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NEW TECHNOLOGIES FOR SUSTAINING DEVELOPMENT IN INFRASTRUCTURE, LOGISTICS AND CONSTRUCTION INDUSTRY

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Abstract: Infrastructure, transport and the construction industry belong to a potentially significant polluted environment. However, the current development of technologies and materials in the construction industry gives the possibility to eliminate the negative effects of transport and construction. Designing and building green buildings can significantly improve the environment and reduce the environmental footprint of transport, logistics and construction. This research discusses the issue and possibilities of new progressive technologies implemented in the construction industry for the needs of sustainable infrastructure, logistics and construction. The paper details the possibilities of green roofs, their advantages and impact not only on the construction industry, but also on infrastructure and transport in general. The aim of the paper is to specify these technologies and possibilities from the theoretical point of view.

1 Introduction

In general, the construction industry, logistics, infrastructure and transport can to a large extent pose a potential risk to environmental pollution [1]. Transport and infrastructure can have a significant negative impact on the environment [2]. Rail transport is one of the potential polluters in this area [3]. The automotive industry can also contribute to the ecological footprint. Electromobility can be one with solutions to combat it [4]. The elimination of the ecological footprint should already be considered in the urban design [5]. There are many possibilities in the construction industry to implement the so-called. green solutions. Implementing green solutions in every industry is very important [1,6]. This issue is a very sensitive topic and its importance does not need to be emphasized. This research discusses the issue and possibilities of new progressive technologies implemented in the construction industry for the needs of sustainable infrastructure, logistics and construction. The paper details the possibilities of green roofs, their advantages and impact not only on the construction industry, but also on infrastructure and transport in general. The aim of the paper is to specify these technologies and possibilities from the theoretical point of view. Infrastructure, logistics, urbanism and the construction industry have much in common. It is the solutions for the design and construction of green buildings and roofs that can be one of the solutions to achieve environmental sustainability while reducing the environmental footprint.

One of the generally accepted indicators of sustainable development is ecological footprint. Ecological footprint is an artificially created unit for measuring the impact of human activity on the planet and the environment. It determines the amount of square hectares of productive area needed to meet the needs of the population (growing food, absorbing waste, absorbing carbon dioxide emissions, etc.) [1,7].

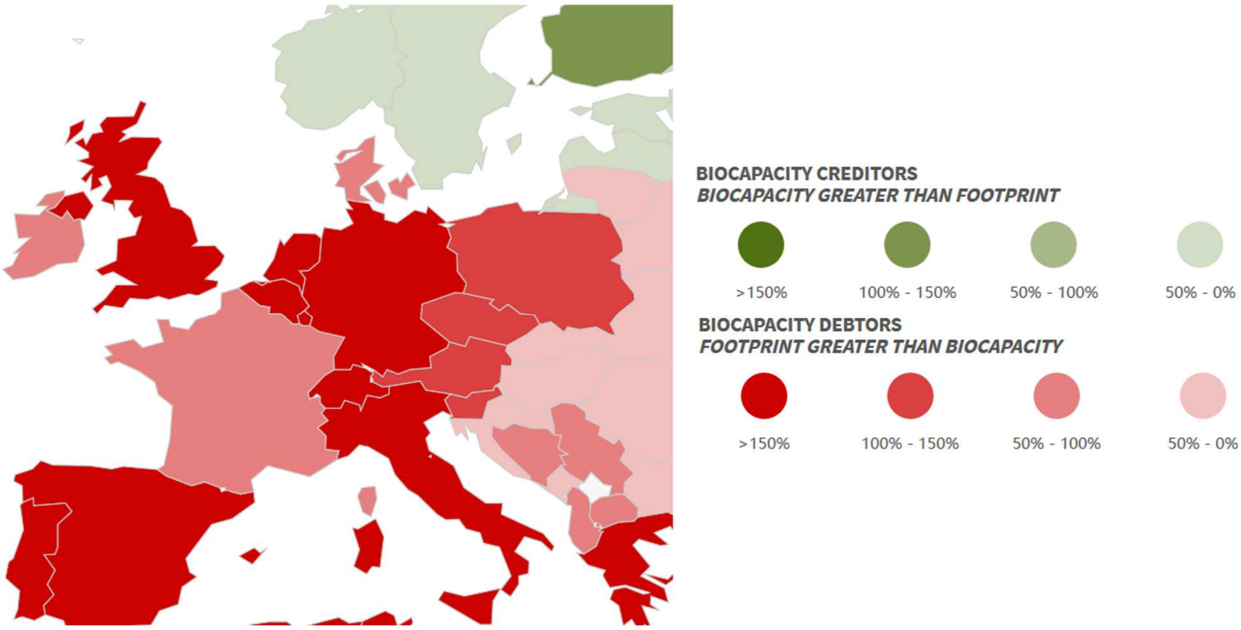

Figure 1 Ecological deficit / reserve, [7]

Of the entire productive surface of the earth, there are an average of 1.7 global hectares (gha) per person. At present, the average ecological footprint of one person has reached up to 2.8 gha, which means over 64% of the Earth's biologically productive capacity [8,9]. In the figure (Figure 1) we can observe the ecological deficit (red colour), respectively. ecological reserve (green colour) of individual states of the European Union. A national ecological deficit occurs when a given country imports biocapacity through trade, respectively. It emits carbon dioxide emissions into the atmosphere.

Data of the last measurement in 2016 (according to [7]) point to 3 gha of total biocapacity in the Slovak Republic, but the ecological footprint is 4.2 gha per person. There is an environmental deficit of 1.2 gha in Slovakia. However, this deficit has been on a downward trend since 2008 (Figure 2).

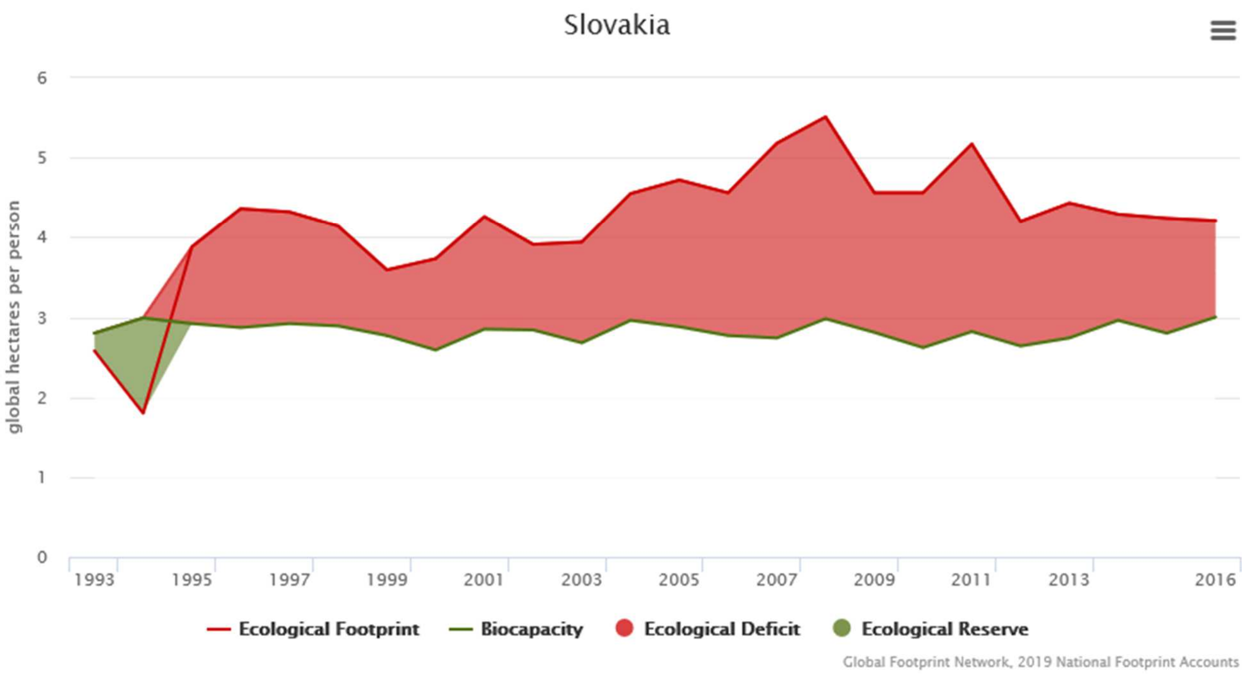

Figure 2 Slovakia - ecological deficit/reserve, [7]

In November 2018, the European Commission presented a long-term strategy to meet the targets for reducing carbon emissions in various sectors to prevent climate change, namely the Emissions Trading System for industry. According to [10], these measures aim to reduce industrial emissions by 43% compared to 2005. However, sectors such as transport, agriculture, buildings, waste management, etc. they produce almost 60% of total emissions in the European Union. The European Commission also aims to reduce these levels by 30% by 2030 compared to 2005. Another, non-important EU objective is to prevent emissions from deforestation, as forests can absorb more than 10% of EU emissions and greenhouse gases [10].

2 Green roofs, infrastructure and construction industry

Buildings are one of the largest environmental polluters. Currently, buildings spend up to 70% of electricity generated, 12% of water and produce almost 70% of all waste and more than 30% of greenhouse gas emissions [11]. This upward trend is related to the constant growth of the global population and the related urbanization and industrialization. The lawns gradually change to impermeable surfaces, roads, roofs. One of the first significant changes in grassland decline is a change in the hydrological status of the river basin, which causes changes in river flows, increased floods in cities [12], soil erosion [13], or increased pollutants in runoff [14]. The study [15] points to the link between increasing urban development and declining natural replenishment of groundwater in the area. With climate change and the occurrence of more frequent heavy rainfall, there is an increasing demand for more efficient rainwater logistics in cities, [16].

2.1 The benefits of green roofs

Designing and building green roofs, which have several benefits, is becoming one of the most advantageous solutions in solving these problems in cities:

- absorption of carbon dioxide,
- rainwater retention,
- reduction of rainwater wastewater,
- protection of the roof from UV radiation,
- protection of the roof against weathering (prolongation of the roof life),
- noise reduction inside the building,
- better thermal insulation properties of the roof,
- reducing heating and cooling costs,
- psychological and aesthetic effect,
- biodiversity creation.

The advantage of green roofs is that they are complementary to existing roofs. They consist of several layers (Figure 3): roof deck, water proofing membrane, insulation layer, root barrier, protection layer, drainage layer, filter fabric, growing media and vegetation.

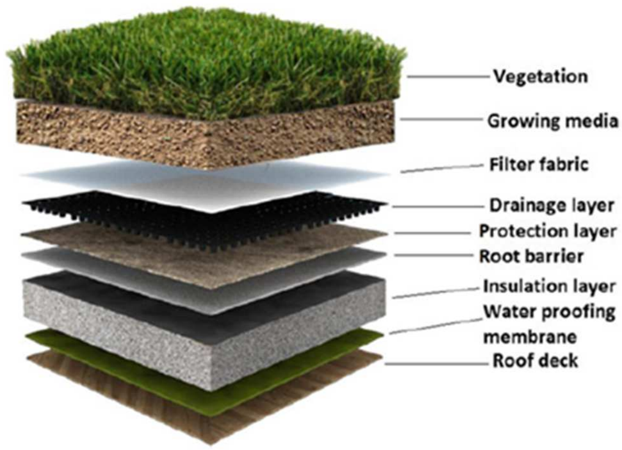

Figure 3 Components of green roof, [17]

2.2 Division of green roofs

Division of green roofs according to maintenance:

- **Extensive** – They require minimal maintenance, are lightweight and inexpensive, but have a low diversity of plants that are placed in a mixture of sand, gravel, clay and peat. However, these plants are resistant to extreme climatic conditions. Maintenance is only required twice a year.
- **Semi-intensive** – using light substrates, requiring more frequent maintenance of a denser and more varied growth medium.
- **Intensive** – are similar to a traditional garden. They require regular irrigation as well as maintenance and reinforcement of the roof structure.

In the Table 1 individual characteristics of extensive, semi-intensive and intensive green roofs are listed.

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Table 1 Characteristic extensive, semi-intensive and intensive green roof, [18]

Main factors	Extensive	Semi-intensive	Intensive
Vegetation	restricted selection of low growing, drought tolerant plants and hardy	grass, herbs, shrubs	trees, shrubs, herbaceous plants
Use of	ecological protection layer	designed green roof	park, garden
Substrate height	< 15 cm	15 – 50 cm	25 – 100 cm
Substrate depth	2 – 15 cm	15 – 50 cm	> 15 cm
Irrigation	no or little	periodically	regular
Weight	50 – 150 kg/m^2	120 – 200 kg/m^2	250 – 1000 kg/m^2
Available	inaccessible	partly accessible	accessible
Capacity construction	existing structures	additional structural support	additional structural support
Maintenance	extensive	periodically	intensive
Roof slope	up to 30°	flat, terrace	flat, terrace
Cost	low	medium	high

3 Environmental benefits of green roofs

3.1 *Noise reduction in buildings*

Last but not least, growth media are excellent sound insulators. Tests show a reduction in indoor air pollution by up to 10 dB. A classic roof reduces noise pollution by 32 dB, a green roof with a 12 cm substrate thickness by 40 dB and a green roof with a 20 cm substrate layer by up to 50 dB [19]. These results show that green roofs can be used mainly in areas with higher noise levels, such as flight halls, discos, etc.

3.2 *Energy consumption reducing in buildings*

In the past, green roofs were mainly used for their thermal insulation properties. Nowadays, their primary task is also to reduce the flow of energy between indoor and outdoor environments. According to a study [20], an overall annual reduction in energy consumption due to the construction of green roofs was noted by 66%. In another study [21], the authors describe that reducing the indoor temperature of a green-roofed building could reduce the cooling energy consumption by up to 8%. Articles [22-24] describe further reducing the cooling load of green-roofed buildings in Singapore, Minnesota and Toronto.

3.3 *Reduce stormwater*

One of the main tasks of green roofs is the retention of rainwater. The substrates either absorb rainwater or return it to the atmosphere via evapotranspiration. A study [25] has shown that through green roofs it is possible to reduce the volume of runoff rainfall by 60-100%. However, this percentage largely depends on the depth and composition of the substrate, roof slope, precipitation characteristics or climatic conditions. For example, in Germany, the authors of the study [26] reported that intensive green roofs showed a 65-85% decrease in annual rainfall runoff and a 27-81% reduction for extensive green roofs.

4 Urban air quality and green infrastructure

Today, more than half of the world's population lives in cities. Cities are constantly growing. According to [27], between 1990 and 2018, the population of medium-sized cities (cities with 1-5 million inhabitants) almost doubled worldwide, with an increase of up to 28% in these areas between 2018 and 2030, today 926 million to 1.2 billion inhabitants.

Air pollution from carbon dioxide (NO2) and other particulate matter (e.g. PM2.5) in these areas is one of the most common causes of death worldwide. According to [28], up to 3 million people worldwide die prematurely annually. On the one hand, as the standard of living increases, the demand for passenger cars is increasing, and on the other, cities must seek effective methods to reduce unwanted air pollutants and thus protect the population. The overall increase in passenger cars is estimated from 0.1 to 109 in 1960 to 1 to 109 in 2017. Also, the relative increase in the number of non-compliant diesel vehicles is another adverse factor in some countries [29,30].

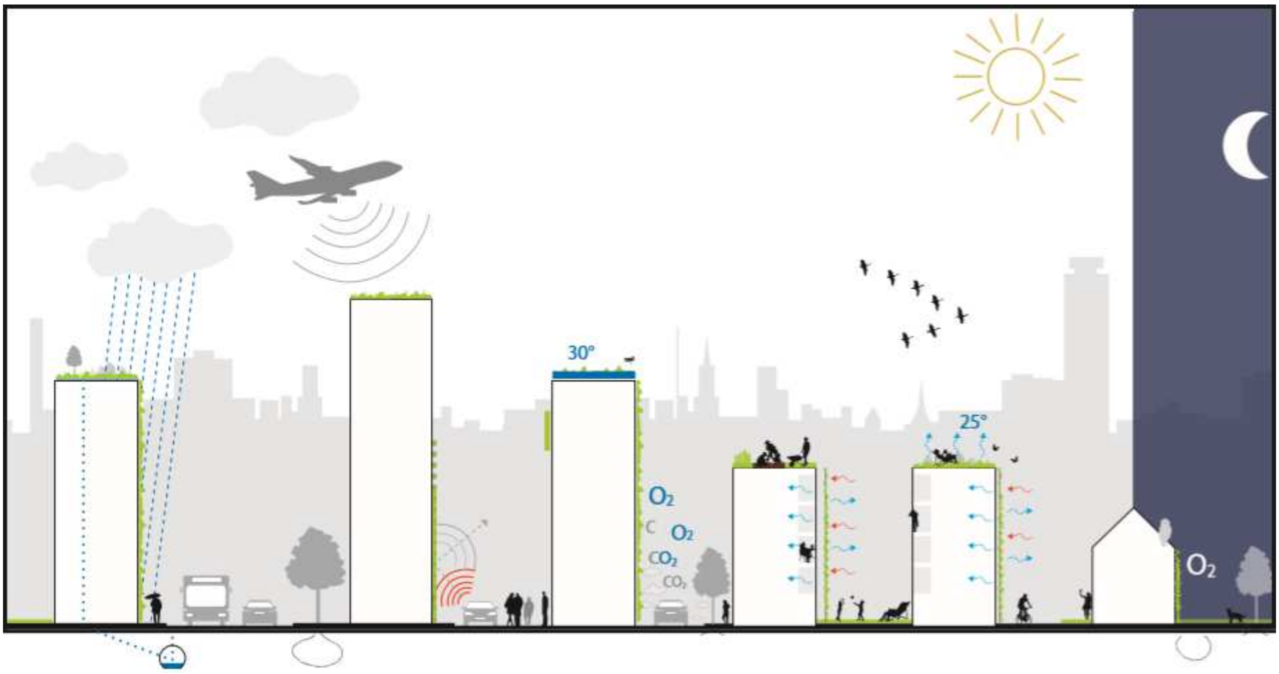

Figure 4 Benefits of green infrastructure [31]

One of the solutions to air pollution in cities is to build green infrastructure: parks, green roofs, green walls, etc. [30]. Figure 4 clearly points out the potential benefits of green infrastructure, which include, in addition to those described above, for example improving air quality, reducing the number of fine particles in the air.

Plants that are part of green roofs act as a filter for carbon dioxide, carbon monoxide, nitrogen oxides, sulphur dioxide and other harmful gases. In a study [32], the authors report that a 21-37% decrease in nitrous oxide and sulphur dioxide in the atmosphere can be observed with newly built green roofs. According to [33], some climbing plants (e.g. Hedera helix, Parthenocissus tricuspidata, etc.) planted as part of green infrastructure can bind up to 1.7 kg / m2 of fine airborne particles to their leaf surface.

However, preference for public transport, promoting environmentally friendly modes of transport (cycling, electric cars, etc.) remains the most effective way to improve air quality in cities, and to support the local economy, including the improvement of logistics and the distribution of food and materials to cities, urban logistics. freight transport, support for the domestic market and an overall change in urban transport for the sake of sustainability [34,35].

5 Conclusions

The ecological footprint of cities and densely populated areas is significantly higher than the ecological footprint of municipalities or sparsely populated areas. Thus, economically more advanced countries produce a higher percentage of emissions compared to less developed countries. With rapid population growth and rising living standards, the amount of impermeable surfaces in cities, dust particles and air pollutants, the amount of waste materials in the water, the amount of noise in cities, and vice versa, will probably increase in the future. One of the more efficient solutions that is increasingly being used is to build green infrastructure in cities and thus reduce the adverse impact of the urban climate on the population. It seems that in this economically advanced world, man as an individual does not have the opportunity to change, respectively. Reduce the percentage of air, land, water, etc. However, only the individual can begin to make changes for the benefit of the whole community and thus change the thinking, lifestyle and worldview in their surroundings. One of these, for the individual undemanding life changes, can also be the creation of a green roof on their dwelling.

Indeed, infrastructure, logistics and construction can pose a risk of increasing the negative impact on the environment. Green roofs are one of the solutions to eliminate the negative impacts of transport, logistics, infrastructure and construction.

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