LANDSCAPE RESTORATION TO MITIGATE AND ADAPT TO CLIMATE CHANGE

Messages from the SIM4NEXUS transboundary case covering the Czech Republic, Slovakia and Eastern Germany

SIM4NEXUS

Water, land, food, energy, and climate are interconnected, comprising a coherent system (the 'WLEFC nexus'), dominated by complexity and feedback. Putting pressure on or solving problems in one part of the nexus may create impacts in one or more of the others. Management of the nexus is critical to securing the efficient use of our scarce resources. SIM4NEXUS aims to assess long-term society-wide **impacts of resource use and policies** in the above-mentioned sectors. Models were developed and policy coherence within the WLEFC nexus was investigated in **twelve cases: global, Europe, Greece, Latvia, the Netherlands, Sweden, Andalusia (Spain), Sardinia (Italy), South West England (United Kingdom), Azerbaijan, two transboundary cases covering the Czech Republic, Slovakia and Eastern Germany and the upper-Rhine basin in Eastern Germany and France**.

Figure 1. The national, regional and transboundary SIM4NEXUS cases, including the transboundary case covering the Czech Republic, Slovakia and Eastern Germany.

Landscape degradation causes heat waves and droughts

The increase in the average temperatures in the Czech Republic, Slovakia and Eastern Germany has been higher than the global average and, in some regions, it rose by 3.5°C between 2000 and 2020. In addition to climate change caused by emissions of greenhouse gases, **mismanagement of the landscape has caused overheating, water losses and increased carbon emissions from degraded soils. The landscape has been drying out.** In the last decade, production of feed crops decreased, fishponds repeatedly did not fill up and deeper wells were drilled both legally and illegally. Shortage of water has become a serious problem in agriculture, forestry, inland fishery and rural areas. Big cities were supplied with water from large water reservoirs. There was a shortage of water in rivers, minimal flow rates could not be kept, the water consumption by the industry was limited during the summer in some regions and shipping on the river Elbe between Germany and the Czech Republic practically stopped.

Landscape degradation in the Czech Republic, Slovakia and Eastern Germany can be considered a 'WLEFC nexus' problem. It was caused by historical developments in agricultural practices and land ownership, leading to large farms and plots. This situation has grown worse intensified by actual European and national agriculture and energy policies, with effects on land, water, climate mitigation and adaptation. The Czech Republic and Slovakia are among the countries with a high percentage of large farms or firms which receive direct payments under the Common Agricultural Policy (CAP). Large farms that receive CAP payments are also common in Eastern Germany. European and national renewable

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energy policies stimulate the large-scale cultivation of bioenergy crops, such as maize and rape. Good Agricultural and Environmental Conditions (GEAC) and Greening measures that are part of the CAP first pillar have only been partially implemented and did not lead to the expected results. Only a few farmers signed up for voluntary measures for sustainable agricultural land use under the second pillar of the CAP because of the administrative burden.

Restoring the landscape for climate change mitigation and adaptation

The case Eastern Germany-Czech Republic-Slovakia has been focusing on the impact of large drained agricultural fields and large sealed urban areas on the water regime and the air temperature, looking at the distribution of solar energy. This resulted in a **passionate plea for paying more attention to the role of land cover changes in the local and regional climate change and carbon sequestration**. Water retention and support of permanent vegetation may cool down the land relatively soon, with higher primary production and carbon accumulation in the recovering soil.
The **European Green Deal** communication (EC, 2019) addresses the Commission's proposal for the **EU Common Agricultural Policy 2021 to 2027**, stipulating that **at least 40% of its budget would contribute to climate action**. Also, the Green Deal communication mentions that ecosystems help regulate the climate and it **promotes nature-based solutions**. **These two policy intentions mentioned in the European Green Deal communication will become reality in landscape restoration as proposed by the transboundary SIM4NEXUS case Eastern Germany-Czech Republic-Slovakia.** Where feasible and useful, landscape restoration should become part of obligatory conditions for direct funding or voluntary measures in Rural Development Programmes of the new CAP. Also, the EU Renewable Energy Directive should pay attention to landscape degradation caused by the cultivation of bioenergy crops.

Treasure up rainwater

Rainwater is the driving force of ecosystem recovery, atmospheric CO_2 reduction and thermoregulation of the landscape. This rainwater is currently rapidly flowing into rivers and seas, causing peak flows without benefit for the land. Measures to retain rainwater in the landscape are based on the principle of slowing down the flow of rainwater from higher to lower places, to allow it to infiltrate and replenish the groundwater. In this way, it can form a water buffer that feeds the base flow of rivers and streams during dry seasons. Measures include restoring natural courses of streams, wetlands, patches of forest and rows of trees, and constructing terraces, ponds, small dams in streams, gullies and balks perpendicular to the slopes. By retaining rainwater in damaged ecosystems, the renewal of vegetation begins, carbon sequestration, soil and groundwater reserves improve, springs are renewed, water vapour is increased and solar energy is transformed into latent heat that is transferred to higher, cooler layers of the atmosphere. There, at the dew point, this latent energy is transformed into sensible heat. The generated rainfall returns to the ground and feeds the ecosystems, stimulates vegetation growth, carbon sequestration and thermoregulation in the landscape (Figure 2). Clouds reduce the entering of solar radiation. This functional model can be quantified and implemented at the individual, local, regional and global levels.

From programmes to action: landscape restoration in the Košice Region

Several conferences and meetings about landscape restoration were organised in the past years, in which representatives from regional governments, municipalities, research institutes and stakeholders -environmental NGOs, farmers and landowners- participated from the Czech Republic, Slovakia and Eastern Germany. Here, a programme was discussed to support pilot studies that aim at water retention in the landscape for climate change mitigation and adaptation. Since then, **a concrete programme of landscape restoration has been elaborated and approved in Eastern Slovakia and a similar one is being prepared for Southern Bohemia in the Czech Republic**. The 'Landscape Recovery Programme' for the Košice Region is being implemented (Košice self - government Region, 2018, Figure 2). Ideas and approaches were discussed with local communities and politicians. Forest owners, agricultural and urban landscape managers, and local and regional authorities have been convinced that spatial rainwater retention will restore ecosystem functions of the local landscape, and are willing to act on it.

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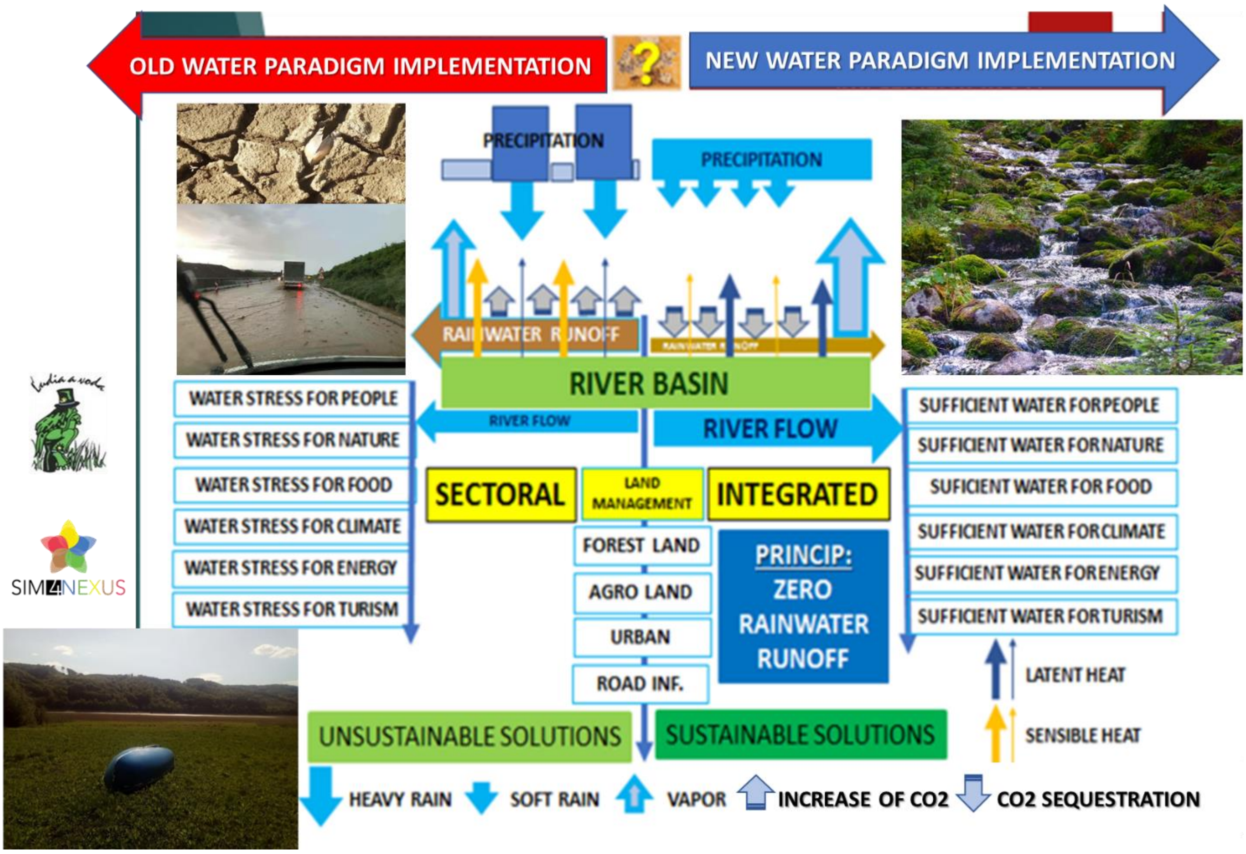

Figure 2. A New Water Paradigm for the Košice Region. Schemes of unsustainable and sustainable landscape management show the principal approaches (Kravčíková, 2020a).

Figure 3 shows the quantified expected positive effects of the Landscape Recovery Programme in the Košice Region in Eastern Slovakia on natural resources and carbon sequestration via primary production and retention in the soil. The return on the invested money is expected to be less than 3 years. This iwould be a concrete contribution of regional policy to climate change mitigation and adaptation in the Slovakian Region Košice. After implementing the whole programme, it is expected that (see Figure 3):

- production of sensible heat will be reduced by increasing latent heat,
- the temperature in summer heats will be reduced,
- 1.3 million tons of carbon will be stored in soil and vegetation,
- food production will increase,
- new water resources will be created,
- employment in rural areas will increase,
- biodiversity will increase.

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Impact of landscape restoration on the water cycle, agricultural production, temperature and carbon sequestration in the Slovakian Region Košice

Land use	Area of territory	Volume of rainwater retention by measures in the landscape	Investment in rainwater retention measures	Yield of new water resources in the springs	Increase of water vapour from the lands to the atmosphere	Increase of agricultural and wood production	Sensible heat reduction to the air	Expected decrease current temperature on heat days	Increasing carbon sequestration
	km3	mil. m3	mil. €	m3/s	mil. m3/year	mil. €/year	GWh/year	celsius	Tons C/year
Agricultural land	**2 040,34**	**20,6**	**102,813**	**4,113**	**13,718**	**30,605**	**9 596**	**- 2,4**	**408 070**
Vineyard	**29,58**	**0,3**	**1,490**	**0,060**	**0,189**	**0**	**139**	**- 2,4**	**5 920**
Gardens	**154,64**	**1,6**	**7,792**	**0,312**	**1,041**	**0**	**727**	**- 3,2**	**30 930**
Permanent grassland	**1109,44**	**11,2**	**55,905**	**2,236**	**7,442**	**10,650**	**5 218**	**- 4,0**	**221 890**
Forest lands	**2691,38**	**10,8**	**54,000**	**2,160**	**7,190**	**26,913**	**5 040**	**- 1,6**	**538 280**
Water lands	**163,76**	**0**	**0**	**0**	**0,000**	**0**	**0**	**0**	**0**
Built-up areass	**344,58**	**9,5**	**47,554**	**1,902**	**6,339**	**0**	**4 438**	**- 7,3**	**68 920**
Road infrastruc.	**220,61**	**6,1**	**30,446**	**1,218**	**4,068**	**0**	**2 842**	**- 7,3**	**44 120**
KOSICE REGION	**6754,32**	**60,0**	**300,000**	**12,000**	**39,988**	**68,168**	**28 000**	**- 2,7**	**1 350 870**
NOTES		Increase water-holding capacity for rainwater harvesting	Total investment	Average over the year	Yearly average		Minimum reduction		

Figure 3. Expected changes in several quantities caused by landscape restoration in the Košice Region (Kravčíková, 2020b).

Scientific background

There is scientific evidence on the role of land use and land cover change in the distribution of solar energy, the water cycle, temperature dynamics, local and regional climate and carbon sequestration or emissions (Pielke, 2005; Pielke et al., 2011, Kravčík et al. 2008). Links between vegetation-cover and climate with a focus on forests and precipitation were reviewed by Sheil (2018). He appealed for a more intense study of the biology of evaporation, aerosols and atmospheric motion, as well as the processes that determine monsoons and diurnal precipitation cycles. He refers to the biotic pump theory formulated by Makarieva & Gorshkov (2007) and Makarieva et al. (2014), which explains how rainfall can be maintained within those continental landmasses that are sufficiently forested. Forest loss and landscape drainage can result in a switch from a wet to a dry local climate. Much remains unknown and multiple research disciplines are needed to investigate the effects of land cover on temperature dynamics, evapotranspiration and fluxes of sensible heat, and to improve the understanding of these mechanisms. Monitoring techniques have improved in the last decades and allow detailed studies and evaluation of the effects of land cover on temperature dynamics, evapotranspiration and fluxes of sensible heat. (Hesslerová et al., 2019). Such studies show that evapotranspiration is a powerful process to equalize the temperature and air pressure potentials, whereas sensible heat produced on drained overheated surfaces transports moisture high into the atmosphere and blocks the input of wet air from the ocean (Pokorný, 2019). Satellite pictures allow an exact evaluation of land cover and linked temperature changes, going back to the 1980s.

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