices exemplify the new water paradigm shift, conserving and enhancing green spaces, reducing the existing stormwater pollutants, and protecting watersheds, biodiversity and climate.

Volunteers construct a log dam to restore the erosion ravine.

Bioretention function is visible within a year. Moisture improves soil biology.

Logging road reclamation.

Malá Lodina, Before (2012) and After (2020)

Gabion wall enclosure built 2005. Photo taken in 2020.

Čermeľske Valley. Ťahanovce.

Bioretention approach to unused forest logging road restoration.

Ťahanovce 2011 – 2020

Revitalized landscape completed in 2011, successive progress: 2012, 2014, 2015, 2020

Erosion gully restoration. Košice KVP, Photo story from 2005, 2007, 2010, 2019

Rainwater conservation. Bioretention ponds in Gemerska Panica. Initiative by farmer Štefan Zsóri.


Bioretention ponds. Design by Ing. František Háber. Hrušov


Log dam slows down the kinetic energy of the stream, preventing erosion. The height of the log dam allows fish to migrate. The picture on the right shows the same location upstream.


Human-made bioretention dam. Built sustainably by artisan forest workers.

LHP Slavošovce

Check dams preventing erosion.

Elaborate check dam.

Log dams cascade repairing an erosion gully.

Sustainable road channel drainage adjacent to the logging road.

Intercepting cross dip and cross drain. Road drainage, utilizing a slope gradient.


Interlaced twig/ wooden barriers.


Cascade of small barrier dams. Sustainable solutions, using local by-product branches.

Bioretention pond after the rainfall.

Rainwater retention-ready.

SCOPE OF ACTIVITIES TO MITIGATE FLOODS, DROUGHTS, AND EXTREME WEATHER EVENTS IN KOŠICE REGION

To estimate the total volume of the bioretention measures needed, we calculated the surface and overland rainwater runoff rate for the extreme torrential rainfall over the period of 24-hour storm duration. Our team applied the land-use data as per the State Land Registry. Our proposal is to construct the water retention volumes that can capture at least half of the avoidable runoff. Thus, when extremes occur in the territory, the extreme flood risk estimation will be at least one order lower than the original flood hazard assessment.

The flood hazard assessment explains the probability that a flood of a given intensity will transpire over an extended time duration. On a scale of three flood hazard categories, we consider downgrading the flood risk by one level a substantial improvement.

A well-implemented water-retaining plan will mitigate the flood risk assessment. In our calculations below, if a high-intensity rainfall of 60 mm falls on the land, all rainwater will remain in the territory without the flooding risk.

	Stormwater runoff at high-intensity 60 mm rainfall (m^3)	**Retention capacity, using weighted average coefficient for urban, forest, or farming land (m^3)**
KOŠICE city	5 084 402	2 542 201
KOŠICE vicinity	23 760 963	11 880 482
ROŽŇAVA	14 181 879	7 090 940
SPIŠSKÁ NOVÁ VES	10 571 575	5 285 788
GELNICA		1 120 368
TREVIŠOV	29 202 107	14 601 053
POONDAVIE	4 098 838	2 049 419
MICHLOVCE	20 377 132	10 188 566
SOBRANCE	9 734 389	4 867 195
Total water volume in cubic meters (m3)	**119 252 021**	**59 626 012**
Table 1	119 milion m3	60 milion m3

The avoidable runoff calculation incorporated the factors such as topography, the rate of rainfall, vegetation mass, urbanization factors, and soil conditions. Recovering the natural watershed function can help hydrological cycles, which will positively help to restore the land. Therefore, we propose to build 60 million cubic meters (m3) of bioretention structures in the Košice region, which will cyclically retain rainwater in the ecosystem and return it to small water cycles.

In terms of cost and market efficiency, this is **economically beneficial for the region**. Farmers frequently face crop losses, and flooded towns suffer property damages. Other stormwater simulations have shown that during 60 mm of precipitation in the Košice region, 60 million m3 of stormwater drains away out to the nearest water stream or river without replenishing the groundwater reserves, carrying away valuable topsoil and debris.

The proposed Green Restoration Plan aims to build land resilience, benefiting the economy and agriculture instead of land deterioration, recently occurring arid climate, and improvement of watersheds and water quality. In case of another large rainfall, we expect the flood hazard to diminish by half after implementing the water-harvesting projects as suggested.

The integrated water-and-land management is economically efficient because naturally available resources are optimally distributed and allocated to provide for the urban and agricultural sectors while sustainably revitalizing the ecosystems and healing the regional climate.

The new integrated system implementation will cyclically retain all rainwater in precipitation up to 60 mm, the area's average rainfall. We anticipate that completing the 60 million m3 of water management measures in the region will stabilize precipitation predictability and occurrence. We expect a mitigation of extreme storms and, at the same time, an increase in horizontal precipitation that is formed by condensation of water vapor (dew). We estimate that there will be about 50 mm of horizontal precipitation increase per year, reflected in soil fertility.

The greening of the countryside and the greening of the cities depend on water. Retaining rainwater where it falls (or nearby) is paramount to groundwater recharge and ample water supply. Ecosystem-based water retention in a combination of forest, agricultural and urban landscapes will strengthen the country's water reserves across the board and increases soil moisture.

FINANCIAL PLAN FOR THE REGION

Integrated water and land management is a natural climate solution. To alleviate the increasing flood and extreme weather risks, we have an outstanding obligation to reinvest in the natural infrastructures—such as degraded land restoration, simple groundwater recharge — implementing the suggested water-retaining measures, conservation agriculture approach, and wetland rehabilitation.

Groundwater recharge will increase water supply and offer a cost-effective way of raising the water table. Allowing rain to infiltrate the ground replenishes the aquifers. Moreover, groundwater saturation is a cheaper and more sustainable alternative to surface water storage. According to People and Water NGO research, the benefits are multifold, depending on the land use and land cover (LULC).

We estimate that the construction of one cubic meter of bioretention volume in a developed, urbanized area will amount to **28 €/m3**. In the countryside and all other land types (such as forest, farming land, pastures, orchards, gardens, vineyards), water retaining projects will cost **5 €/m3**. € stands for the European currency, EUR.

Note: Provided one cubic meter is 35.3147 cubic feet, then urban bioretention expense will amount to $ 0.95 per cubic foot, or $ 0.17 per cubic foot in other land-use respectively, assuming a 1.2 USD to EURO currency conversion rate.

We have based our forecast on the previous experience with the completed water-retention projects (one hundred thousand projects installed in Slovakia between 2000-2011), taking the land use, land cover and geographical difficulty of the implementation into consideration.

The entire Košice region will require € 408 million investment over ten years (see Table 3). The most significant expense will go into urban areas. The water-retention projects on the agricultural land will demand the second-highest funding, and the forest ecosystem will claim the third-highest allowance.

Based on the need to eliminate the creation of urban heat islands above the urban areas, we need to cool the towns and villages inside the region, with highest focus on Košice, the capital of the region. Košice Water Advisory Boards maintain that bioretention should be a leading strategy in eliminating the urban heat islands in cities and villages. Greening the city means increasing the tree and vegetative cover and installing permeable pavements, green roofs, and bioretention projects urban projects, preserving moisture in the residential or industrial environment. From a public health perspective, the advantage of bioretention projects and urban forestry are higher than the expense. Water improves the air humidity, the local microclimate and clean air, reduces air pollution, dust particles, and allergens in the air.

All Slovak municipalities and regions maintain the land and property records, geographical maps, and land ownership statistics by the land use. Each community can assess its needs and resources in the Land Registry. The Košice green restoration plan accessed these land and property records to calculate the range of water-retaining management projects. Based on sectoral support programs, we can quantify the exact financial needs per geographical area and land use.

The European Union's Common Agricultural Policy (CAP) outlined the green direct payments to farmers if they comply with one of the three goals: dedicate 5% of their arable land to promote biodiversity, promote crop diversification, or maintain perennial grasslands. As the payment is currently based on acreage regardless of the outcome, this income support scheme for the farmers is inefficient and inequitable and benefits a few large producers.

Direct agricultural support must incentivize farmers to implement water management measures directly in the agrarian landscape. This simple logical consideration implies a need to change the subsidy schemes for direct payments in agriculture to incentivize farmers to retain rainwater for their own sake. **Sustainable water compliance** is the key.

This implies a need for systemic changes to the common agricultural policy and setting up a direct payment system so that farmers are more and effectively motivated to link food security to environmental needs and climate recovery. If green subsidies reflect the necessity to retain rainwater on the land, there will be a fundamental repair of the previous soil degradation and short hydrological cycle damages. Our environment needs healthy and well-directed government funding for fundamental analysis and development of rainwater-retaining groundwater recharge projects. Subsidized development would advance to cut the costs of these renewable technologies. The revitalized landscape will deliver cost-effective solutions for advancing infrastructure and agricultural demands.

ACTION PLAN TIMELINE

The sooner the rainwater conservation and land restoration begin, the more swiftly the revitalized landscapes can offer ecosystem services into the future.
To foster green recovery, we need to safeguard the land, water, and biodiversity of the region by 2030. Therefore, the timetable is divided into four main steps of the project over 2021-2030 timeline:

1. The year 2021 – building technical, institutional, and financial capacity to prepare the program's implementation. Preparation of ordinances at the municipal level, public review and education, pilot projects completion.
2. Conduct case studies in regions according to the Water Advisory Board geographic districts.
    1. Rozhanovce (Abov)
    2. Gemerská Panica (Gemer)
    3. Žehra (Spiš)
    4. Kazimír (Zemplín I - Trebišov)
    5. Rakovec nad Ondavou (Zemplín II - Poondavie)
    6. Jovsa (Zemplín III - Michalovce, Sobrance)
3. 2021-2030 implementation of the projects across the board (forest, agricultural, and urbanized landscapes) in all districts under the Water Boards' responsibilities.
4. 2021-2030 Monitoring and research.

PROJECT PLANNING AND IMPLEMENTATION OF THE STRATEGIC ACTION PLAN AT INDEPENDENT KOŠICE REGIONAL GOVERNMENT

Institutional outline.
Košice Region Parliament instituted an umbrella Regional Water Advisory Board, whose members will be key Water Advisory Board affiliates currently involved in the existing districts. Other state legislators and deputies, independent regional government, and professional executives involved in the country's administration will be invited to join. We anticipate a possibility for further subdivision within the Water Boards.

Successful completion of the projects requires necessary research. Therefore, we furthermore propose the establishment of a Regional Research Council. We advise inviting the Slovak Academy of Sciences for cooperation. The Academy would provide expertise and research analysis for the Water Board of the Košice Region. Slovak Academy of Sciences assists in advising capacity to the Slovak government and is a state-funded research institution.

Water Boards will coordinate the water- retaining projects and supervise their completion.

District 1:	Abov	(Košice city and vincinity)
District 2:	Gemer	(Rožňava county)
District 3:	Spiš	(Spišská Nová Ves county and Gelnica county)
District 4:	Zemplín I.	(Trebišov county, Zemplin Middle)
District 5:	Zemplín II.	(Poondavie - Michalovce county West)
District 6:	Zemplín III.	(Zemplin South, Michalovce & Sobrance counties)

Drawing from the experience and the previous thirty conventions up to date, we approve the current Water Advisory Boards, as per chapter one of this report. Water Boards will coordinate the water- retaining projects and oversee their completion.
Each municipality will participate in the recovery program to green their communities. Township and borough councils will support the program and at the same time choose its Water Ambassador to coordinate the projects at the municipal level. Their plans will be subject to the Umbrella Regional Water Board's coordination and the Regional Research Council.

EXPECTED ACTION PLAN BENEFITS

Rainwater that currently drains away without benefit should preferably seep into the soil, thereby restoring and strengthening groundwater reserves. Recharged aquifers will supply enough moisture for the vegetation, enabling the evaporation that pumps the heat from the overheated Earth's surface into the atmosphere's higher colder layers. Consequently, retained rainwater strengthens the land thermoregulation, ensuring that carbon is deposited from the atmosphere in biomass and soil through photosynthesis and prevents permanent soil degradation, increasing soil fertility.

Flood risk mitigation.
This ecosystem restoration plans on "greening" the landscape by retaining the avoidable stormwater runoff, which otherwise intensifies the degraded land, amplifying flood risk and contributing to local floods. Košice region prepares to install 59.63 million cubic meters of water-retaining measures (water-harvesting, water-holding, bioretention, groundwater recharge projects - see Table 2).
That is almost **60 million cubic meters** of projects that will cyclically detain all the precipitation up to 60 mm. Such flood mitigation measures will prevent infrastructure damages, crop devastation, property destruction and basement flooding, other economic losses, and the impacts on ecosystems.
The chart shows the summary of required water-retaining measures to reach the desired outcome for each region. Calculations are based on land type for each district, pertaining to unique geographical landscape features. Land type character determines the methodology and project planning. Detailed investigations for each region and land type are attached to the original Slovak report and are not included in this abbreviated version.

Retention measures in million cubic meters (m3)	Arable Land	Vineyard	Garden	Orchard	Grassland	Forest	Wetland	Built-up Urban Land	Other Land	**Total by region** (in million m3)
Abov	7,822	0,008	0,154	0,032	1,104	2,439	0	1,542	1,322	14,423
Gemer	1,432	0,024	0,043	0,005	1,288	3,075	0	0,441	0,783	7,091
Spiš	1,647	0	0,03	0,002	0,972	2,604	0	0,547	0,604	6,406
Zemplín I Trebišov	9,096	0,38	0,257	0,096	1,751	0,998	0	1,04	0,983	14,601
Zemplín II Poondavie	1,367	0,008	0,045	0,006	0,344	0,039	0	0,134	0,106	2,049
Zemplín III Michalovce, Sobrance	8,404	0,132	0,212	0,031	2,878	1,295	0	1,082	1,022	15,056
Total retention measures	**29,768**	**0,552**	**0,741**	**0,172**	**8,337**	**10,45**	**0**	**4,786**	**4,820**	**59,626**

Table 2.

The concept of land renewal of the Košice Region is designed to increase and strengthen water storage capacity across the board. Water storage can increase the damaged forest's potential to recover and provide healthy ecosystem services, and rainwater can improve degraded agricultural land productivity. Water can also heal a polluted urban landscape.

Drought prevention.

Integrated water and land-use management will increase the country's water supply. More water in the country means more vegetation, an increase of crucial evapotranspiration, lower temperatures, and even carbon sequestration in biomass and soil.

An economic cost-effectiveness analysis.

Our cost analysis shows that it is possible to accomplish one cubic meter of rainwater storage volume for an average of 5 EUR in the countryside and 28 EUR on urban lands. The expense of 5 or 28 EUR/m3 includes the project preparation, implementation, engineering, and evaluation. With a certain amount of simplification, we have arrived at this estimate considering our past experience. (one hundred thousand projects built ten years ago). Detailed reviews for each region and land type are attached to the original Slovak report and are not included in this abbreviated version.

Investments are needed to improve the country's water regime and integrated land-and-water management in towns and countryside boroughs. The total expense will reach **EUR 408.43 million**, which we propose to invest over ten years in 2021-30. A table below sums up the Kosice region's investment amount for each of the Water Advisory Board, per region, per land type.

Financial investments (in million EUR)	Arable Land	Vineyard	Garden	Orchard	Grassland	Forest	Wetland	Built-up Urban Land	Other Land	**Total mil .EUR**
Abov	39,10	0,04	0,77	0,16	5,52	12,20	0,00	43,16	6,61	107,56
Gemer	7,16	0,12	0,22	0,02	6,44	15,38	0,00	12,34	3,91	45,59
Spiš	8,23	0,00	0,15	0,01	4,86	13,02	0,00	15,33	3,02	44,62
Zemplín I Trebišov	45,48	1,90	1,29	0,48	8,75	4,99	0,00	29,11	4,92	96,92
Zemplín II Poondavie	6,87	0,04	0,22	0,03	1,71	0,17	0,00	3,51	1,02	13,57
Zemplín III Michalovce, Sobrance	42,02	0,66	1,06	0,15	14,39	6,48	0,00	30,30	5,11	100,17
Total Investment by Land Type	**148,86**	**2,76**	**3,71**	**0,85**	**41,67**	**52,24**	**0,00**	**133,75**	**24,59**	**408,43**

Table 3 Note: Slovak numerical notation uses a comma to denote decimal points

A hydrologic principle exists that approximately two thirds of precipitation remains in the soil (capillary water), and 1/3 is involved in creating saturated layer water reserves. Many complex factors determine the output, such as the soil infiltration capacity, soil structure, vegetation, or its absence, impervious surface expansion, etc. The combination of land use, geographic factors, environmental conditions determine the scale and distribution of runoff from a watershed. The overland runoff results after the soil is saturated. We have used this basis and the regional Land Registry details for our forecasts.

The aquifer recharge potential.

The aquifer recharge potential estimates how much yield of water resources we can obtain in the territory. Our experience gained at the Horna Torysa watershed confirms that even during the driest months of the year, it is possible to obtain one liter of spring water per second by implementing 5,000 m3 water-retaining measures.

The recharge projects will improve the water resources in the region for each land type. In lowland areas, these reserves will contribute to the increase of the water table and groundwater supply. We estimated the yield of **12 thousand liters per second**. That is a critical piece of information.

If we were to assess the economic return on investments in the acquisition of water resources funding, EUR 35,000 should be invested per liter, per second. Conventional solutions for obtaining water resources through surface water construction are at least five times or more expensive. The conservation of rainwater resources offers solutions that are at least five times cheaper and are furthermore sustainable.

Soil Erosion Control. Runoff Control. Integrated land and water solutions.

The second important fact comes next. Rainwater retention management will slow down the outflow of rainwater from the country and reduce soil erosion in the forest and agricultural landscapes. The likely loss of soil due to erosion would affect the region's food production and profoundly affect the ecosystems. The reduction of soil deterioration on the one hand, and rehabilitation of water quality and quantity, on the other hand, should be the highest priorities of the region.

It is essential to keep the agricultural soil out of the rivers during floods. Rainwater retention will reduce the off-farm soil loss and the deterioration of the soil nutrients during floods. The frequency and intensity of erosion will be reduced several times. Deposition of soil and nutrients from the farm landscape during floods will be notably lowered. This will improve the conditions for aquatic life in the waterways. Fish stocks in our watercourses are expected to increase significantly. Sustainable land use and water management can reduce the soil erosion impacts on agriculture, livestock, and aquatic life.The attached table evaluates the increased yield of water resources by region and landscape structure.

Aquifer recharge Yield/ Water augmentation (in l/s)	Arable Land	Vineyard	Garden	Orchard	Grassland	Forest	Wetland	Built-up Urban Land	Other Land	**Total liters per second in each region**
Abov	1 564	2	31	6	221	488	0	308	265	2 885
Gemer	286	5	9	1	258	615	0	88	156	1 418
Spiš	329	0	6	0	194	521	0	109	122	1 281
Zemplín I Trebišov	1 819	76	52	19	350	200	0	208	197	2 921
Zemplín II Poondavie	264	2	9	1	67	6	0	25	21	395
Zemplín III Michalovce, Sobrance	1 681	26	42	39	576	259	0	216	204	3 043
Increased aquifer recharge rate in liters per second	**5 943**	**111**	**149**	**66**	**1 666**	**2 089**	**0**	**954**	**965**	**11 943**

Table 4. Note: Thousand comma separator was not used in this chart. Total aquifer recharge is almost 12,000 l/s

Water is the primary resource essential for the production of crops. The stabilization of the hydrological regime in the country will increase agricultural productivity through sustainable practices. See Table 5:

Arable Land

We estimate that arable land will increase crop production by at least eighty EUR per hectare **(80 EUR/ ha)**. On arable land, revenues will increase by more than **EUR 16 million** in total for all six regions (Table 5), provided, of course, that farmers follow our rainwater conservation methods and water-retaining measures are implemented. The whole Košice region would need to invest almost EUR 150 million (Table 3) to achieve the before-mentioned crop production growth on arable land. That means that the return on investment is about ten years.

Grasslands

The expected increased yield on permanent grasslands is at least **EUR 40/ha**. As a result, investing EUR 42 million in water management measures on pastures and meadows in the Košice Region (Table 3) will also return investments within ten years. The annual increase will exceed **5 million euros** (Table 5).

Forests and Biomass

The projected growth in the forest biomass due to the rainwater retention program will exceed at least twenty EUR per hectare or **EUR 20/ha**. That means wood production in the region will increase every year by almost **EUR 9 million** (Table 5). In addition to direct economic benefits - better wood mass yield, this will positively impact the more immeasurable health of forests, thus increasing forests' resilience to pests and enhancing biodiversity. More water in the landscape structure means higher humidity and prevention from spring frosts, which is another benefit for farmers.

Rainwater retention programs in the woodlands of each region will speed up forest growth and reforestation initiatives. Instead of planting new trees only, we need a new forestry model to restore degraded forests and replace the "forests of sticks" monocultures, with new methods maintaining various species. The pathway to a healthy, vital forest is to prepare the ground by retaining the rainwater, which in turn supports the dispersed tree seed germination. It is also important to rehabilitate the logging roads and restoring the forest landscape by making sure the rainwater stays where it falls.

Orchards

The country had very poor rainfall in recent years, and it is dry. Therefore, it should be noted that much-needed solution is to protect fruit trees from frosts at the time of spring blossoms when the harvest is threatened. Orchard resilience to the spring frost develops with the rainwater conserved in the landscape.

Table 5 compiles the crop yield improvement for each Water Board region and by landscape structure. The projected increased production of total agricultural crops will amount to EUR 31.57 million per year. If we assume that the planned investment in water-retaining strategies is almost EUR 410 million over the next decade, the investment will be returned in less than 13 years.

Annual crop yield increase in million EUR	Arable Land	Vineyad	Garden	Orchard	Grassland	Forest	Wetland	Built-up Land	Other Land	**Total**
Abov	4,84	0,01	0,31	0,05	1,14	4,38	0	0	0	10,73
Gemer	0,84	0,01	0,11	0,01	0,98	1,45	0	0	0	3,40
Spiš	0,81	0	0,06	0,01	0,82	1,55	0	0	0	3,25
Zemplín I Trebišov	4,57	0,14	0,26	0,05	0,96	0,87	0	0	0	6,85
Zemplín II Poondavie	0,72	0,01	0,01	0,01	0,10	0,01	0	0	0	0,86
Zemplín III Michalovce, Sobrance	4,54	0,07	0,10	0,02	1,13	0,62	0	0	0	6,48
Total	**16,32**	**0,24**	**0,85**	**0,15**	**5,13**	**8,88**	**0**	**0**	**0**	**31,57**

Table 5. Note: Slovak numerical notation uses a comma to denote decimal points. Crop yield will be almost 32 mil Eur annually.

The essential contribution of the country's green recovery program is the increased evaporation of the retained water from land. Currently, it is collected and emptied into straight channels, flowing away without benefit. **Increased evaporation** has at least two positive effects. The first is that it transports transformed latent heat from solar energy from the Earth's surface to the higher layers of the atmosphere. The second positive effect is that humidifying the air will affect air quality and subdue air pollution levels. Nature-based solutions will assist asthma and allergic disease prevention, especially in the youngest members of the population.

The highest evaporation will positively affect those regions that are currently most overheated. From Zemplín, close to 20 million cubic meters (m3) of water will return annually to short water cycles. The Abov rainwater harvesting projects will generate almost 10 million m3 of moisture returned to the atmosphere. Spiš and Gemer are among the most forested in Slovakia; therefore, the secondary precipitation estimates are lower.

Table 6 sums up evapotranspiration for each region and land-use category.

Evapo-Transporation gain (million m^3)	Arable Land	Vineyard	Garden	Orchard	Grassland	Forest	Wetland	Built-up Land	Other Land	**Total**
Abov	5,21	0,01	0,10	0,02	0,74	1,63	0	1,03	0,88	9,62
Gemer	0,96	0,02	0,03	0,00	0,86	2,05	0	0,29	0,52	4,73
Spiš	1,10	0,00	0,02	0,00	0,65	1,74	0	0,36	0,40	4,27
Zemplín I Trebišov	6,06	0,25	0,17	0,06	1,17	0,67	0	0,69	0,66	9,73
Zemplín II Poondavie	0,89	0,00	0,03	0,00	0,22	0,02	0	0,09	0,07	1,32
Zemplín III Michalovce, Sobrance	5,60	0,09	0,14	0,13	1,92	0,86	0	0,72	0,68	10,14
Total annual volume of water vapor gain, returned to hydrological cycle	**19,82**	**0,37**	**0,49**	**0,21**	**5,56**	**6,97**	**0**	**3,18**	**3,21**	**39,81**

Table 6. Note: Slovak numerical notation uses a comma to denote decimal points. Evapotranspiration gain will be almost 40 million m3 of water returned to the short hydrological cycles.

The first law of thermodynamics asserts that energy cannot be created or terminated; energy can only shift from one form to another until they are balanced. Per this energy conservation law, we know that solar energy is transformed from radiant heat into latent heat when water evaporates from vegetation. This latent energy is transported by water vapor to higher layers of the atmosphere because they are colder. The warm air heated at the surface ascends, and cool air higher in the troposphere sinks.

When the ground is dry, solar energy cannot be converted by vapor, so it turns into sensible heat and overheats the atmosphere's ground layers. Dry environments receive more radiant heat than those with cloud cover. When the ground contains plenty of water, 80% of the solar energy transforms into latent heat.
When one cubic meter (1000 liters) of water evaporates, 700 KWh of the Sun's energy is transformed. If there is inadequate moisture in the landscape, there is less vapor, and solar energy conversion into sensible heat increases. On this basis, we calculated a decline in the production of sensible heat, provided the moisture conservation methods are applied.
Table 7 reviews the amount of reduction in sensible heat production at each region.
It is a whopping 31,228 GWh (31 TWh). The sensible heat causes temperature changes felt by humans. Such a vast amount of energy is equivalent to seventeen months of production at all power plants in Slovakia.

Sensible heat mitigation in GWh	Arable land	Vineyard	Garden	Orchard	Grassland	Forest	Wetland	Built-up land	Other land	**Total**
Abov	5474	6	108	23	773	1707	0	1079	926	10096
Gemer	668	11	20	2	601	1435	0	206	365	3308
Spiš	769	0	14	1	454	1215	0	256	281	2990
Zemplín I Trebišov	4245	177	120	45	817	466	0	485	459	6814
Zemplín II Poondavie	617	3	20	1	157	14	0	61	48	921
Zemplín III Michalovce, Sobrance	3921	61	98	91	1343	604	0	504	477	7099
Total	**15 694**	**258**	**380**	**163**	**4 145**	**5 441**	**0**	**2 591**	**2 556**	**31 228**

Table 7 **Note: Thousand comma separator was not used in this chart. Total is 31, 228 GWh (31 TWh)**

We expect significant benefits of increased rainfall yield and more regular moderate precipitation by reducing sensible heat generation, especially in the South Zemplín region. The frequent and severe storms in the Carpathian mountain range are influenced by the intense overheating of the open urban and agricultural landscapes.

The full implementation of the recovery action plan, restoring the damaged countryside in the Košice Region, will also reduce the occurrence of extreme torrential rains in the adjacent Prešov region. As a result, more horizontal clouds can realistically be expected, anticipating a lower incidence of weather extremes.

Based on the physical characteristics of air humidity effect on the air temperature regime, we calculated the impact of increased evaporation on temperature reduction. **Table 8** shows the resulting drop in average temperatures in each region according to individual landscape structures. The program's implementation will reduce the Košice region's climate by an average of **0.77 degrees Celsius**. Urban cities will experience a decline in heat stress by **1.13 degrees Celsius**. A corresponding temperature change on the farming landscape will ensue. The highest drop in temperatures will be achieved in South Zemplín. The most substantial temperature change of **1.74 degrees** Celsius is reported in the category "other land," which includes roads, and other impervious surfaces, amongst other things.

It is possible to mitigate the heat waves and alleviate the average regional climate. Stabilizing the hydrological regime in the watersheds will help to sustain the temperatures. A decrease in heat is possible by changing rainwater management and encouraging soil and moisture conservation. Old stormwater runoff methods need to be replaced by a new water restoration paradigm shift. It is possible to keep the temperature increase under 2°C. The Nature Conservancy and other researchers estimate that natural climate solutions could account for almost 40 percent of the carbon savings needed to keep the world on the 2-degree Celsius path.

Temperature mitigation in ⁰C	Arable land	Vineyard	Garden	Orchard	Grassland	Forest	Wetland	Built-up land	Other land	**Total**
Abov	-1,36	-1,49	-0,41	-0,59	-0,61	-0,35	0	-1,4	-2,27	-0,85*
Gemer	-0,32	-0,38	-0,08	-0,13	-0,12	-0,1	0	-0,29	-0,5	-0,14*
Spiš	-1,71	0	-0,39	-0,38	-0,5	-0,35	0	-1,35	-2,13	-0,58*
Zemplín I Trebišov	-1,68	-2,25	-0,85	-1,48	-1,15	-0,72	0	-1,7	-2,51	-1,43*
Zemplín II Poondavie	-0,53	0	-0,27	-0,23	-0,47	-0,17	0	-0,54	-0,73	-0,48*
Zemplín III Michalovce, Sobrance	-1,56	-1,5	-0,62	-1,81	-1,07	-0,44	0	-1,48	-2,31	-1,13*
Total	**-1,19**	**-0,94**	**-0,44**	**-0,76**	**-0,65**	**-0,36**	**0**	**-1,13**	**-1,74**	**-0,77***

Table 8 Note: Slovak numerical notation uses a comma to denote decimal points.

Note: (*) denotes a weighted average calculation, reflecting the individual land-use data sets.

An essential contribution of the eco-restoration plan is the strengthening of photosynthesis due to rainwater retention in the ecosystem. Research shows that a naturally rainwater-supplied meadow (grassland) can store up to 18 tonnes of carbon per year in biomass and soil. Soil is a significant sink for carbon storage in the form of soil organic carbon. We estimate that about one-third of the carbon is sequestered in the soil. Moreover, the carbon, which is deposited in the soil through the plant roots, improves soil fertility.

Our team devised the following plan after a consultation with experts. We used a **conservative estimate of 2.8 tons per hectare** carbon storage due to increased photosynthesis through ecosystem rainwater retention. Table 9 summarizes the carbon sequestration results for each region and land use. It is important to realize that Košice Region can **achieve a neutral carbon footprint** simply within a few years! Rainwater storage will aid the biomass and soil carbon sequestration of more than 1.8 million tons of carbon per year.

Let us evaluate the benefit of reaching carbon neutrality and the return on investment in terms of carbon pricing over 20 years. Over the period 2030-2050, the Košice region green recovery projects will sequester more than 36 million tonnes of carbon in biomass and soil due to improved integrated land-and-water management strategies. If the total investment is over 408.43 million EUR (see Table 3), the carbon-offset cost would result in **EUR 11 per tonne of carbon**. In comparison, a carbon offset pricing for industry-related carbon dioxide emission calls for an average of EUR 25 to reduce one ton of CO2. The following chart uses a comma to denote decimal points.

Soil and biomass carbon storage (thousands of tons)	Arable land	Vineyard	Garden	Orchard	Grassla nd	Forest	Water-ways	Built-up land	Other land	**Total carbon storage**
Abov	169,42	0,17	11,06	1,60	53,38	204,57	0	32,37	17,14	489,71
Gemer	29,35	0,41	3,74	0,23	68,52	202,96	0	10,15	10,28	325,64
Spiš	28,41	0,00	2,30	0,12	57,37	216,71	0	11,96	8,33	325,20
Zemplín I Trebišov	159,70	4,97	8,90	1,91	44,89	40,75	0	17,99	11,53	290,64
Zemplín II Poondavie	25,47	0,14	1,61	0,26	7,25	2,24	0	2,46	1,42	40,85
Zemplín III Michalovce, Sobrance	158,95	2,58	10,05	1,52	79,25	86,36	0	21,56	13,06	373,33
Total carbon storage by land-use	**571,30**	**8,27**	**37,66**	**5,64**	**310,66**	**753,59**	**0**	**96,49**	**61,76**	**1845,37**

Table 9 . Total 1,845.37 tonnes = 1. 8 million tonnes of carbon sequestration per year.

A significant benefit of the green recovery program will be new employment opportunities in all the regions and social security improvement. The new plan will create almost 3 300 jobs, which is very much needed today. The employment of a low-skilled workforce will provide a break for the unemployed, introducing new opportunities for socially vulnerable people and reducing criminality.

Table 10 assesses new workforce requirements per each region and sector for the duration of the project. **EUR 25,000** provides an annual salary per person, providing the wage, income tax payment, social security contributions, health insurance, work equipment and tools. The Zemplín region projects will offer the most employment opportunities. In total, there are 1,685 jobs planned. Zemplín deserves it. The agriculture sector will create 1 582 jobs, forestry 418 jobs, and transport infrastructure will provide 197 job opportunities. The urban landscape eco-restoration projects will require a 1,070 workforce.

Workforce estimate	Arable land	Vineyard	Garden	Orchard	Grassland	Forest	Wetland	Built-up land	Other land	**Total**
Abov	313	0	6	1	44	98	0	345	53	860
Gemer	57	1	2	0	52	123	0	99	31	365
Spiš	66	0	1	0	39	104	0	123	24	357
Zemplín I Trebišov	364	15	10	4	70	40	0	233	39	775
Zemplín II Poondavie	55	0	2	0	14	1	0	28	9	109
Zemplín III Michalovce, Sobrance	336	6	8	1	115	52	0	242	41	801
Total	**1 191**	**22**	**29**	**6**	**334**	**418**	**0**	**1070**	**197**	**3 267**

Table 10

To calculate the benefits, we used the results of the SIM4NEXUS project (www.sim4nexus.eu). This European Commission-funded program made the recommendations based on research, case studies, international cooperation, and data analysis. Scientific teams, including ours, offered pathways in sustainable resource and low-carbon solutions, supporting evidence for the role of rainwater in the regeneration of water resources and environmental, food, social, and climate security at a local, regional, and national level.

The vital part of the Košice recovery action will be research, collecting data, measuring the impact of water-retaining measures on groundwater recharge, i.e., the water resource supply yield. Another task will be mapping the increase of the agricultural crop yield and forest biomass production potential. We predict that forest productivity will not remain constant, a widely held assumption, but will improve with more rainwater availability and groundwater supply. Gathering and analyzing sensible heat production data, their response to improved and integrated water-and-land-use management will provide attractive solutions to other parts of Slovakia, and the world.

Conclusion:

As the Green Restoration Program of Landscape Recovery of the Košice Region introduction asserts, we live through a period of new challenges, calling for the nexus between water, energy, food and climate. Business-as-usual trends alter hydrology and water resources of the region and the country. Water, Energy, and Food are the cornerstones of each community. Investing in ecosystem rainwater management will apply a sustainable holistic approach and improve the water, food, and climate security of the Košice Region.

Communities will enjoy further benefits from the plan implementation, which cannot be economically quantified. The recovery plan will certainly make a significant contribution to enhancing biodiversity, reducing health risks, and social benefits in the county. Increased evaporation will reduce air pollution and dust, improving the air quality and public health. The region will become more attractive, transforming the quality of life, developing higher estate property values, and encouraging local tourism, aiding the local economy.

Green restoration program with integrative land-and-water management will accelerate the economic recovery on a local level, providing local solutions to global problems. However, greening and re-wilding of our landscapes is not attainable without recovery of the blue watersheds. A green landscape without blue water would become an arid yellow desert.

It is no accident that the color **green** results from combining the colors blue and yellow. The colors of **blue** water and **yellow** sun provide a strong visual effect that reminds us that promoting green spaces is impossible without water. Green landscape restoration is not possible without blue watershed restoration.

The Košice Parliament approved the Green Restoration Program for the Košice Region of Slovakia unanimously on February 19, 2021.

Košice, April 19, 2021