

How trees cool down towns in summer

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Introduction

In the temperate zone during a clear sunny day the income of solar irradiance is about 1000 W m^{-2} , which means that an area of 1ha gets up to 10 MW of solar energy. What happens with this energy depends on the availability of water and the type of land cover^{2, 5}. Most of the solar energy on dry surfaces is converted into sensible heat, which warms up the ground and the air above it³. In summer, temperatures of such surfaces can exceed 50°C . However, if the surface is covered by functional vegetation (and well stocked with water) 70 – 80 % of the energy can be dissipated through water evapotranspiration (the sum of transpiration and evaporation), which means conversion into latent heat, responsible for landscape cooling^{2, 6}. As a consequence of the cooling effect of evapotranspiration, the vegetation cover well supplied with water is substantially cooler than adjacent dry surfaces. This can be conveniently documented by means of thermo-vision⁴. The aim of this poster is to demonstrate how trees may work as a perfect air-conditioning system driven by the solar energy and using water. We present several IR photographs of towns with adjacent tree stands in South Bohemia (Czech Republic), which clearly illustrate how vegetation cover in urban areas have a substantial effect on the local climate.

A tree and its air conditioning capability

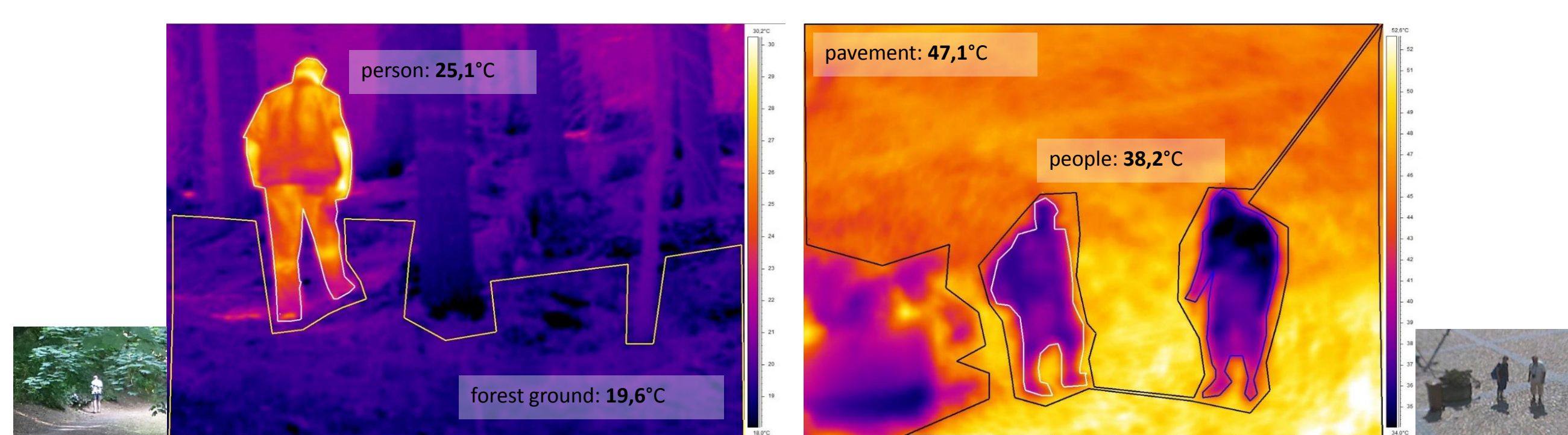


Fig. 1. The person standing in the shade of a tree in a park has a surface temperature of $25,1^\circ\text{C}$, while the lawn under the tree has only $19,6^\circ\text{C}$. Because the person is warmer than its surroundings it emits heat (long wave radiation) to cooler objects. In the contrary, a person standing on a pavement exposed to direct sunlight is about 10°C cooler than the surroundings. Sealed surfaces of towns are uninhabitable, reaching temperatures of 50°C or more.

Trees uptake water by their roots and the water then flows through the vessels in the trunk (sap) into leaves and evaporates via numerous stomata. A large tree can evapotranspirates several hundred litres of water vapour, using $0,7 \text{ kWh/L}$ of energy for conversion of liquid water into water vapour^{4, 5}. The cooling effect is a result of the use of large amounts of solar energy. This energy is later released in cool air or on cool surfaces, where the evaporated water vapour then condensates. In this manner, the evaporation and condensation processes have a double air-conditioning function - plant stands are cooled in the evapotranspiration process while the places where the water vapour precipitates are heated. Evapotranspiration thus possesses a huge capacity to equalize temperature differences in time and space¹.

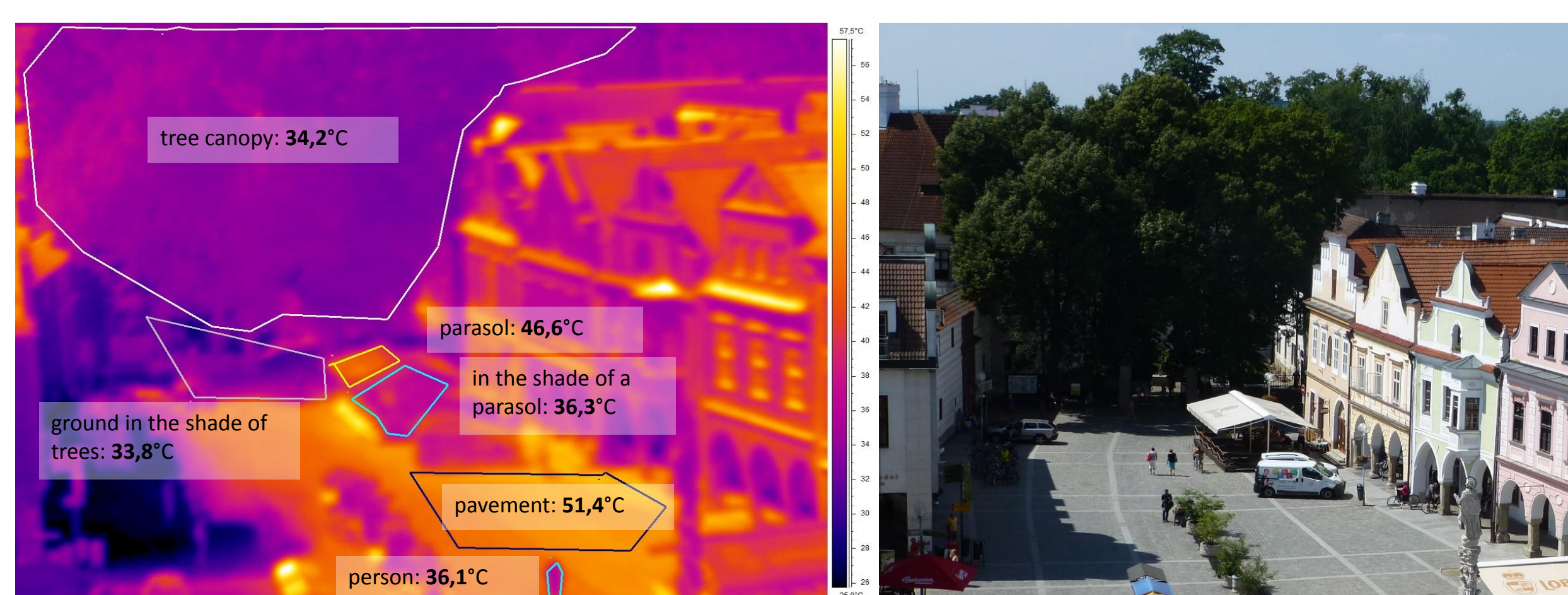


Fig. 2. Overall view to Třeboň town square taken from the tower on a sunny summer day. Sun exposed roofs and pavement have surface temperature of more than 50°C . Surface temperature of tall trees in adjacent park is $34,2^\circ\text{C}$. Temperature of a parasol in outdoor restaurant is $46,6^\circ\text{C}$.

The role of parks in towns

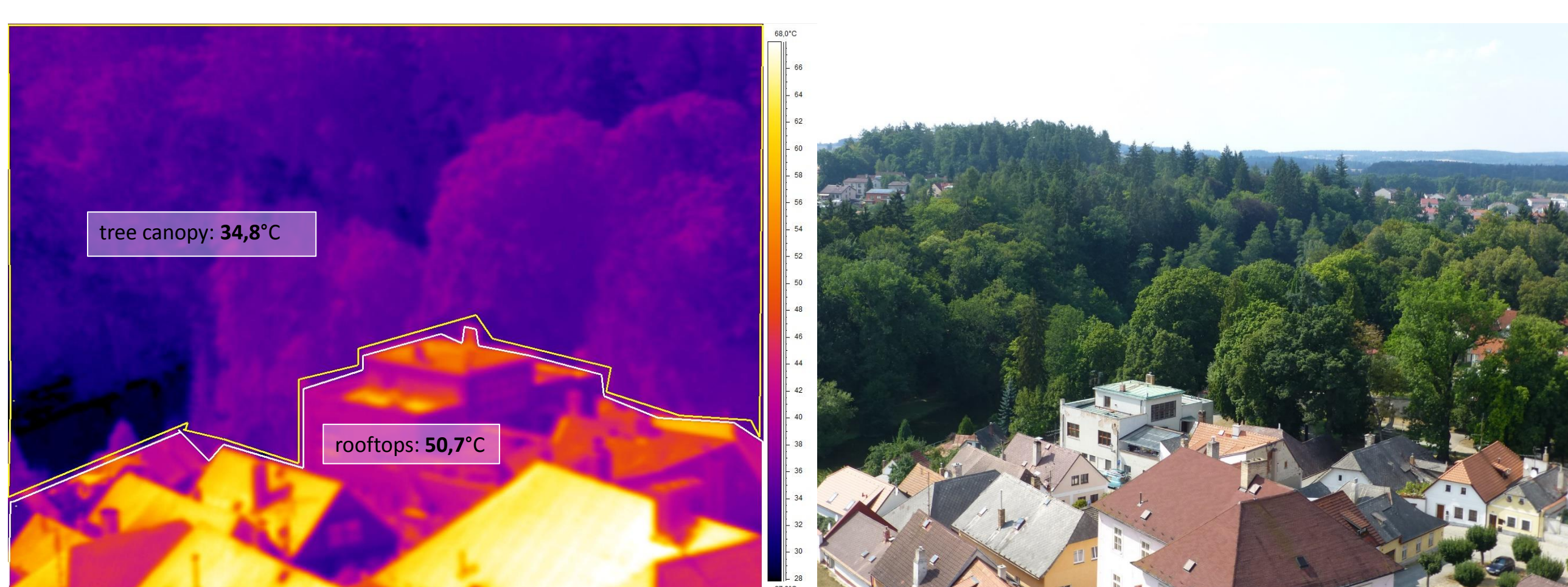


Fig. 4. Overall view to a part of Jindřichův Hradec town. Surface temperature of the trees in the park is about 35°C whereas the temperature of adjacent buildings is more than 50°C . The trees from the park the size of 1 ha cool with the efficiency of at least 3000 kW, which is equivalent to 1000 aircond units

Tree vs. parasol

What is the difference between the shade of a parasol and the shade of a tree? A tree not only reflects solar radiation (about 20 %) but also actively cools by water evaporation. A parasol on the other hand only reflects solar radiation (about 23 %) and is thus not as successful in cooling as the tree is. Therefore, a person sitting under the tree feels nice and cool whereas a person sitting under a parasol receives heat from the warmer surroundings.



Fig. 3. A parasol over a person in a restaurant has a temperature of $51,3^\circ\text{C}$ while the temperature of the tree crown is only $32,7^\circ\text{C}$. The area under the parasol is still quite hot, reaching a temperature of $36,3^\circ\text{C}$ (see also Fig. 2), whereas the lawn in the park has only $24,1^\circ\text{C}$.

Conclusion

Vegetation well stocked with water has a significant cooling effect and air-conditioning capability³. Therefore, it is essential to bare its capacity for dissipation of incoming solar energy in mind - not only when managing the landscape in larger perspective, but also when making plans for rearrangments in the urban areas.

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