Predicting Maps of Green Growth in Košice

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Abstract. The paper deals with the changing of the traditional roofs in the city of Košice into green roofs. Possible areas of city housing estates, after taking into account the conditions of each of them (types of buildings, statics of buildings), are listed in the paper. The research is picturing the prediction maps of Košice city from 2017 to 2042 in 5-years interval. The paper is a segment of a dissertation work focusing on changing traditional roofs into green roofs with the aim to retain water, calculate the amount of retained water and show possibilities how to use this water.

1. Introduction
Košice (48° 43’ 16” N 021° 15’ 29” E) city is located in the Košice region, the Abov region. It lies on the both sides of the Hornád River. The city lies in the eastern part of Slovakia in the Košice region, near the border with Hungary (20 km), Ukraine (80 km) and Poland (90 km) in the intersection of historic trade routes. The area of the city is 244 km² and the number of population is 234 237 inhabitants, according to the population count from 2007, [1].

2. Relief
Three geomorphologic units are presented in the cadastral area of Košice. Major part of Košice is located in Košická kotlina. Volovské vrchy and Čierna hora affect only the north-western part of Košice. The highest point in the territory of Košice is Vysoký vrch (851 m.a.s.l.) in the mountains of Čierna hora. The city centre lies with an altitude of about 200 m.a.s.l. Plains and hills (Košická kotlina) dominate the territory of Košice. In the west and northwest, Čierna hora and Volovské vrchy are situated. The city is surrounded from the east by neo-volcanic mountains Slanské vrchy [1].

3. Relief
The town belongs to the basin of Hornád River.

The major river flowing through the cadastral territory of Košice is Hornád River. Hornád rises in the Low Tatras under Kráľova hoľa. In Hungary, near Miskolc city it flows into the Slaná River. Origin of the river is characterized by a rain-snow runoff regime. The highest rate of flow is in March and the lowest in April. Košice city is characteristic with its north - south direction. The largest tributaries of Hornád River in the Košice are Čermel’ stream and Myslavský stream. Ida River flows from north to the south through the urban neighbourhood Šaca (in the western part of the Košice city). Torysa and Olšava flow into Hornád River in the south of Košice. Flood protection of the city provides dam Ružín situated at the Hornád River.
4. Climate and weather

Košice as well as the entire territory of Slovakia lies in the temperate climate zone characterized by the alternation of four seasons. Warm zone and temperate zone represent two of the three main climatic zones of Slovakia. Košická kotlina and lower areas of the mountains belong to the warm climate. Mountains in the north-western part of Košice belong to the temperate areas. Warm zone has an average of 50 or more summer days per year (the daily air temperature maximum is over 25 °C). Temperate zone has an average of less than 50 summer days per year [2].

The climate is moderately warm with average temperatures of -3°C in January and 19°C in July. The average air temperature in Košice reaches 8.4 to 8.7°C. The temperature distribution depends on the altitude. With an increasing altitude, the air temperature drops. Rainfall is increasing with an increasing altitude. Average annual precipitation reaches 600 - 700 mm annually in the planar areas and 700 - 800 mm in the mountains. The north-south orientation of Košická kotlina is the most important factor in shaping the direction of flow, resulting in northerly winds. The southern part of Košická kotlina is open and fairly windy. Part of the city of Košice, particularly Hornád valley and ridge of the surrounding hills are very windy. Strong winds (wind speed of more than 10.8 m/s) occur 80 days in year [2].

5. Housing estates

Approximate areas of roofs on blocks of flats representing eventual change in future are pictured in Figure 1, 2, 3, 4, 5, 6, 7 and defined in Table 1 [3,4,5,6]. These areas are calculated using Map client ZBGIS ®Geodesy, Cartography and Cadastre Authority of the Slovak Republic, Municipal plan of Košice city from UHA (Útvar hlavného architekta, Department of chief architect) and data of newspaper Denník N [7].

| Housing estate          | Roof area / m² |
|------------------------|----------------|
| Dargovských hrdinov    | 85.121         |
| Košice Juh             | 82.381         |
| Nad Jazerom            | 75.358         |
| Košice Sever           | 85.762         |
| KVP                    | 80.248         |
| Sídlisko Ťahanovce      | 87.313         |
| Košice Staré mesto     | 62.85          |
| Šaca                   | 16.51          |
| Košice Západ           | 186.4          |
| TOTAL ROOF AREA        | 761.943        |
| 10% of the roof area in m² (elevator shafts, attics, air shafts) | 76.194 |
| Net total roof area on housing estates in KOŠICE | 685.749 |
Figure 1. Current stage of green areas in Košice (02/2017)
Figure 2. Predicting map - redesigning roofs in Ţahanovce and Furča (02/2022), Nad Jazerom and Juh (02/2027)
Figure 3. Predicting map - redesigning roofs in Západ and KVP (02/2022) and Sever (02/2037)
Figure 4. Predicting map - redesigning roofs in Staré mesto (02/2042)
6. Conclusions
Ecologically balanced housing estate area is an area with 40 – 60 % green areas. Detailed description of housing areas in Table 1, [3-7] shows how many square meters could be changed into green. Taking into account the change of traditional roof into green roof might raise a number of green area and nature area in each city district. The paper is a part of ongoing doctoral research focusing on green roofs in the city and their qualities in terms of retention. This paper is a partial outcome of work that will have a conclusion leading to designing "perfect" green roof for each housing estate in Košice. Each construction will be fitting specifically into housing estate and changing the environment exactly the way, how it should change it. Lowering the temperature, humidifying the environment and retaining water are the main goals of this doctoral research.

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