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ADVERSE AND BENEFICIAL EFFECTS OF WOODY BIOMASS FEEDSTOCK PLANTATIONS ON BIODIVERSITY AND WILDLIFE HABITATS

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Woody biomass feedstock is suitable for direct combustion, gasification, pyrolysis, ethanol or methanol production yielding heat, charcoal, pyrolysis oil, green electricity and bio-propellants. However, there are several issues concerning the environmental, social and economic sustainability of woody biomass production connected to land use, protection of wildlife habitats, conservation and remediation of landscapes. Establishing energy plantations on arable lands or on grasslands is generally considered as working against nature conservation, while setting them up in polluted areas or wastelands could be advantageous for wildlife, because of 1. more permanent cover that provides shelter and biomass for feeding, which is especially important in winter periods; 2. higher architectural complexity of vegetation providing more place for nesting and feeding for wildlife; 3. exploiting the advantages of root filtration, phytoremediation, or using less chemicals; 4. forbs in the undergrowth and young shoots able to provide better quality food for wildlife than the intensive monocultures. The solution is a complex management system, including land use, phytoremediation, waste and wastewater management and ecosystem-based planning incorporated in one dynamic structure.

Keywords: biomass production, biodiversity, phytoremediation, wildlife habitats, agroforestry, short rotation forestry (SRF), short rotation coppicing (SRC), polycyclic arboriculture

Energy production and use are realized at several levels: we can talk about local, regional, national and global energy systems and their location in natural terrestrial systems linked and interrelated to biogeochemical cycles, which are often altered by human activities. The production and use of renewable energy (with particular emphasis on bioenergy, solar power, wind and geothermal energy) is the key for all aspects of sustainability, including economic viability.

Agricultural lands occupy 37.4% of the earth's land surface (https://data.worldbank.org/indicator/AG.LND.AGRI.ZS). Agriculture and agriculture-related activities account for 44.4% of methane (https://data.worldbank.org/indicator/EN.ATM.METH.AG.ZS/) and 70% of global anthropogenic nitrous oxide emissions (https://data.worldbank.org/indicator/EN.ATM.NOXE.AG.ZS). The best way to reduce these greenhouse gases is the substitution of fossil fuels for energy production by agricultural feedstocks (e.g. crop residues, dung and dedicated energy crops). In agriculture it is possible to establish combined production structures, which include organic, chemical-free crop production, the use of bio-energy plantations and other dedicated energy crops as biological filters, the application of biologically cleaned waste water, free from heavy metals, as crop nutrient through irrigation and the use of waste water sludge and fermentable organic waste for production of biogas and, if sufficiently purified, biosolids as plant nutrients. Dedicated bio energy crops may increase the soil carbon sequestration, hereby contributing to the reduction of global warming (McCalmont et al., 2017). In this way, complete ecological cycles can be created, which utilize all energy sources in optimal ways and minimize solid waste production. The economics, environmental impact and the social acceptance of the practical aspects of ecosystem approach are indispensable for the energy management of these energy systems at different scales and these must be taken into consideration when planning regional development projects. Bioenergetics plays an important role in circular economy that forms the basis of a sustainable society, based on the renewable energy – finished product – zero waste system and sustainable use of ecosystem services. The operation of this system is ensured by the environmentally conscious production of commodities based on life cycle assessment (LCA), waste management focusing on recycling and waste to energy programs. It is important to take into consideration the principle of plurality in the use of renewable energies, which requires the complementary use of these types of energy not only for economic, but also for environmental and energy security reasons (Sovacool and Murkherjee, 2011; Némethy, 2018).

Bioenergy itself is diverse and closely linked to agriculture, forestry, wastewater treatment, energy recovery from solid waste and industries (waste heat) and services producing organic, compostable waste. Biomass supplies an increasing share of electricity and heat and continues to provide the majority of heating produced with renewable resources. Trends of using biomass include increasing

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consumption of solid biomass pellets (for heat and power use) and use of biomass in combined heat and power (CHP) plants and in centralized district heating systems. Due to the aforementioned complexity and limitations of bioenergetics, biomass production should be combined with other renewable energy sources such as geothermal energy, solar cells, wind turbines, hydroelectric power plants and non-polluting high-tech waste incinerators (Némethy, 2018). It can also be the key to solving the "energy trilemma"[1]. In a holistic and integrated food and energy system there is no conflict between bioenergy production and food supply; the ecological footprint is sufficiently small. A transition is needed from fossil fuel centred, ineffective and inefficient societies to the ecologically and economically viable, recycling society. Technological developments (in conversion, as well as long-distance biomass supply chains such as those involving intercontinental transport of biomass-derived energy carriers) can dramatically improve competitiveness and efficiency of bioenergy (Hamelinck et al., 2004; Faaij 2006).

Shortage of natural wood is a common problem in different countries – particularly for forest industries in developed countries and for fuel production in developing countries. The agricultural expansion of the last decades resulted in deforestation and forest degradation and the illusion of economic development, seemingly benefiting billions of people in a short term and causing severe environmental and social problems for future generations. The rapid expansion of agriculture for food, fuel and other products has resulted in significant greenhouse gas (GHG) emissions. An estimated 4 to 14 per cent of global GHG emissions are associated with deforestation and degradation, making agriculture a major component of the human factors of global climate change mitigation efforts (Vermeulen et al., 2012). It is therefore critical that we fully understand the relationship between the development of the agriculture sector and its impact on forests and propose appropriate integrated solutions. Fast growing woody bioenergy plantations can produce large quantities of biomass in a relatively short time. The raw material produced is suitable for direct combustion, gasification, pyrolysis, ethanol or methanol production yielding heat, charcoal, pyrolysis oil (biocrude), green electricity and bio-propellants. Current liquid fuels are produced nearly entirely from starch or sugars – mainly from corn, sorghum and sugarcane – and from oils extracted from soy, camelina and aquatic plants (for more comprehensive source, see, e.g., Busic et al., 2018; Barnwal and Sharma, 2005; Cerveró et al., 2008, respectively). However, the importance of cellulosic materials produced from perennial grasses and trees is increasing even in the production of liquid biofuels. Woody biomass is usually used in form of pellets and wood chips for combustion in power plants, but there is a great potential for production of liquid biofuel, biochar and pyrolysis oils as well. Although woody biomass production is environmentally sustainable in terms of carbon dioxide emissions and low pollution, the impact of the expansion of this industry on wildlife habitats has not been sufficiently investigated so far. To determine possible wildlife impacts, a number of questions and scenarios based on the current status of ecosystems and the carrying capacity of ecosystem services should be taken into consideration. The most important factors include change of land use, the type of energy crop and the cultivation method:

1. The extent of land use change:
    a) replacement of natural vegetation by bioenergy crops,
    b) land reclamation – remediation, conversion of industrial land to agricultural land,
    c) change of managed forestry to intensive monoculture,
    d) the type of bioenergy crop produced.
2. The biodiversity status of the site.
3. The productivity of the site in terms of fertility, growing season and moisture.
4. The intensity and inputs of production.
5. The size and proportions of the landscape areas occupied by the feedstock.
6. The length of rotation cycles (frequency of harvest).
7. Wildlife species and communities currently occupying the site:
    a) size and dynamics of populations,
    b) conditions of survival,
    c) ecological advantages of invasive species induced by anthropogenic changes.
8. The direct impact on current or projected future wildlife habitats:
    a) complementation,
    b) improvement,
    c) change of habitat structure – having either adverse or beneficial effects depending on the current state of the habitats at the establishment of bioenergy plantations,
    d) elimination of habitats – adverse impact.
9. Willingness to trade some production potential for wildlife habitat conservation.
10. Potential to maintain elements of habitat structure (e.g. snags, buffers, etc.) on the landscape

Another important factor of biomass energy from FAO's point of view is that it creates a lot of jobs. By creating or improving rural infrastructure, it opens new opportunities. Also, it has a tremendous potential for rehabilitating degraded land, since several plant species are suitable for phytoremediation, and such a plant, if used for energy, has an added value. It makes land reclamation economically even more viable.

Short Rotation Forestry (SRF), Short Rotation Coppicing (SRC), Agroforestry and Polycyclic Arboriculture: agriculture or forestry? – ecological implications

The planting of woody energy crops requires thorough knowledge of the ecological conditions and the economic environment such as the mapping of the upstream market, which is essential for developing sustainable business strategies. It is safe to cultivate these plants where, within a radius of up to 50 to 80 km, the energy-producing sector that needs chips appears. Furthermore, the realistic estimation of possible trade-offs regarding environmental sustainability is important (e.g. the degree of biodiversity

1 The World Energy Council's definition of energy sustainability is based on three core dimensions – energy security, energy equity, and environmental sustainability – this is the "energy trilemma".

and the short-term efficiency of the cultivation methods). In addition to thermal power plants, more and more municipalities want to rely wholly or partly on biomass, which will provide a safe market for chips from woody plantations. Woody biomass production can be established in different forms, but not all of them can be considered as fully ecological structures, since their impacts on ecosystem services, habitats and landscape structure are different.

Short Rotation Forestry

Short-rotation forestry (SRF) is a fast-expanding sustainable silvicultural practice where high-density plantations of fast-growing tree species produce woody biomass preferably on low quality agricultural land less suitable for food production or on fertile but degraded forest soils. In SRF systems trees are cut when they reach a size of typically 10 to 20 cm diameter at breast height, which usually takes between 8 and 20 years depending on the tree species and growing conditions. While short rotation coppicing (SRC) cuts the tree back to a stool to promote the growth of multiple stems, on a regular cycle of roughly 2–4 years or sometimes every year, SRF makes it possible to practice something more closely akin to conventional forestry, though on a shorter timescale (Facciotto et al., 2014). Thus, the timescale of the production is between SRC and conventional forestry, which has several ecological advantages; even if the short-term biomass production is lower than in intensive SRC systems. This has the effect of retaining the high productivity of a young plantation, but increasing the wood to bark ratio. Applying similar techniques to sustainable conventional forestry practices, it is currently proposed that only the stem wood would be removed from the site, while the bark stripped during harvesting together with other residues should be left on site to return nutrients to the soil preventing soil depletion. Greater attention to SRF could offer a way to provide forest industries with enough wood resources and people in the developing world with enough fuel, while conserving natural forests (Christersson, 2005).

Short Rotation Coppicing

Fast-growing tree species can be cut down to a low stump (or stool) when they are dormant in winter and start producing many new shoots in the following growing season. Short rotation coppicing (SRC) is an intensive and well controlled cultivation method for production of woody biomass and has a rotation period of about 25 years and with an annual woody production of at least 10 metric tonnes of dry matter or 25 cubic meter per hectare, depending on the species and growing conditions (Table 1).

This system has been developed to provide large-scale biomass production instead of conventional forestry, where due to economic and ecological difficulties in creating optimal water and nutrient conditions, competition from herbaceous plants and other tree species and biotic and abiotic damage are serious threats for the entire growth and, therefore, the biomass producing potential of conventional forestry is not sufficiently utilized. Ecologically, SRC cultivations are closer akin to arable farming than to conventional forestry. Many species and varieties are suitable for providing biomass for energy purposes, but in practice, few species can be selected for the establishment of SRC energy plantations. The main criteria for bioenergy plants include high rate of growth, good frost tolerance, simple and economical reproducibility, high adaptability, disease-resistance to pests and easy harvesting. The three most successfully used trees for SRC systems are willow (*Salix* sp.), poplar (*Populus* sp.) and black locust (*Robinia pseudo-acacia* L.); other trees include eucalyptus, alder (*Alnus* sp.), ash (*Fraxinus* sp.), and birch (*Betula* sp.).

Willow is the most commonly used tree in SRC plantations for energy in Europe due to a number of advantageous properties such as fast growth and high yields, suitability for coppicing, wide tolerance of soil pH and structure (pH 5 to 7.5, from heavy clays to lighter soils, respectively), tolerance of highly anoxic (waterlogged) conditions and elevated nutrient and heavy metal concentrations (suitability for phytoremediation). Willow requires humid conditions and grows best in cool-temperate climate, but there are clones suitable for warmer climate conditions such as Eastern and Central Europe.

Poplar is the second most important woody plant grown for bioenergy in Europe (Elbersen et al., 2012). Its ecological preferences are different from willow, including areas with milder climates (e.g. Central and Southern Europe), sandier and drier soils due to lower water needs of poplar than willow. The plantations are less dense, and the rotation periods are substantially longer (10 to 15 years) than for the willow SRC systems. Poplars bloom early, well before

Table 1 Short rotation coppice (SRC) in Europe

Traits	Species		
	willow	**poplar**	**black locust**
Crop density stools per hectare	18–25,000	10–15,000	8–12,000
Rotation years	3–4	1–3	2–4
Avg. butt diameter at harvest (mm)	15–30	20–40	20–50
Avg. height at harvest (meter)	3.5–5.0	2.5–7.5	2.0–5.0
Growing stock at harvest (fresh metric tons per hectare)	30–60	20–45	15–40
Moisture content (%) of dry weight	50–55	50–55	40–45
Part of Europe (main cultivation areas)	Northern Europe, British Islands	Central Europe	Central and Southern Europe

Source: Proceedings of First Conference of the Short Rotation Woody Crops Operations Working Group, Paducah, KY, September 23–25, 1996 (modified) budding; wind pollinators. Their fruits develop rapidly, ripening 3 to 6 weeks after flowering. Due to the white cotton wool – like flyers, the seeds are able to spread on large areas by the wind. The flyer detaches itself from the seed soon after landing. On uncovered soil, in a humid environment, some poplar species germinate within 1 to 2 days. About 35 poplar species are known, which belong to the deciduous vegetation of the northern temperate zone. Despite the small number of species, it is a highly differentiated genus both morphologically and ecologically. Most poplars are fast growing pioneer species in the temperate regions and the arid regions of the subtropics, which mainly grow on the alluvial soils of riverbeds, flood plains and deltas. Close-range species are easily crossed and, therefore, so many natural and artificial hybrids are known, whose identification may be extremely difficult in many cases. The most widely cultivated noble poplar varieties are *P. deltoides*, *P. nigra*, *P. deltoides* × *P. nigra hybrids*, and *P. deltoides* × *P. trichocarpa hybrids*. Poplar plantations are less dense, and the rotation periods are substantially longer (4 to 6 or 10 to 15 years) than for the willow SRC systems.

Black locust (*Robinia pseudoacacia* L.), originating from the Eastern United States, was introduced to Europe during the 17^{th} century first as ornamental tree but later conquered vast areas by extensive plantations for timber production and by natural propagation mostly in central and south-eastern parts of Europe. Black locust is quite drought-resistant, nitrogen fixing, able to grow on bare soils under extreme conditions, which makes it ideal for soil regeneration and reclaiming former mining sites. It is fast-growing with good coppice ability after harvest, and its high wood density makes it very useful as SRC for bioenergy production. Even if black locust has invasive properties, the interest is increasing for *Robinia* SRC on agricultural land, especially in areas where land reclamation is required. In view of the recently emerging debate regarding the invasive character of black locust, its multi-purpose use must be emphasized, particularly as timber, bio-energy feedstock, raw material for pulp, as melliferous tree, an important plant for phytoremediation of both heavy metals and Polycyclic Aromatic Hydrocarbons (PAHs), soil improvement due to its nitrogen fixing ability, and even as a natural habitat – cover for wildlife, browse for deer and nesting place for birds (Szemethy et al., 2003; Mátrai et al., 2004). The economic viability of biomass production by black locust has been debated many times (particularly in SRC systems), but established in a multi-purpose, ecocycle-based agricultural system where its invasive character is carefully controlled and its usefulness is fully utilized (applying even clone selection for site-adaptation and best possible performance), both environmental sustainability and profitability should be guaranteed.

Eucalyptus is a genus of fast-growing tree species originated from Australia, which contains more than 700 species. This tree has been extensively planted in southern Europe and even in South Africa for pulp and paper production and its use for wood biomass is gaining interest not only in southern Europe, but also in higher latitudes e.g. in the UK and Ireland, where more cold-tolerant clones (*E. gunnii* and *E. nitens*) are being cultivated. *Eucalyptus* SRC plantations are traditionally planted in single-stem plantations in 3 × 3 meter distances (or similar) and harvested after 7 to 12 years for pulp production, but in some cases, particularly for energy feedstock, very short rotation of 2 to 4 years is applied, which resembles the willow coppice systems.

Agroforestry

Agroforestry is a complex land-use system in which woody perennials are deliberately integrated with crops and/or livestock on the same land-management unit either in a spatial mixture or in a temporal sequence. There are both ecological and economic interactions between the woody and non-woody components in agroforestry, which is based on four key features: competition, complexity, profitability and sustainability (Oelbermann et al., 2004). "Agroforestry is a dynamic, ecologically based, natural resource management system that, through the integration of trees in farm- and rangeland, diversifies and sustains smallholder production for increased social, economic and environmental benefits" (Leakey, 1996). Agroforestry practices can be divided into two groups – those that are sequential, such as fallows, and those that are simultaneous, such as alley-cropping (Cooper et al., 1996). The sustainable management of the competition between trees and crops for light, water and nutrients is the plant-physiological determinant of successful agroforestry systems. Simultaneous agroforestry systems are more susceptible to competition than sequential ones.

In agroforestry systems the requirement of fast growth is slightly less important than in SRC systems and this allows a greater diversity of trees and the non-woody components. This is particularly important regarding the functions of agroforestry and the possibilities to create new habitats and maintain or increase the biodiversity of agroecosystems. Using indigenous trees with high-value products in agroforestry systems enhances profitability, particularly those that can be marketed as ingredients of several finished products.

Polycyclic arboriculture – permanent polycyclic tree farms

The advantages of these artificial forests compared to intensive poplar plantations are addressed not only to technicians, farmers and ordinary citizens, but also and above all to regional and national political decision makers, who could focus on the development of these plantations that combine wood production and environmental improvement. These mixed plantation methods with valuable broadleaved species and poplar clones have been implemented both in tree farming plantations and in agroforestry systems (Facciotto et al., 2014). This type of tree farming is called "polycyclic plantation", which contains main crop trees, with different cultivation cycles, coexisting in the same plantation area with:

a) very short rotation trees for biomass production (SRCs);
b) short rotation trees for veneer production (poplar clones);
c) medium long rotation trees for timber and high quality veneer production (walnut and other valuable broadleaved species).

Higher biodiversity and species composition make polycyclic plantations more resistant to environmental stress and less demanding in terms of energetic input, they are innovative, and more sustainable than monocultures.

Connecting systems of woody biomass production and environmental management

Natural wastewater cleaning and irrigation with biologically cleaned wastewater

Short rotation forests, short rotation coppice plantations and even agroforestry are excellent objects for natural wastewater cleaning. Agricultural deployment of wastewater for irrigation is based on the value of its constituents, which are used as fertilizers. However, crop irrigation with insufficiently treated wastewater may result in health risks. Use of untreated sewage effluent for irrigation exposes the public to the dangers of infection with a variety of pathogens such as protozoa, bacteria and viruses. Thus, the benefit of wastewater reuse is limited by its potential health hazards associated with the transmission of pathogenic organisms from the irrigated soil to crops, to grazing animals and humans (Gupta et al., 2009; Qadir et al., 2010). Wastewater should satisfy some quality indicators such as chemical structure, availability of gases, content of organic substances and bacteria, muddiness, temperature, etc. Those indicators depend on salt tolerance of the cultivated crops, chemical structure and water permeability of the soil, drainage of the ground, characteristics of rainfalls, background content of heavy metals, meteorological and hydro-geological circumstances, irrigation technology, applied agricultural techniques, etc. The suitability of the treated water for irrigation can be determined on the basis of results from chemical analyses, vegetation and field experiments, as well as comparing various crops irrigated with clean and treated wastewater during a longer period of time (Panoras et al., 1998, 2003). Thus, biologically cleaned wastewater is a substantial resource.

Utilization of short-rotation forests as vegetation filters for waste products

This holistic system is strongly supported in Sweden (Perttu and Obarska-Pempkowiak 1998; Dimitriou and Aronsson, 2004). After biological cleaning, a simple sand filter system or other particle filters can remove particles – if needed – and low concentration of disinfectants will assure the appropriate water quality. This water should be almost entirely free of bacteria and can be used for irrigation. For the safety of public health and the protection of groundwater and surface watercourses and natural habitats the environmental legislation in all developed countries requires the thorough control and environmental consequence analysis as well as the systematic monitoring of the re-use of partially cleaned wastewater, which together with natural mineral-based soil improvement substances (Némethy, 2019) can maintain bio energy plantations without any other artificial fertilizers. Furthermore, the potential for phytoremediation should be taken into consideration, since waste products can also contain polluting heavy metals and organic pollutants, which some willow and poplar clones are able to absorb efficiently. When wood from this type of plantation is burned, heavy metals can be extracted from both the fly ash and bottom ash. However, this process is not yet economical, so today most of the ashes are deposited at safe city waste disposal sites.

Phytoremediation with woody plants combined with biomass production for energy

Phytoremediation is a fast developing and expanding environmental technology for contaminated soils, groundwater, and wastewater that is both low-tech and low-cost, defined as the engineered use of green plants (including grasses, forbs, and woody species) to remove, contain, or render harmless environmental contaminants such as heavy metals, trace elements, organic compounds, persistent organic pollutants (POPs) and radioactive compounds in soil surface waters and groundwater (Watanabe, 1997). There are several phytoremediation techniques with variable effectiveness depending on the biochemical and physiological properties of the plant and the pollutant.

Phytodegradation also known as phytotransformation, when pollutants or complexes are broken down to simple compounds and then transferred into the plant tissue, is the most effective technique against organic contaminants, including certain POPs (Watanabe, 1997), while phytoextraction and phytostabilisation are best suited to remove inorganic pollutants (e.g. heavy metals) but might be effective even for POPs (Gyulai et al., 2013).

Phytovolatilization, a process, in which plants take up contaminants from soil and release them as volatile form into the atmosphere through transpiration, and rhizofiltration, a technique of utilizing plant roots to absorb, concentrate, and precipitate pollutants (often toxic metals) from ground water or polluted effluents, are effective both with inorganic and even organic contaminants. Furthermore, the safe use of transgenic plants might be possible for detoxification of organic pollutants (Merino et al., 2008).

Thus, phytoremediation technologies involve processes, which are able to isolate, destroy, transport, and remove organic and inorganic pollutants from contaminated media (Echereme et al., 2018).

The landscape and ecosystem approach and the role of biodiversity in the cultivation of woody bioenergy crops – ecological and economic implications, impact on wildlife habitats

There are several issues concerning the environmental, socio-cultural and economic sustainability of woody biomass production connected to land use, protection and/or creation of wildlife habitats, conservation and remediation of wastelands and derelict cultural landscapes. These problems include the land use where biomass production is established instead of cultivating agricultural crops for food, the limited suitability of short rotation coppice (SCR) plantations as wildlife habitats and alteration of the structure and appearance of cultural landscapes (Némethy and Walas, 2016).

The Biodiversity – Ecosystem Function and woody bioenergy feedstock production

Willow, due to its wide ecological tolerance, ecophenotypic variability, large number of available species and clones, fast growth, and tolerance of environmental stress and certain similarities to grassland systems, in SRC systems creates suitable structures for testing the biodiversity-ecosystem function (BEF) theory (Weih et al., 2019), which often lacks a sound understanding and comprehensive interpretation of the complex mechanisms behind the observed patterns of diversity-productivity relationships. It is important to take into consideration the complete set of factors within each category of BEF components (Fig. 1). According to the BEF theory, levels of ecosystem functions (e.g., primary and secondary productivity, nutrient cycling, decomposition) and the stability of those functions depend directly on all levels of biodiversity, including diversity of all biota at the level of genotypes, species, and functional groups, which are considered as sets of physiologically or morphologically similar species. Ecosystem functions are conceived as a subset of ecological processes and ecosystem structures, which are typically estimated from measures of stocks such as plant biomass or crop nutrients, in response to vascular plant diversity.

While woody bioenergy plantations and some perennial feedstocks can improve soil quality and biodiversity, reduce greenhouse gas emissions and enhance water quality, some large-scale industrial models of modern biofuel production can negatively impact ecosystem services through the excessive use of synthetic fertilizers and agrochemicals, grassland conversion and deforestation (Pacheco et al., 2012).

Particularly serious concerns were raised concerning food security, especially in regions with widespread poverty, political uncertainty, and fragile agricultural systems, which are likely to be exacerbated with accelerating climate change (Brown and Funk, 2008). However, the right choice of bioenergy crops, the territory of cultivation and cultivation methods might counteract the harmful environmental and social effects of monoculture, particularly if connected to phytoremediation and soil improvement programmes often creating new employment opportunities. A number of studies have demonstrated, that there is considerable potential for increasing economically and ecologically viable bioenergy production even further, to meet a substantial fraction of future energy needs without compromising any aspect of sustainability (Smeets et al., 2007; Somerville et al., 2010). Thus, bio-energy development may offer developing countries many advantages, ranging from energy security to poverty reduction, infra-structure development and economic growth.

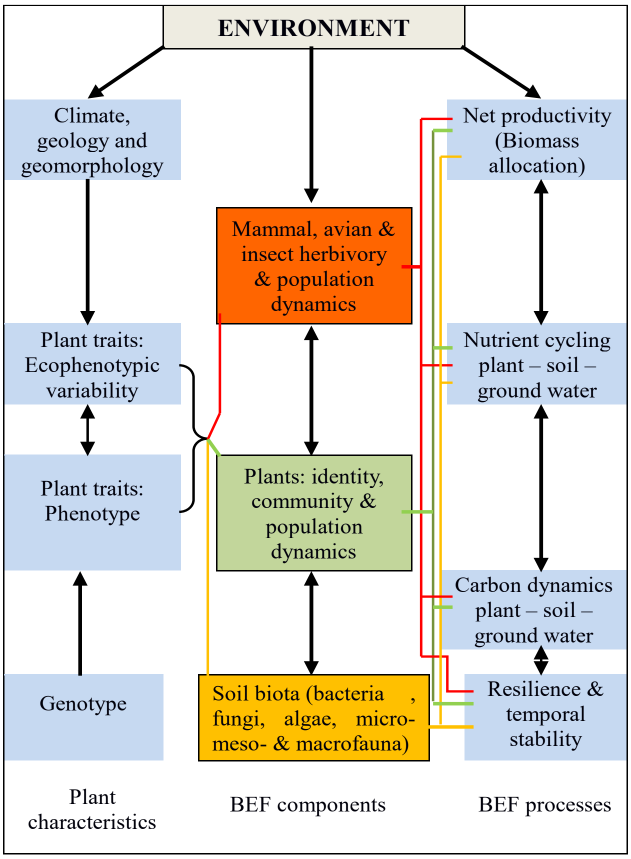

Figure 1 The most important relationships between plant traits and the biodiversity-ecosystem function (BEF) components and processes based on willow short-rotation coppice (SRC) systems. The BEF components are intimately connected to growth and productivity (green); mammal, avian and insect herbivory (above ground trophic interactions, red), and soil biota representing below ground trophic interactions (yellow)
Source: redrawn and substantially modified after Weih et al., 2019

Woody bioenergy crops, biodiversity and wildlife habitats

According to quite recent field experiments, species abundance in SRC plantations can be more heterogeneous than in arable lands and therefore, SRC plantations form novel habitats leading to different plant species composition compared to conventional land uses. Their landscape-scale value for biodiversity changes depending on harvest cycles and over time. As a structural landscape element, SRC plantations can positively contribute to biodiversity in rural areas, especially in land use mosaics where these plantations are admixed to other land uses with dissimilar plant species composition such as arable land, coniferous forest and even mixed forests (Baum et al., 2012). However, the ecological effects of SRC plantations are dependent on climate and soil conditions, the ecological preference of the cultivated main-crop species, rotation cycles, the species composition of the plantations, and the cultivation methods, including irrigation and nutrient supply and the degree of monoculture.

Regarding the effects of bioenergy crop cultivation on wildlife habitats, the conversion of natural ecosystems (e.g., forests, woodlands, grasslands) to ones dominated by crop monocultures is often associated with losses of wildlife habitat and biodiversity. Sustainable game management and forestry actively contributes to maintaining biodiversity. In natural areas where intensive wildlife management is practiced, it is important to maintain the natural ecosystem. Wildlife needs a natural habitat, a feeding, hiding and breeding ground. Therefore, game management can only be successful where these conditions are provided to the wildlife. This means that large areas of forests, diverse habitats with natural waters and sheltered areas, where free-moving wildlife can be maintained, should be preserved for this purpose. In traditional forestry and even in sustainable, organic cultivation of woody bioenergy crops such as longer rotation cycle plantations, agroforestry and polycyclic arboriculture, high energy crops, free of agrochemicals, provide an abundant source of food for animals. In these areas, of course, not only the wildlife to be exploited can find optimal living conditions, but every living creature that makes up the ecosystem (Fig 3). Such carefully managed hunting areas have much greater biodiversity. The number of species

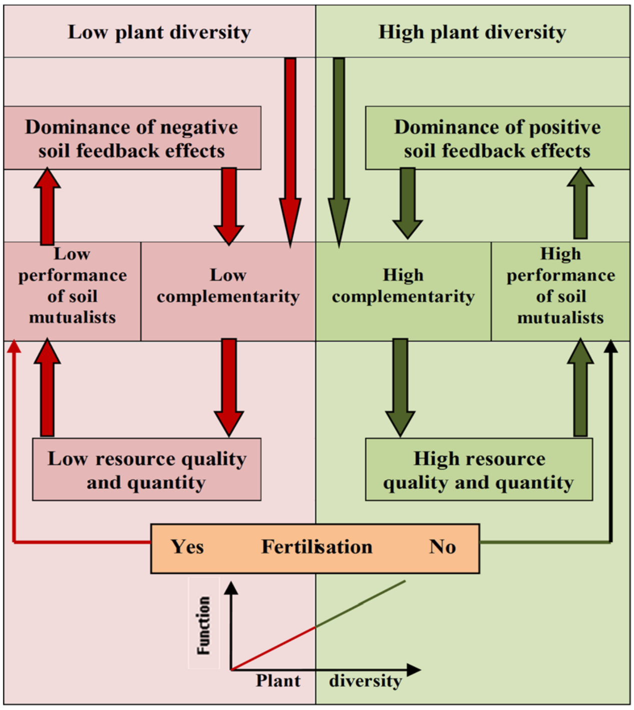

Figure 2 The influence of aboveground – belowground interactions on the positive relationship between biodiversity and ecosystem functioning. Resource use complementarity is higher in high communities with high plant diversity. Mutualists will mitigate or superimpose adverse effects of antagonists on plants (Eisenhauer, 2018; Latz et al., 2012). Artificial fertilisation may have negative effect on the performance of soil mutualists, such as arbuscular mycorrhiza fungi (Collins Johnson, 1993)
Source: redrawn and modified after Eisenhauer (2018)

and the number of individuals is noticeable. At the same time, soil life is enriched, which results in more vegetation. This in turn creates a new habitat for the entire ecosystem. When assessing the ecological viability of bioenergy crop cultivation, the relationships between biodiversity and ecosystem function (BEF) should be determined from the observed characteristics of aboveground – belowground multitrophic interactions, which may substantially improve the often far too mechanistic interpretation of BEF relationships. Thus, the previously mentioned BEF-theory, which has been tested on willow SRC systems (Fig. 1), can be applied in connection with the analysis of the balance between negative and positive plant-soil feedback effects and the consequences for ecosystem functioning (Fig. 2). Research on the connection of biodiversity and plant biomass production showed that plant community biomass was marginally significantly higher in species-rich plant communities than in species-poor ones suggesting varying net soil feedback effects depending on plant diversity (Eisenhauer, 2018). The development of plant biodiversity in SRC is greatly influenced by light availability, which changes at every coppice rotation and the planted area evolves from a bare field to a shrubby vegetation, that later will become similar to a forest with a closed canopy. These changes in the plant community determine the diversity of the fauna, such as bird populations, which evolve from open space to forest communities, continuously co-existing in shifting ratios. Arthropods and small mammals can satisfy their habitat needs from SRC while birds and large mammals only use the SRC for a limited number of resources. Hence, cultivation of bioenergy feedstocks could compensate for habitat losses for species that inhabit shrubby areas or regenerating forests (Tarr et al., 2017).

Furthermore, the previous use of land and the preceding vegetation cover may play an important role in the development of additional vegetation in the area of bioenergy plantations, since residual plants (seeds, roots, remaining stubbles, etc.) may develop new populations together with the newly established bioenergy plantations, contributing herewith to greater biodiversity and the development of more variable wildlife habitats.

From the above analyses it is obvious, that the value of wildlife habitats depends on the similarity of habitat properties to the natural, undisturbed state or the ability to develop sustainable, with the surrounding natural ecosystems compatible substitutions in cultivated areas (Fig. 3). The degree of plant architectural complexity: if higher, the habitat contains more strata, more and diverse branches, the wildlife is characterized by more microhabitats with higher chance for niche segregation, and more species; lower complexity results in habitats with simple layer, linear structures of wildlife, fewer microhabitats, and niches for fewer species (Fargione et al., 2009).

In case of cultivation of woody bioenergy feedstocks, the value of wildlife habitats depends on the planted material (i.e., alien, invasive vs. native, non-invasive), the timing and frequency of harvest and disturbances, cultivation factors, which include the type of the habitat, plant diversity, the invasive character of the ability of post-harvest recovery, habitat refugia as a function of the sizes of unharvested areas within the cultivated fields, the landscape content and the impact of cultivation methods on wildlife. Furthermore, plant biodiversity depends on the aboveground – belowground trophic interactions, which can be maintained only with sustainable, preferably with organic cultivation methods. Even if the biomass production is lower in ecologically managed systems, additional benefits (food, raw material for crafts, etc.) will compensate for these losses.

Conclusions

Linking woody bioenergy plantations and phytoremediation can greatly increase the sustainability of biomass production by improving soil and/or groundwater quality, removing hazardous substances from the environment, keeping biomass production in those areas, which are less suitable for food production.

In woody biomass production, longer rotation cycles and greater biodiversity are particularly beneficial in agroforestry systems and polycyclic arboriculture or in those short rotation plantations, where the length of rotation cycles allows newly established plant communities to develop asatisfactory level of biodiversity suitable for habitats.

When assessing the impact of bioenergy crop production of wildlife habitats taking into consideration the demand for bioenergy, the following factors are the most important:

– estimating gains and/or losses in the number of habitats for individual species at the landscape scale, based

Lower	Wildlife Habitat Value	Higher
Cropland	Habitat type	Diverse native habitats
Exotic monocultures	Plant diversity	Diverse native grasslands/forests
Alien, invasive	Invasiveness of planted material	Native, non-invasive
Breeding/nesting season	Harvest and disturbance timing	Late fall/early spring
Multiple harvests in one year	Harvest and disturbance frequency	Single harvest in ≥ 1 year
Little/no remaining stubble	Stubble height, post-harvest plant architectural complexity	Tall stubble or regrowth
No unharvested area in field or nearby	Habitat refugia, formation of connection corridors among more natural but fragmented habitat patches at least temporally	Unharvested area within field
Isolated patch/field	Landscape Content	Complex of habitat patches/fields
Higher	**Wildlife Impact**	**Lower**
Native prairie/forest/wetland	Land use replaced with biomass crop	Marginal cropland
High input	Use of fertilizers	Minimal input
High input	Use of Pesticides	Minimal input
Annual crops – high erosion	Soil Erosion and Sedimentation	Perennial plants – low erosion
Intensive monocultures	Phytoremediation of Degraded Soils	Selected, mixed species

Figure 3 The value of wildlife habitats depending on the cultivation factors of bioenergy crops. For each factor, the qualities associated with greater wildlife benefit (or less impact) are listed on the right side of the figure, and the qualities that are associated with less wildlife benefit (or greater impact) are listed on the left side of the figure
Source: modified after Fargione et al., 2009

on a sufficiently large demand of bioenergy on realistic levels;
- the effect of different bioenergy portfolios on wildlife habitats;
- relationships between specific sources of biomass and individual species;
- possibilities for ecocycle-based organic bioenergy feedstock production in SRC systems (e.g. irrigation of woody bioenergy crops with purified wastewater) linked to conservation of habitats;
- establishing connections of natural ecosystems and artificial ecosystems created by bioenergy crop cultivation: enlarging suitable habitats and increasing habitat complexity, which may yield in great potential for ecological networks;
- potential in greening agriculture.

The investigation of these factors may provide information for constructing future strategies of bioenergy systems with particular emphasis on the impact on wildlife habitats and create feedstock portfolios that support sustainable wildlife populations (Tarr et al., 2017).

References

BARNWAL, B.K. – SHARMA, M.P. 2005. Prospects of biodiesel production from vegetable oils in India. Renewable and Sustainable Energy Reviews. In Elsevier, vol. 9, no. 4, pp. 363–378. https://ideas.repec.org/s/eee/rensus.html

BAUM, S. – BOLTE, A. – WEIH, M. 2012. Short Rotation Coppice (SRC) Plantations Provide Additional Habitats for Vascular Plant Species in Agricultural Mosaic Landscapes. In Bioenerg. Res., 2012, no. 5, pp. 573. https://doi.org/10.1007/s12155-012-9195-1

BROWN, M. E. – FUNK, C. C. 2008. Food Security Under Climate Change NASA Publications. 131. http://digitalcommons.unl.edu/nasapub/131

BUŠIĆ, A. – KUNDAS, S. – MORZAK, G. – BELSKAYA, H. – MARĐETKO, N. – ŠANTEK, M.I. – KOMES, D. – NOVAK, S. – ŠANTEK, B. 2018. Recent Trends in Biodiesel and Biogas Production. In Food Technol Biotechnol., vol. 56, 2018, no. 2, pp. 152–173. https://doi.org/10.17113/ftb.56.02.18.5547

CERVERÓ, J.M. – COCA, J. – LUQUE, S. 2008. Production of biodiesel from vegetable oils. In Grasas Aceites, vol. 59, 2008, no. 1, pp. 76–83. https://doi.org/10.3989/gya.2008.v59.i1.494

CHRISTERSSON, L. 2005. Plant physiological aspects of woody biomass production for energy purposes. In Verma, K.S. – Khurana, D.K. – Christersson, L. eds. Short rotation forestry for industrial and rural development. Nauni, Solan, Himachal Pradesh, India, Indian Society of Tree Scientists, 2005.

COLLINS JOHNSON, N. 1993. Can Fertilization of Soil Select Less Mutualistic Mycorrhizae? In Ecological Applications, vol. 3, 1993, no. 4, pp. 749–757. https://doi.org/10.2307/1942106

COOPER, P.J.M. – LEAKEY, R.R.B. – RAO, M.R. – REYNOLDS L. 1996. Agroforestry and the mitigation of land depletion in the humid and sub-humid tropics of Africa. In Experimental Agriculture, 1996, no. 32, pp. 235–290.

DIMITRIOU, I. – ARONSSON, P. 2004. Nitrogen leaching from Short-Rotation Willow Coppice after intensive irrigation with wastewater. In Biomass and bioenergy, vol. 26, 2004, no. 5, pp. 433–441.

ECHEREME, C.B. – IGBOABUCHI, N.A. – IZUNDU, A.I. 2018. Phytoremediation of Heavy Metals and Persistent Organic Pollutants (POPs): A Review. In Ijsrm. Human, vol. 10, 2018, no. 4, pp. 107–125. www.ijsrm.humanjournals.com

EISENHAUER, N. 2018. Aboveground-belowground interactions drive the relationship between plant diversity and ecosystem function. In Research Ideas and Outcomes, 4:e23688. https://doi.org/10.3897/rio.4.e23688

ELBERSEN, B. – STARTISKY, I. – HENGEVELD, G. – MART-JAN SCHELHAAS, M-J. – NAEFF, H. 2012. Atlas of EU biomass potentials Deliverable 3.3: Spatially detailed and quantified overview of EU biomass potential taking into account the main criteria determining biomass availability from different sources. Biomass role in achieving the Climate Change & Renewables EU policy targets. Demand and Supply dynamics under the perspective of stakeholders. IEE 08 653 SI2. 529 241. https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/

documents/biomass_futures_atlas_of_technical_and_economic_biomass_potential_en.pdf

FAAIJ, A.P.C. 2006. Modern biomass conversion technologies. In Mitig. Adapt. Strat. Global Change., 2006, no. 11, pp. 335–367.

FACCIOTTO, G. – MINOTTA, G. – PARIS, P. – PELLERI, F. 2014. Tree farming, Agroforestry and the New Green Revolution. A necessary alliance. Proceeding of the II International Congress of Silviculture: Designing the future of the forestry sector; Florence, vol. 2, 2014. http://dx.doi.org/10.4129/2cis-gf-tre

FARGIONE, J.E. – COOPER, T.R. – FLASHPOHLER, D.J. – HILL, J. – LEHMAN, C. – McCOY, T. – MCLEOD, S. – NELSON, E.J. – OBERHAUSER, K.S. – TILMAN, D. 2009. Bioenergy and Wildlife: Threats and Opportunities for Grassland Conservation. In BioScience, vol. 59, 2009, no. 9, pp. 767–777. https://doi.org/10.1525/bio.2009.59.9.8

GUPTA, N. – KHAN, D.K. – SANTRA, S.C. 2009. Prevalence of intestinal helminth eggs on vegetables grown in wastewater-irrigated areas of Titagarh, West Bengal, India. In Food Control, 2009, no. 20, pp. 942–945.

GYULAI, G. – BITTSÁNSZKY, A. – SZABÓ, Z. – WATERS, L. JR. – GULLNER, G. – KAMPFL, G. – HELTAI, G. – KOMÍVES, T. 2013. Phytoextraction potential of wild type and 35S-gshI transgenic poplar trees (*Populus* × *Canescens*) for environmental pollutants herbicide paraquat, salt sodium, zinc sulfate and nitric oxide *in vitro*. In International Journal of Phytoremediation, vol. 16, 2013, no. 4. https://doi.org/10.1080/15226514.2013.783553

HAMELINCK, C.N. – SUURS, R.A.A. – FAAIJ, A.P.C. 2004. Techno-economic analysis of international bio-energy trade chains. In Biomass Bioenergy, 2004, no. 29, pp. 114–134.

LATZ, E. – EISENHAUER, N. – RALL, B. – ALLAN, E. – ROSCHER, C. – SCHEU, S. – JOUSSET, A. 2012. Plant diversity improves protection against soil-borne pathogens by fostering antagonistic bacterial communities. In Journal of Ecology, vol. 100, 2012, no. 3, pp. 597–604. https://doi.org/10.1111/j.1365-2745.2011.01940.x

LEAKEY, R.R.B. 1996. Definition of agroforestry revisited. In Agroforestry Today, vol. 8, 1996, no. 1, pp. 5–7.

MÁTRAI, K. – SZEMETHY, L. – TÓTH, P. – KATONA, K. – SZÉKELY, J. 2004. Resource use by red deer in lowland nonnative forests, Hungary. In Journal of Wildlife Management, vol. 68, 2004, no. 4, pp. 879–888.

McCALMONT, J.P. – HASTINGS, A. – McNAMARA, N.P. – RICHTER, G.M. – ROBSON, P. – DONNISON, I.S. – CLIFTON-BROWn, J. 2017. Environmental costs and benefits of growing *Miscanthus* for bioenergy in the UK. In Glob Change Biol Bioenergy, vol. 9, 2017, no. 3, pp. 489–507. Epub 2015 Aug 18. Review. https://doi.org/10.1111/gcbb.12294 PMID: 28331551

MERINO, I. – CAMPOS, V.M. – CASADO, R. – PACIOS, L.F. – GOMEZ, L. 2008. Review. Phytoremediation of organic pollutants. In Spanish Journal of Agricultural Research, vol. 6, 2008, no. S1, pp. 38. https://doi.org/10.5424/sjar/200806S1-372

NÉMETHY, S. – WAŁAS, B. 2016. Bioenergy crops as new components of rural and agricultural landscapes: environmental and social impact, conservation, cultural heritage and economy. In Journal of Central European Green Innovation, (JCEGI 3(TI)) HU, Hungary. ISSN 2064-3004.

NÉMETHY, S. 2018. Bioenergetika társadalmi, gazdasági és környezeti kontextusban (Bioenergetics in the context of society, economy and environment). In Magyar Tudomány (Hungarian Science), vol. 179, 2018, no. 8, pp. 1232–1243.

NÉMETHY, S. 2019. Ásványi alapú talajjavító anyagok jelentősége a szőlészetekben (The importance of mineral-based soil improvement substances in viticulture. In Hungarian). In Értékálló Aranykorona, országos mezőgazdasági szaklapm vol. 19, 2019, no. 3, pp. 16–18. ISSN 1586-9652.

OELBERMANN, M. – VORONEY, R.P. – GORDON, A.M. 2004. Carbon sequestration in tropical and temperate agroforestry systems: a review with examples from Costa Rica and southern Canada. In Agric. Ecosyst. Environ, 2004, no. 104, pp. 359–377.

PACHECO, P. – WARDELL, A. – GERMAN, L. – JOHNSON, F.X. – NEIL, B. – van GELDER, J.W. – SCHWAIGER, H.P. – SCHONEWELD, G.C. – OBIDZINSKI, K. – GUARIGUATA, M. R. 2012. Synthesis: Bioenergy, Sustainability and Trade-offs: Can we Avoid Deforestation while Promoting Biofuels? In CIFOR Infobriefs, 2012, no. 54. www.cifor.org

PANORAS, A. – A. ZDRAGAS. – A. ILIAS, K. 1998. Anagnostopoulos Microbiological quality criteria for municipal wastewater reuse in agriculture. In Geothenical Scientific Issues, vol. 9, 1998, no. 31, pp. 90–103.

PANORAS, A. – EVGENIDIS, G. – BLADENOPOULOU, S. – MELIDIS, V. – DOITSINIS, A. – SAMARAS, I. – ZDRAGKAS, A. – MATSI, Th. 2003. Corn irrigation with reclaimed municipal wastewater. Selected from papers presented at the 7th Conference on Environmental Science and Technology, 3–6 September 2001, Ermoupolis, Syros island, Greece. In Global Nest: The Int. J., vol. 5, 2003, no. 1, pp. 39–45.

PERTTU, K. – OBARSKA-PEMPKOWIAK, H. eds. 1998. Sewage treatment by means of pine, willow, reed and grass vegetation filters. Proceedings of a joint Polish-Swedish workshop in Starbienino, Poland, 25–28 May 1997. Department of Short Rotation Forestry, Report No. 61. Uppsala, Sweden, SLU.

QADIR, M. – WICHELNS, D. – RASCHID-SALLY, L. – McCORNICK, P. G. – P. DRECHSEL, P. – BAHRI, A. – MINHAS, P. S. 2010. The challenges of wastewater irrigation in developing countries. In Agricultural Water Management, 2010, no. 97, pp. 561–568.

SMEETS, E.M.W. – FAAIJ, A.P.C. – LEWANDOWSKI, I.M. – TURKENBURG, W.C. 2007. A bottom up quick scan and review of global bio-energy potentials to 2050. In Prog. Energy Combust. Sci., 2007, no. 33, pp. 56–106, 329, 790–792.

SOMERVILLE, C. – YOUNGS, H. – TAYLOR, C. – DAVIS, S.C. – LONG, S.P. 2010. Feedstocks for lignocellulosic biofuels. In Science, vol. 329, 2010, no. 5993, pp. 790–792. https://dopi.org/10.1126/science.1189268.

SOVACOOL, B.K. – MURKHERJEE, I. 2011. Conceptualizing and measuring energy security: A synthesized approach. In Energy, vol. 36, 2011, no. 8, pp. 5343–5355. https://doi.org/10.1016/j.energy.2011.06.043

SUN, W.H. – LO, J.B. – ROBERT, F.M. – CHITTARANJAN, R. – CHUNG-SHIH TANG. 2004. Phytoremediation of petroleum hydrocarbons in tropical coastal soils I. selection of promising woody plants. In Environ Sci & Pollut Res, 2004, no. 11, pp. 260. https://doi.org/10.1007/BF02979634

SZEMETHY, L. – MÁTRAI, K. – KATONA, K. – OROSZ, Sz. 2003. Seasonal home range shift of red deer hinds, *Cervus elaphus*: are there feeding reasons? In Folia Zoologica, vol. 52, 2003, no. 3, pp. 249–258.

TARR, N.M. – RUBINO, M.J. – COSTANZA, J.K. – McKERROW, A.J. – COLLAZO, J.A. – ABT, R.C. 2017. Projected gains and losses of wildlife habitat from bioenergy-induced landscape change. In GCB Bioenergy, 2017, no. 9, pp. 909–923. https://doi.org/10.1111/gcbb.12383

VERMEULEN, S.J. – AGGARWAL, P.K. – AINSLIE, A. – ANGELONE, C. – CAMPBELL, B.M. – CHALLINOR, A.J. – HANSEN, J.W. – INGRAM, J.S.I. – JARVIS, A. – KRISTJANSON, P. – LAU, C. – NELSON, G.C. – THORNTON, P.K. – WOLLENBERG, E. 2012. Options for support to agriculture and food security under climate change. In Environmental Science & Policy, vol. 15, 2012, no. 1, pp. 136–144. https://doi.org/10.1016/j.envsci.2011.09.003

WATANABE, M. 1997. Phytoremediation on the bank of commercialization. In Environmental Science and Technology, vol. 31, 1997, no. 4, pp. 182A–186A.

WEIH, M. – GLYNN, C. – BAUM, C. 2019. Willow Short-Rotation Coppice as Model System for Exploring Ecological Theory on Biodiversity-Ecosystem Function. In Diversity, vol. 11, 2019, no. 8, pp. 125. https://doi.org/10.3390/d11080125

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CALORIFIC VALUE OF BASIC FRACTIONS OF ABOVE-GROUND BIOMASS FOR SCOTS PINE

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In this work, the calorific value content in the dry matter of the Scots pine (*Pinus sylvestris* L.) trees was evaluated. This dry matter was obtained only from the above-ground fractions of its biomass. Our experimental material was taken from five Scots pine trees situated in Slovakia. Wood and bark samples were obtained from the discs which were cut off from three locations, namely from the stem, branches of tree crowns and needles. Then, calorific value capacity (J g^{-1}) in the dry matter of each sample was determined. The impact of statistically significant factors on the calorific value capacity was determined by means of analysis of variance. The average values are, according to the fractions, approximately in the range of 20,000–22,200 J g^{-1}. The smallest capacity of the calorific value, approximately 20,000 J g^{-1}, has the dry matter from bark obtained from the middle and crown parts of the stem. Then, the dry matter from stem wood and branches follows with a value of approximately 20,700 J g^{-1}. Then follows dry matter of the coarse bark occurring on the stem butt and twigs that are covered with needles with a value of about 21,900 J g^{-1}; and finally pine needles with the highest values of about 22,200 J g^{-1}. The calorific value variability is relatively low with coefficients of variations of 0.9–2.8%.

Keywords: calorific value, pine, wood, bark, branches, needles

For the efficient energy use of tree biomass, it is necessary to know the calorific value content of not only whole trees but also of their parts. The primary process in biomass formation is photosynthetic assimilation, when organic substances are formed from inorganic ones and then solar energy accumulates in them. The amount of accumulated energy is very varying and depends on not only the amount, but also on the biomass structure that a particular tree produces for a fixed period of time. In forestry, biomass production is mostly expressed in volume units. The example here is presented in particular by the generally known tree volume tables, which indicate the biomass volume by the diameter and height of trees (Petráš and Pajtík, 1991). These tables are also found in the form of continuous mathematical models and simulate the biomass volume of not only whole trees (in m^3), but especially also by their major parts such as volume of wood, bark and branches for instance. Such separation of tree biomass is usual mainly for the purposes of its industrial processing. For the energy use of biomass, it is necessary to know its energy equivalent. The easiest way for this expression is to recalculate the volume of biomass to its weight and, consequently, calorific value capacity. To do this, it is necessary to know not only the density of biomass (kg m-3) by individual fractions, but also the calorific value (J g^{-1}).

The knowledge of wood density are most commonly. They are reported for several tree species by Požgaj et al. (1997), but in particular Niemz and Sonderegger (2003). Matovič and Šlezingerová (1992) and Petráš et al. (2010, 2018) derived density values for bark and tree branches, too. Similar results are observed with the calorific value of individual biomass fractions. Pretzsch (2009) reports values of 20.36–20.79 MJ kg^{-1} for spruce wood and 20.34–21.14 MJ kg^{-1} for branches and roots outside bark. Then, values for beech wood are 19.72–20.10 MJ kg^{-1} and 20.78–23.13 MJ kg^{-1} for branches and roots outside bark. Klašnja and Kopitovič (1999) report the calorific value for willow wood at the level of 16.4–23.2 MJ kg^{-1} and for locust at the level of 21.9–24.2 MJ kg^{-1}. Calorific values of locust bark are lower by 1.5–5.5 MJ kg^{-1}. Oszlányi and Biskupský (1979) determined the calorific value for wood, bark and leaves of hornbeam, field maple, durmast oak and Turkey oak in the range of 18.12 to 20.65 J mg^{-1}. Petráš et al. (2013a) derived the average calorific values of wood for poplar clones at 18,430 J g^{-1}, thin bark at 18,029 J g^{-1} and coarse bark at 17,38 J g^{-1}. Larcher (2003) reports that tree species are richer in energy than herbaceous species, and in general, energy content depends directly on the carbon content in a substance. Of the plant substances, lignin with 26.4, lipids with 38.9 and terpenes with up to 46.9 kJ g^{-1} have the highest energy content.

Based on the results of the domestic research into calorific value for poplar clones (Petráš et al., 2013a, 2013b; Jamnická et al., 2014), research with the same focus for other 11 economically important tree species continues at this time. The research starts with the density of basic fractions of the above-ground biomass of trees (Petráš et al., 2018a, 2019), then continues with their calorific value

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capacity (Petráš et al., 2018b) and ends with the production of calorific value of whole trees and stands.

The aim of this work is to investigate the calorific value content of above-ground biomass of scots pine trees (*Pinus sylvestris* L.) by their basic fractions (wood, bark, branches and needles).

Material and methods

The experimental material was obtained from five trees (Table 1), which were cut down in the areas of Zvolen (Stráž), the Little Carpathians (Smolenice), Záhorie (Gbely) and Spiš (Hranovnica). The selected trees are best characterized by their diameter in the range of 24–51 cm, the height of 24–30 m and the age of 85–105 years. According to these values, we can conclude that they all have parameters of mature trees. They were cut in middle to high site index stands with an altitude of 165–850 m.

Three discs with bark were cut off from stems of each tree. The first disc was obtained from the foot of the stem; the second one from the middle part of the stem (approximately below the tree crown) and the third one from the crown part of stem. All three samples taken from stems were separated into wood and bark. For a more representative representation of the bark samples, a larger amount of bark had to be peeled from that part of the stem, where discs were cut off. Other samples were taken from tree crowns. The fourth sample was obtained from the branches outside bark; the fifth one from twigs, which are usually covered with needles and the sixth one represents needles only. Nine samples were available for each tree in total. Three samples from stems were intended for wood, three for bark and one sample separately for branches outside bark, twigs and needles. The total of 45 samples was taken from all five trees in total.

Large stem discs were cut radially to smaller triangular parts before drying so that the direct proportion of sapwood and core wood was preserved. All samples were dried at 103 ±2 ° C and then pulverised. The weight of dried samples was approximately 180-750 g. Needles and twigs samples were the smallest samples and wood samples were the largest samples. The calorific value of samples was determined by means of an IKA C-4000 calorimeter (program C-402, standard DIN 51900). Two determinations were obtained from each sample and then average values (J g^{-1}) from these determinations were calculated. The variability was examined and the most important factors on which the calorific value capacity depends were determined. A single factor analysis of variance (ANOVA) was used for that purpose by using the computer program QC.Expert (Kupka, 2013). ANOVA proceeds from the principle of addition of variances of known reasons (factors) σ_i^2 and unknown (random) $\sigma^2_{residual}$ to total variance σ^2_{total}:

$$\sigma^2_{total} = \sum \sigma_i^2 + \sigma^2_{residual} \quad (1)$$

In the analysis of variance, only one factor (biomass fraction) was considered as a reason with nine levels (wood and bark in three locations of stem, then branches outside bark, twigs and needles).

Results and discussion

From the results of single factor analysis of variance we can conclude that the effect of the biomass fraction on the calorific value content is statistically significant. The calculated p-value of 4.92E-12 is smaller than the given significance level (p = 0.05). The bark in the middle and crown parts of the stem (Figure 1) has the lowest calorific values, approximately 20,000 J g^{-1}. Three fractions, namely twigs, bark from the stem foot and needles, have highest values of about 21,900–22,200 J g^{-1}. The variability of these fractions is relatively low with a coefficient of variation of 0.9-3.3%. Subsequently, the differences between the pairs of averages of all nine fractions were tested by the Scheffe method. Differences among three fractions with the highest-values (Twigs, B1 and Needles) were statistically insignificant and the differences among other six fractions with the lowest values were also statistically insignificant. Based on this result, the fractions among which there were no significant differences were merged together. The actual content of the fraction was also taken into account when merging. Six sets were first created (Fig. 2) from nine sets, and later five larger sets. This resulted in a separate fraction for wood and branches outside bark, for bark in the middle and crown part of stem, for twigs, for bark from the foot of stem and for needles (Fig. 3). Average values remained in the range of approximately 20,000–22,200 J g^{-1}, but their variability decreased slightly to 0.9–2.8%.

According to preliminary results (Petráš et al., 2018), other economically important tree species also have a similar but slightly lower calorific value content. Spruce and fir needles are in the range of about 20,000 to 21,600 J g^{-1}, which is 90–97% of the pine level. Other fractions have 20,000–20,300 J g^{-1}, which is 97% of the pine level. The deciduous tree species such as oak, beech and hornbeam have a calorific value of wood and branches in the range

Table 1 Basic characteristics of cut trees and stands

Tree number	Diameter $d_{1.3}$ (cm)	Height *h* (m)	Age	Site index	Altitude (m)	Area (locality)
14	24	25	105	30	350	Zvolen
27	26	27	90	30	275	Smolenice
29	35	24	88	26	165	Gbely
33	36	26	85	26	165	Gbely
75	51	30	101	24	850	Hranovnica

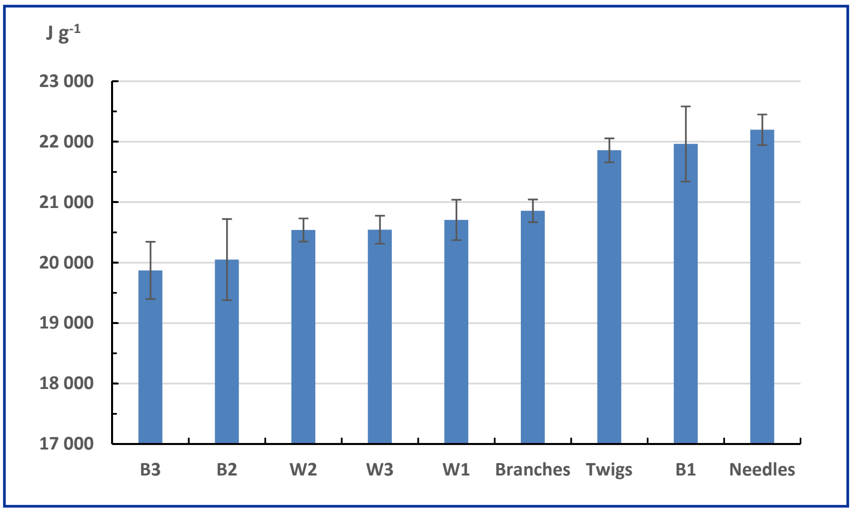

Figure 1 Calorific value capacity by basic fractions
B – bark, W – wood, by its location within the stem: 1 – the foot, 2 – the stem middle, 3 – in the stem crown

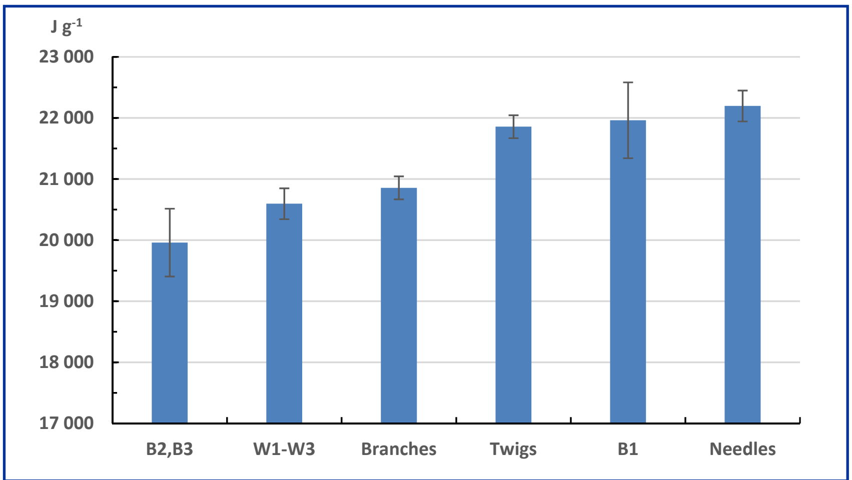

Figure 2 Calorific value capacity by merged fractions
B – bark, W – wood, by its location within the stem: 1 – the foot, 2 – the stem middle, 3 – in the stem crown

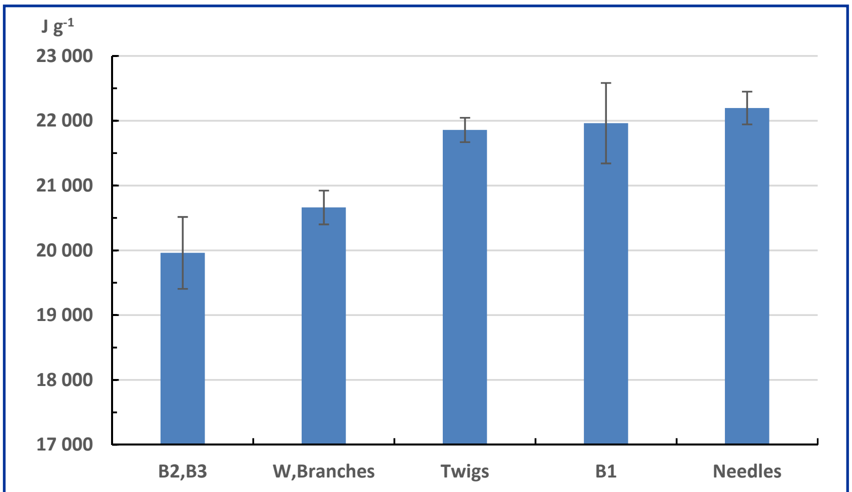

Figure 3 Resulting calorific value capacity for merged fractions
B2,3 – bark in the middle and crown part of the stem, W – wood of the whole stem, K1 – bark from the stem foot

of 19,200–19,800 J g^{-1}, but the bark achieves only 17,700–18,700 J g^{-1}. In proportion to pine, it is 98% for wood and 90% for bark. Hardwoods have lower calorific value content even though they have higher density of wood than coniferous species. Accordingly, we can conclude that the calorific value content of biomass is not increasing only due to its higher density, but also because of the content of other non-wood substances such as e.g. lipids or terpenes. Pine biomass has the most of these substances compared to other wood species.

Conclusions

The calorific value content was determined in the dry matter of the above-ground biomass of scots pine. Experimental material was obtained from five trees growing in the forests of Slovakia. Nine samples of biomass matter were taken from each tree. These samples consisted of separate wood and bark samples from the lower, middle and top parts of stems. Then, samples of branches outside bark and twigs covered with needles were taken from the tree crowns. In the laboratory, these were manually separated into needles and twigs. All samples were then dried at 103 ±2 ° C and pulverised. Calorific value capacity for each fraction was then determined (J g^{-1}). The analysis of variance examined the effect of statistically significant factors on the calorific value capacity. The results showed that the average values of above-ground biomass of scots pine are in the range of 20,000–22,200 J g^{-1} by their specific biomass fraction. The lowest calorific value capacity, approximately 20,000 J g^{-1}, has dry matter of the thinner bark in the middle and crown part of stem. This is followed by the dry matter of stem wood and branches with its value of approximately 20,700 J g^{-1}, then by dry matter of coarse bark from the foot of stems, and twigs that are covered with needles follow with a value of nearly 22,000 J g^{-1}, and the highest calorific values, approximately 22,200 J g^{-1}, have pine needles. The calorific value variability is relatively low with its coefficients of variation of 0.9–2.8%. The calorific value content of the pine biomass is higher compared to other tree species mainly due to higher resin content in all fractions.

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References

JAMNICKÁ, G. – PETRÁŠOVÁ, V. – PETRÁŠ, R. – MECKO, J. – OSZLÁNYI, J. 2014. Energy production of poplar clones and their energy use efficiency. In iForest, 2014, no. 14, pp. 150–155.

KLAŠNJA, B. – KOPITOVIČ, Š. 1999. Quality of wood of some willow and robinia clones as fuelwood. In Drevársky výskum, 1999, no. 44, pp. 9–18.

KUPKA K. 2013. QC.Expert 3.1. In Uživatelský manuál, Pardubice : TryloByte, Ltd., 2013, 266 pp.

LARCHER, W. 2003. Physiological Plant Ecology: Ecophysiology and Stress Physiology of functional groups. 4th ed., New York : Springer, 2003, 513 pp.

MATOVIČ, A. – ŠLEZINGEROVÁ, J. 1992. Konvenční hustota dřeva větví smrku obecného (*Picea abies* Karst.). In Zborník medzinárodnej vedeckej konferencie Les, drevo, ekológia, Sekcia 4. Štruktúra a vlastnosti dreva v technologickom využití, 1992, pp. 53–59.

NIEMZ, P. – SONDEREGGER, W. 2003. Untersuchungen zur Korrelation ausgewählter Holzeigenschaften untereinander und mit der Rohdichte unter Verwendung von 103 Holzarten. In Schweizerische Zeitschrift für Forstwesen, 2003, no. 154, pp. 489–493.

OSZLÁNYI, J. – BISKUPSKÝ, V. 1979. Energetická hodnota nadzemnej biomasy drevín v dubovo-hrabovom lese. In Acta Ecologica, 1979, no. 20, pp. 59–105.

PETRÁŠ, R. – PAJTÍK, J. 1991. Sústava česko-slovenských objemových tabuliek drevín. In Lesnícky časopis, 1991, no. 37, pp. 49–56.

PETRÁŠ, R. – MECKO, J. – NEUSCHLOVÁ, E. 2010. Density of basic components of above-ground biomass of poplar clones. In Wood Research, 2010, no. 55, pp. 113–122.

PETRÁŠ, R. – MECKO, J. – OSZLÁNYI, J. – PETRÁŠOVÁ, V. – JAMNICKÁ, G. 2013a. Landscape of danube inland-delta and its potential of poplar bioenergy production. In Biomass And Bioenergy, 2013, no. 55, pp. 68–72.

PETRÁŠ, R. – MECKO, J. – PETRÁŠOVÁ, V. 2013b. Energy potential in production of fast-growing poplar clones in slovak regions. In Acta Regionalia et Environmentalica, 2013, no. 10, p. 53–56.

PETRÁŠ, R. – MECKO, J. – KRUPOVÁ, D. – SLAMKA, M. 2018a. Predbežné výsledky výskumu hustoty nadzemnej dendromasy hospodársky významných druhov drevín. In Baláš, M. – Podrázský, V. – Gallo, J. (eds.): Proceedings of Central European Silviculture. Praha : ČZU, 2018, no. 8, pp. 94–101.

PETRÁŠ, R. – MECKO, J. – KUKLOVÁ, M. – KUKLA, J. 2018b. Výskum kapacity spalného tepla lesných drevín. In Gálik, B. – Zelinková, G. (eds.): Recenzovaný zborník vedeckých prác Slovenskej spoločnosti pre poľnohospodárske, lesnícke, potravinárske a veterinárske vedy pri Slovenskej akadémii vied, pobočka Nitra. Nitra : SPU, 2018, pp. 277–284.

PETRÁŠ, R. – MECKO, J. – KRUPOVÁ, D. – SLAMKA, M. 2019. Aboveground biomass basic density of softwoods tree species. In Wood Research, 2019, no. 64 (in print).

POŽGAJ, A. – CHOVANEC, D. – KURJATKO, S. – BABIAK, M. 1997. Štruktúra a vlastnosti dreva. Bratislava : Príroda, 1997, 485 pp.

PRETZSCH, H. 2009. Forest Dynamics, Growth and Yield. Berlin : Heidelberg, Springer, 2009, 664 pp.

DOI: 10.2478/aree-2019-0008

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Nitra, Slovaca Universitas Agriculturae Nitriae, 2019, pp. 38–44

SEASONS OF DROUGHT IN SLOVAKIA DURING THE PERIOD FROM 1957 TO 2016

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The aim of the paper was to describe the occurrence of dry seasons in Slovakia. Dry seasons in the period from 1957 to 2016 were determined according to the monthly Palmer Drought Severity Index (PDSI). For this purpose, ten sites based on limit climatic parameters were chosen – Bratislava, Piešťany, Hurbanovo, Čadca, Sliač, Boľkovce, Poprad, Košice, Milhostov, and Kamenica nad Cirochou. The results showed the alternation of dry and wet episodes and the variability of weather not only over time, but also over space. The analysis of linear trends showed that the arid trend was identified on most sites (9 localities).

Keywords: drought, Plamer Drought Severity Index, climate change

The comprehensive definition of drought is unclear because many types of it exist, for instance meteorological, physiological, hydrological, soil – agricultural and socio-economic drought. Generally, drought is a long-term occurring state of imbalance between precipitations and evaporation when evaporation is higher than precipitations which are presented by negative variation of their average value in a certain area (EPA, 2016). Drought is one of the most dangerous phenomena that can have a serious impact on economics (mainly in agricultural sector), as well as on social and natural sphere (White, 2000).

The frequency of drought and its severity has been more intensive since 1950 in Europe and also in Slovakia (Spinoni et al., 2015). Thus, analysis of occurrence and recognition of drought during past periods is necessary for proposal and implementation of adaptations to this phenomenon nowadays. The PDSI (Palmer´s Drought Severity Index) quantifies the meteorological drought based on variation in average precipitations, while precipitations and temperature are taken into account and drought is evaluated over a long-term period (Šťastný, Turňa, 2013). There are many indices that represent local conditions in the world, for example, the PDSI is used in the USA, the RDDI in Australia, the Z-index in China, and the SPI in India (Vinit, 2015). The PDSI is a suitable indicator for determining the severity of drought in Slovakia, especially if a larger amount of reference locations is selected for comparison of the differences between them (Litschmann et al., 2001).

The aim of the paper is to determine the occurrence and severity of drought in the territory of the Slovak Republic between 1957 and 2016 on the basis of measured meteorological elements and provide a basis for the proposal of adaptations to climate change in the country. Evaluation of historical data and assessment of significant drought periods are some of the main components for the conception of drought risk reduction in the Guidelines for Drought Management Plans (Fatulová, 2015).

Material and methods

Identification of dry seasons was realized by calculations of the Palmer Drought Severity Index (Palmer, 1965). The index is standardized for different regions and different time series, so it can be used for assessment of drought in the localities with various climate conditions (Dunkel, 2009). The method involves not only climatic, but also pedological characteristics of the region. The calculation was realized by the program, which was developed by Tom Heddinghaus from the University of Nebraska-Lincoln in 2003. Input data include monthly precipitation totals, monthly average air temperature, average air temperature for the whole period, latitudes of the sites and available water capacity. Climatic data were provided by the Slovak Hydrometeorological Institute and pedological data from the Soil Science and Conservation Research Institute in Bratislava.

Ten sites were chosen for evaluation of drought in Slovakia according to limited climatic parameters: Bratislava, Piešťany, Hurbanovo, Čadca, Sliač, Boľkovce, Poprad, Košice, Milhostov, and Kamenica nad Cirochou (Fig. 1).

The drought variability was characterized during the 60-year time series from 1957 to 2016. We created charts for each site from the output values of the PDSI. Dry seasons were identified as those with values ≤ -1.00 and also at least one month of the season in the category moderate drought (-2.00 to -2.99) (Žalud et al., 2006). The linear trend was added into the charts for determining the character of the period on each site.

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Figure 1 The sites selected for drought assessment
1 – Bratislava, 2 – Piešťany, 3 – Hurbanovo, 4 – Čadca, 5 – Sliač, 6 – Boľkovce, 7 – Poprad, 8 – Košice, 9 – Milhostov, 10 – Kamenica nad Cirochou

Table 1 Palmer's classification

PDSI	Class
≥4.00	extremely wet
3.00 to 3.99	very wet
2.00 to 2.99	moderately wet
1.00 to 1.99	slightly wet
0.50 to 0.99	incipient wet spell
0.49 to -0.49	near normal
-0.50 to -0.99	incipient drought
-1.00 to -1.99	mild drought
-2.00 to -2.99	moderate drought
-3.00 to -3.99	severe drought
≤-4.00	extreme drought

Results and discussion

Sixteen dry seasons were observed in Bratislava in the selected period: February – March 1959; September 1959 – May 1960; January – September 1964; January 1973 – September 1974; September 1977 – January 1979, when two months were extremely dry; August 1983 – August 1984; June – December 1986; June 1988 – October 1991 with nine extremely dry months in 1990; August 1992 – September 1993; December 1997 – August 1998, when three months were extremely dry; May 2000 – July 2005 with extreme drought during 16 months; October 2006 – August 2007, when last two months were extremely dry; May 2009 – March 2010; October 2011 – September 2012; December 2013 – June 2014; June 2015 – December 2016. The linear trend was decreasing, it means arid and it was caused by extremely wet and very wet months in the first half of the period and the onset of extremely dry months and more long-term dry seasons in the second half of the period (Fig. 2).

Sixteen seasons of drought were recorded in Piešťany: December 1963 – September 1964; June 1967 – July 1968; September 1969 – January 1970; July 1971 – March 1972; June 1973 – July 1974; July 1977 – May 1979; November 1982 – January 1984; January 1989 – September 1993, when nineteen months were extremely dry; December 1996 – August 1998, when last three months were extremely dry; May 2000 – August 2001; October 2001 – June 2002; May – December 2003; October 2006 – August 2007, when three months were extremely dry; September 2011 – December 2012; December 2013 – September 2014; June 2015 – December 2016. The linear trend was decreasing, arid, caused by extremely wet months from 1965 to 1967 replaced by extremely dry months at the beginning of the second half of the period (Fig. 3).

We recorded 17 significant dry seasons in Hurbanovo during the period 1957–2016: January – August 1964; July 1967 – February 1969, when there was recorded one extremely dry month; July – November 1969; October 1970 – March 1972; October 1973 –

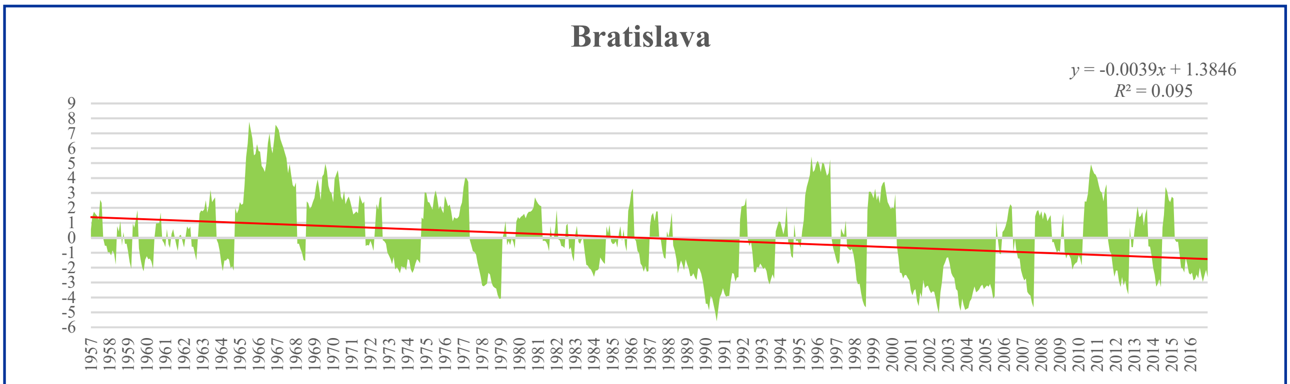

Figure 2 Monthly PDSI in Bratislava during the period from 1957 to 2016

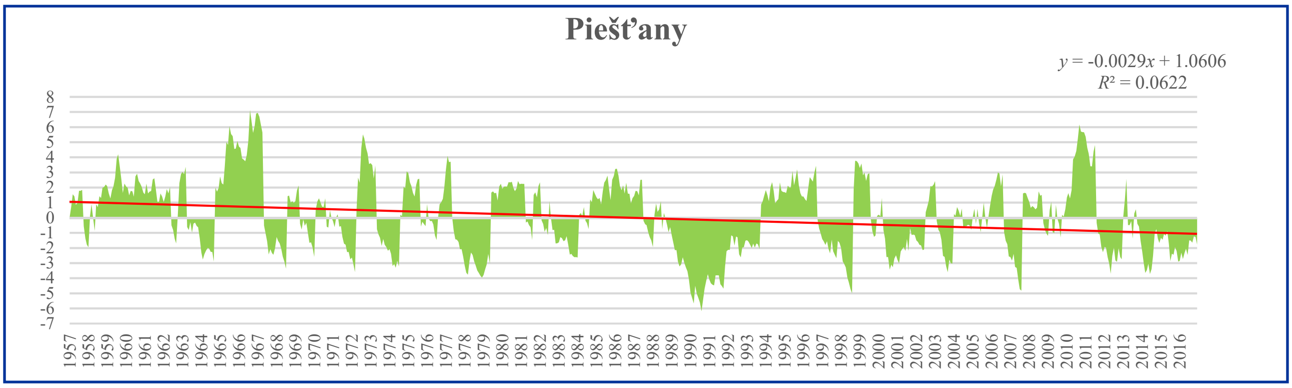

Figure 3 Monthly PDSI in Piešťany during the period from 1957 to 2016

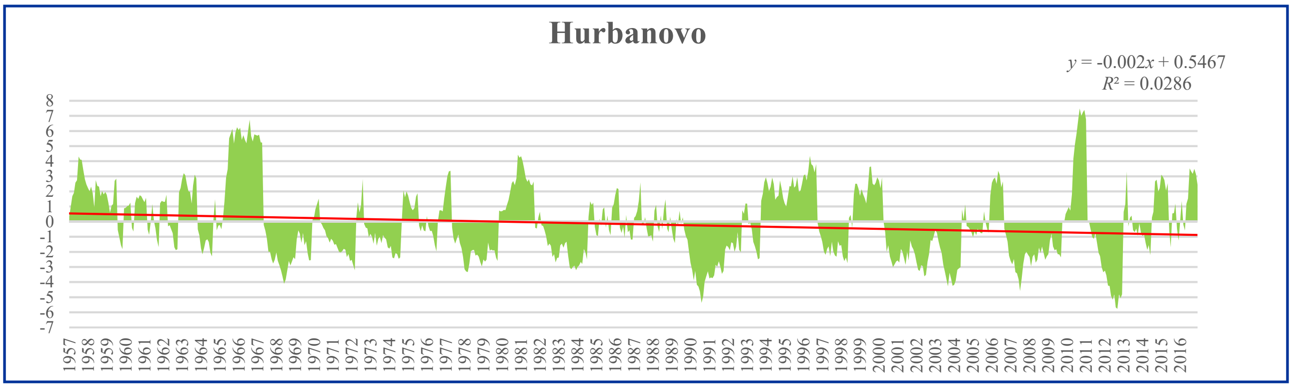

Figure 4 Monthly PDSI in Hurbanovo during the period from 1957 to 2016

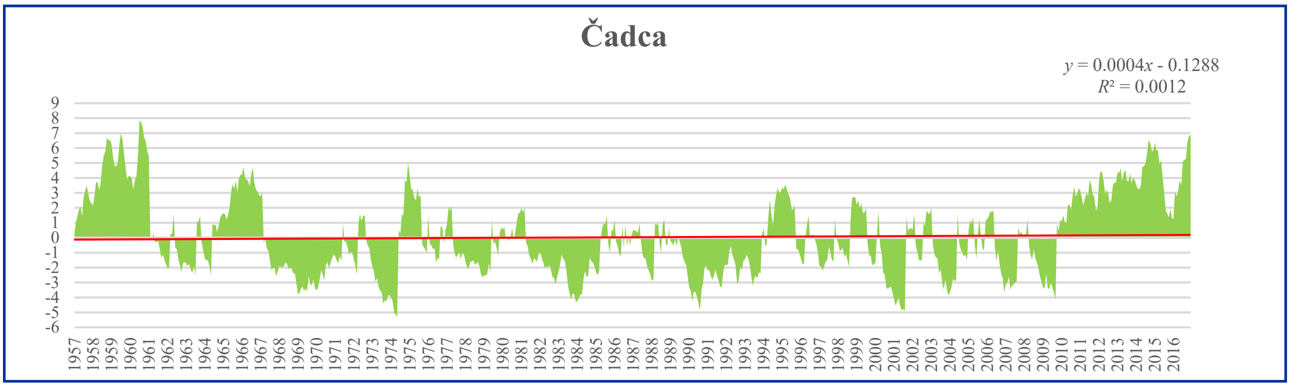

Figure 5 Monthly PDSI in Čadca during the period from 1957 to 2016

August 1974; October 1977 – October 1979; June 1982 – July 1984; November 1989 – June 1992 with five extremely dry months; August – September 1992; May – September 1993; January 1997 – May 1998; June 2000 – November 2002; March 2003 – May 2004, when three extremely dry months were observed; November 2006 – February 2009 with one extremely dry month; April – September 2009; August 2011 – December 2012, when extreme drought was recorded during the last ten months and March – June 2014. Linear trend was arid, which was caused by two significant wet seasons at the beginning of the period and the subsequent onset of extreme drought in the second half of the period (Fig. 4).

Several case studies dealt with the assessment of drought in Hurbanovo. Patassiová et al. (2002) used the PDSI for the evaluation of drought period in the period 1961–2000 and also considered linear trends during this period. They focused on the assessment of drought during April and May. They stated that the years 1968, 1974 and 1990 were very dry in April; the years 1984, 1974, 1978, 1997 and 1998 were moderately dry in April. In May, extreme drought values were recorded in 1990 and very dry values in 1968. Moderate dry years were in 1971, 1973, 1974, 1978, 1997 and 1998 in May. In comparison with our results, there are several differences. The PDSI values in April were extremely dry in 2012, as a longer time period was evaluated. Very dry years (April) were 1968, 1990, 1991, 2004 and 2007. Moderate dry years (April) were 1974, 1978, 1984, 1998, 2002 and 2008. The extreme drought in May was recorded in 1990 and also in 2012. Very dry May was not only in 1968, but also in 2004 and 2007. Moderately dry May was in 1971, 1974, 1991, 1998, 2001, 2002, 2003 and 2008.

Litschmann et al. (2002) evaluated the drought during the period 1876–2000. The lowest monthly PDSI value (-6.0) was recorded in August 1990. In this article, the monthly PDSI value in August 1990 was -5.38, however, this is in the same category of extreme drought. The lowest PDSI value (-5.77) was recorded in September 2012.

The variability between the results of different studies using the PDSI method (although the same locations were evaluated) is probably due to the evaluation of different time series.

Sixteen seasons of drought were identified in Čadca during the selected period: September 1961 – February 1962; August 1962 – July 1963; January – May 1964; July 1967 – May 1971; December 1971 – March 1972; December 1972 – May 1974, when seven extremely dry months were recorded; June 1977 – May 1979; February 1982 – March 1985 with four extremely dry months; July 1987 – February 1988; September 1989 – March 1992, when three extremely dry months occurred in 1990; May 1992 – November 1993; December 1996 – June 1997; May 2000 – August 2001, in which eight months were classified as extreme drought; March 2003 – May 2004; September 2006 – August 2007; August 2008 – September 2009 with one extremely dry month, that was the last month from the season. The linear trend was increasing, humid, due to an extremely wet season from 2000 to 2014 and in 2016 (Fig. 5).

Sixteen dry seasons were observed in Sliač in the period: May 1958 – March 1959; August – October 1961; January – May 1964; October 1967 – August 1968; May 1969 – January 1970; May 1973 – April 1974; February – August 1976; July 1983 – April 1984, when three months were extremely dry, July 1987 – August 1990, when four extremely dry months were observed in 1990; June 1992 – September 1993; June 2000 – June 2011; March 2003 – March 2004; October 2006 – February 2009 with three extremely dry months in 2008; April – September 2009; September 2011 – September 2012, when the last seven months were extremely dry; October 2013 – June 2014. The linear trend was arid, what was the result of an occurrence of significantly wet seasons at the beginning of the period and extreme drought that appeared mainly in the second half of the time series (Fig. 6).

Eighteen seasons of drought were recorded in Boľkovce in the period 1957 – 2016: June – October 1961; July – October 1962; December 1963 – July 1964, when the last month of the season was extremely dry; December 1967 – October 1968 with two extremely dry months; July 1971 – March 1972; July 1973 – April 1974; June 1977 – March 1978; February 1982 – April 1984; August 1986 – April 1987; October 1988 – May 1989; September 1989 – March 1990; August 1992 – April 1994, when two extremely dry months occurred; November 1994 – February 1995; August – October 2000; October 2001 – March 2005 with eight extremely dry months; October 2006 – May 2008, when July 2007 was classified as extremely dry; June – September 2009; September 2011 – September 2012 with six extremely dry months. The linear trend was decreasing, arid, due to extremely wet months at the beginning of the period and occurrence of seasons of extreme drought mainly from 1993 (Fig. 7).

There were eighteen seasons of drought observed in Poprad: July – October 1961; June 1963 – July 1964, when

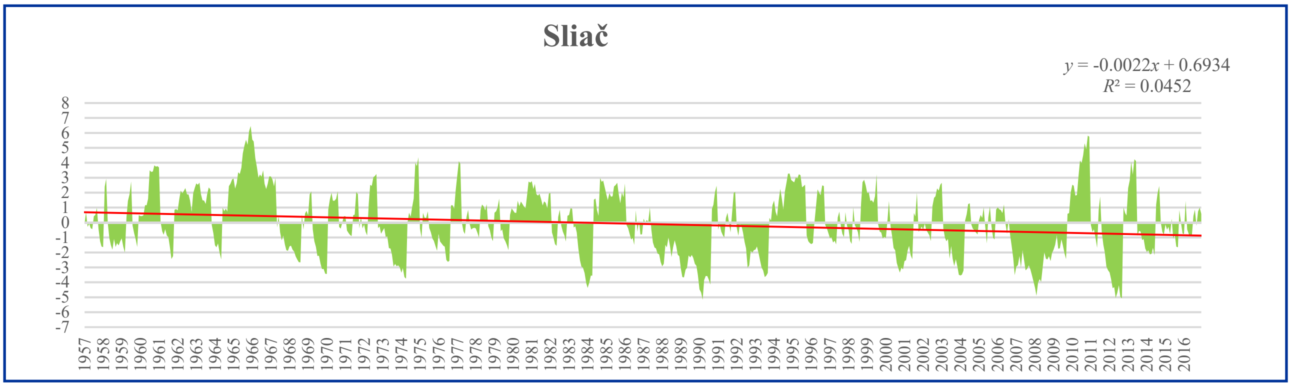

Figure 6 Monthly PDSI in Sliač during the period from 1957 to 2016

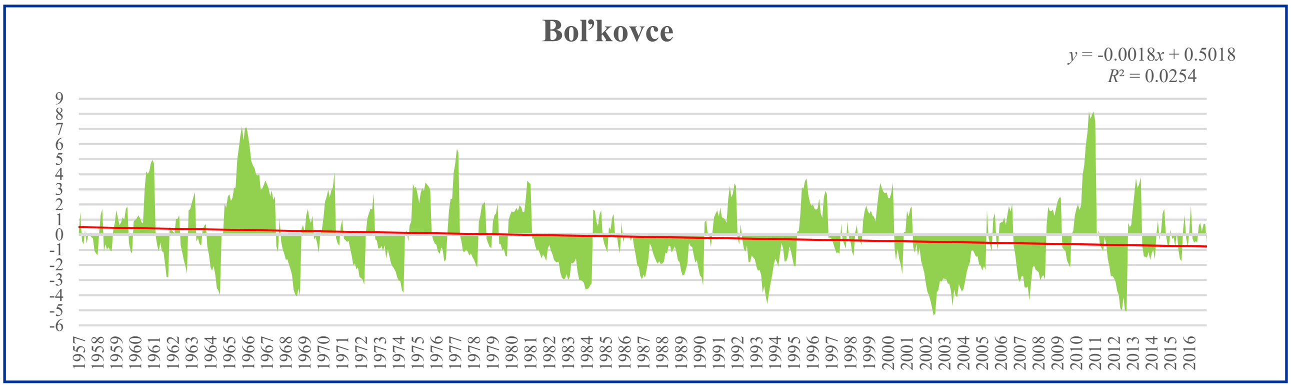

Figure 7 Monthly PDSI in Boľkovce during the period from 1957 to 2016

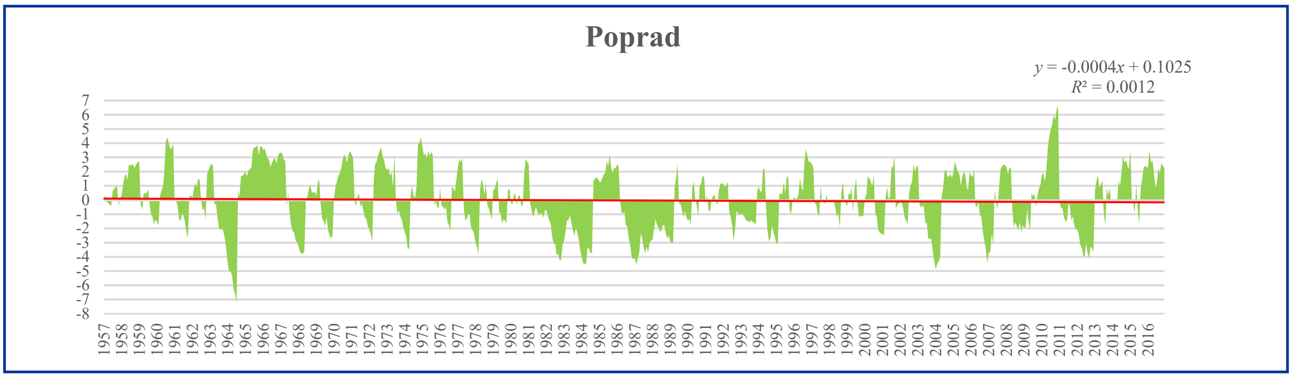

Figure 8 Monthly PDSI in Poprad during the period from 1957 to 2016

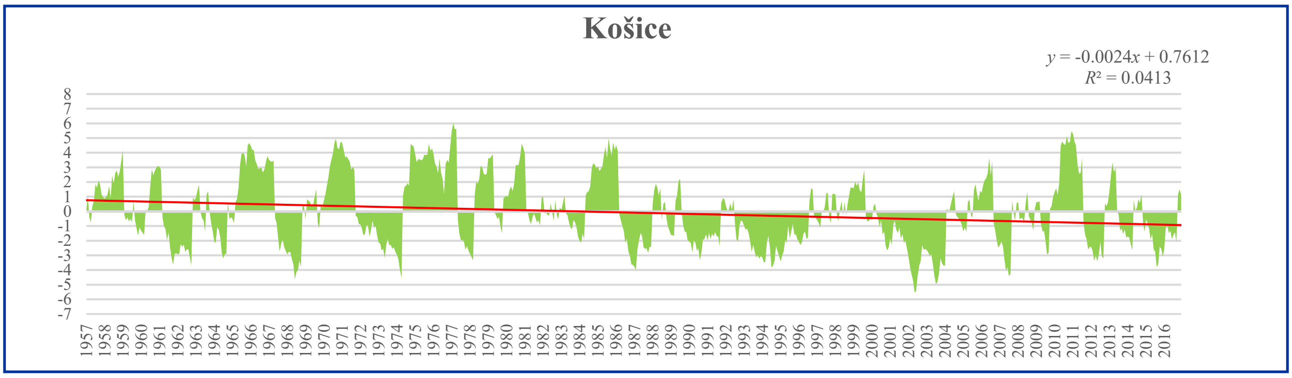

Figure 9 Monthly PDSI in Košice during the period from 1957 to 2016

last six months were extremely dry; August 1967 – May 1968; May – December 1969; October 1971 – March 1972; October 1973 – April 1974; June – August 1976; June 1977 – March 1978; February 1982 – August 1984, when five extremely dry months were recorded; July 1986 – March 1989 with five extremely dry months; June – September 1992; July 1994 – February 1995; September 2000 – February 2001; June 2003 – April 2004, when last five months were classified as extremely dry; July 2006 – April 2007 with an extremely dry month; June 2008 – February 2009; April – May 2009; September 2011 – December 2012, when one extremely dry month was observed. The linear trend was arid, however, very slightly decreasing. The trend was balanced by the extremely wet year 2010 (Fig. 8).

Eighteen dry seasons were recorded in Košice during 1957–2016: April 1961 – October 1962; December 1963 – September 1964; July 1967 – October 1968, when extreme drought was recorded during three months; October 1972 – April 1974 with two extremely dry months; June 1977 – March 1978; November 1983 – April 1984; June 1986 – December 1987, in which one extremely dry month was observed; October 1989 – September 1991; August – September 1992; January 1993 – May 1995; October 1995 – July 1996; August 2000 – February 2001; May 2001 – January 2004 with nine extremely dry months; October 2006 – August 2007, when three months were extremely dry; May – September 2009; September 2011 – September 2012; August 2013 – April 2014; March 2015 – September 2016. The linear trend was decreasing, arid, caused by significant wet seasons in the first half of the period and the onset of two long term droughts in the second half (Fig. 9).

Sixteen dry seasons were observed in Milhostov in the time series 1957–2016: April 1961 – October 1962; November 1963 – July 1964; August 1967 – December 1969; December 1971 – August 1972; December 1972 – April 1974, when last three months were classified as extremely dry; September 1986 – November 1987; September 1989 – October 1991; January 1992 – February 1993; May 1993 – March 1994; July 1999 – June 2000; February – July 2002; May – August 2003; October 2006 – August 2007 with four extremely dry months; July – September 2009; October 2011 – September 2012, one extremely dry month was observed during the season; August 2013 – December 2016, when sixteen extremely dry months were recorded during 2015 and 2016. The linear trend was arid, which could be significantly influenced by an occurrence of very dry months in 2012, 2014 and 2015 and extremely dry months in 2012, 2015 and 2016 (Fig. 10).

In addition, the drought periods in Milhostov can be compared with the results of Tall and Gomboš (2011). They evaluated the series of years 1961–2007 and pointed to extreme drought years 1974 and 2007, when the monthly PDSI index hit the values -5.0 and -4.5. Our results in Milhostov showed the extreme drought in 2007 from May to August with the lowest value (- 5.77) in August. The years 2015 and 2016 with the lowest value of -6.6 in September 2015 were also extremely dry.

Eighteen seasons of drought were recorded in Kamenica nad Cirochou during the time series: April 1961 – July 1964, when twenty-nine extremely dry months were observed; August 1967 – July 1968; November 1971 – April 1972; August 1973 – April 1974; September 1975 – February 1976; June –

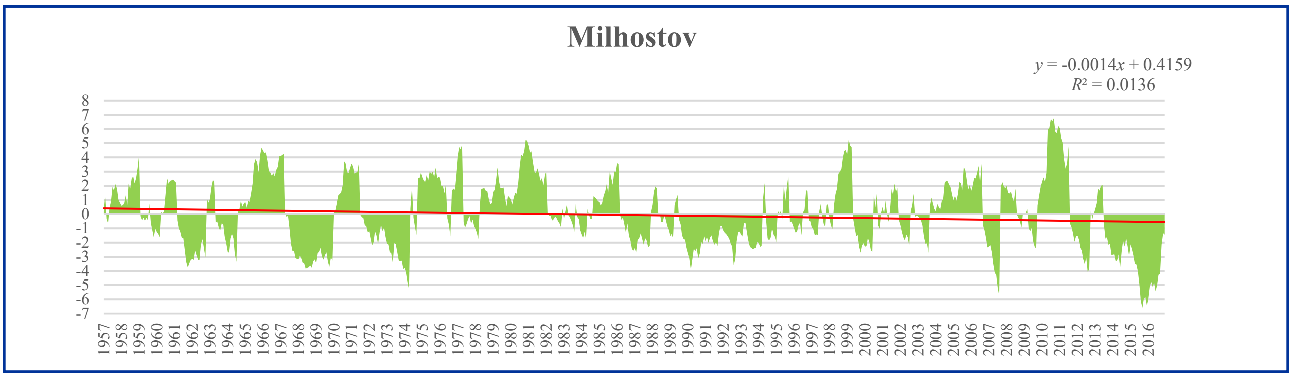

Figure 10 Monthly PDSI in Milhostov during the period from 1957 to 2016

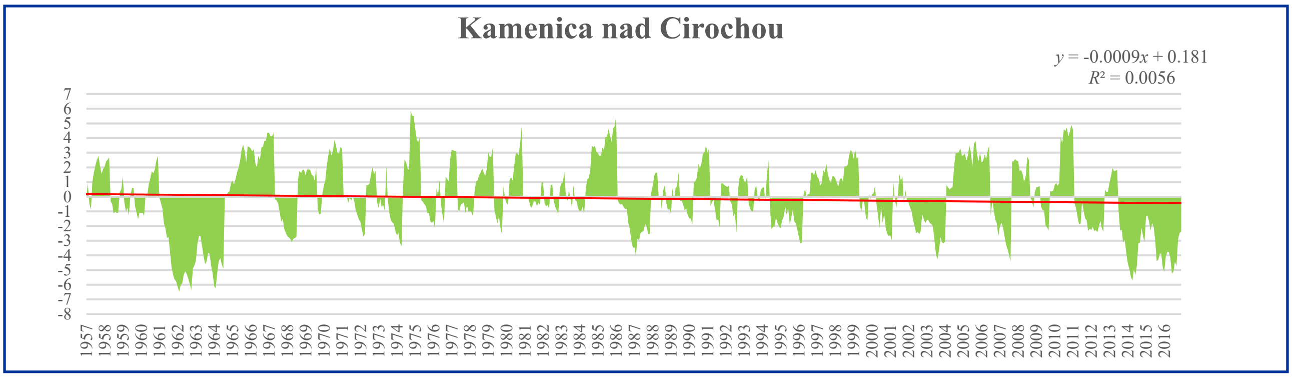

Figure 11 Monthly PDSI in Kamenica nad Cirochou during the period from 1957 to 2016

October 1979; September 1986 – November 1987 with one extremely dry month; July – September 1991; June – August 1992; July 1994 – March 1995; October 1995 – March 1996; May – June 2000; August 2000 – February 2001; April 2002 – January 2004 with one extremely dry month; October 2006 – August 2007, when the last one was extremely dry; July – September 2009; September 2011 – September 2012; July 2013 – December 2016, when extreme drought was observed during seventeen months. The linear trend was decreasing, arid, due to balanced distribution of wet and dry months during the period with more significant occurrence of extremely dry months at the beginning (1961–1964) and at the end (2014–2014) of the period (Fig. 11).

The results of the drought assessment in Slovakia showed several years when drought affected all locations (1964, 1973, 1974, 1992, 2000, 2003, 2006, 2007, 2011 and 2012). The drought periods that occurred in the years were often parts of long-term droughts that lasted several years, but on the other hand, there were also those that lasted several months in given years. The results showed certain conformity with previous studies from other authors, for instance, Valach et al. (2014) analyzed the occurrence of drought in the Horné Požitavie region using the SPEI index (Vicente-Serrano et al., 2010) in the period 1966–2013. They stated in the paper that the periods of extreme drought were recorded from August 1967 to January 1968, August 1982 to June 1984, August 1989 to March 1994, May 1997 to May 1999, June 2000 to August 2001, May 2003 to May 2004, December 2006 to June 2008 and September 2011 to April 2013. Similarly, Vido et al. (2014) evaluated the same location and time period, however, they used the SPI index (McKee et al., 1993). The most significant periods of drought occurred during the years: 1968–1969, 1978–1979, 1989–1994 and 2012–2013. It is clear that the results of both research teams found out that there were cyclical changes of dry and wet periods, which were also graphically demonstrated in this paper.

Conclusion

The article focused on drought assessment in Slovakia by the PDSI in the period 1957–2016. The results of evaluation on the ten selected sites showed several dry seasons, which appeared on all sites at the same time. These represented different time length during the years 1964, 1973, 1974, 1992, 2000, 2003, 2006, 2007, 2011 and 2012. Despite the occurrence of ten common seasons of drought, we can conclude, that results showed the variability of weather conditions in Slovakia not only in time horizon, but also in spatial distribution. The linear trends on nine sites were decreasing, which means that the aridity of the areas was predominant. The humid trend was detected in Čadca, the most northern site. It was caused by a significant occurrence of very wet and extremely wet months from 2010 to 2016.

References

DUNKEL, Z. 2009. Brief surveying and discussing of drought indices used in agricultural meteorology. In Időjárás : Quarterly Journal of the Hungarian Meteorological Service, vol. 113, 2009, no. 1–2, pp. 23–37. ISBN 0324-6329.

EPA. 2016. Climate change indicators in the United States, 2016. 4th ed., EPA 430-R-16-004. www.epa.gov/climate-indicators

FATULOVÁ, E. – MAJERČÁKOVÁ, O. – HOUŠKOVÁ, B. 2015. Globálne vodné partnerstvo pre strednú a východnú Európu. Príručka pre prípravu plánov manažmentu sucha. Vypracovanie a implementácia plánov v kontexte Rámcovej smernice EÚ o vode ako súčasť plánov manažmentu povodí, 2015, 48 pp. ISBN 978-80-972060-0-0.

LITSCHMANN, T. – KLEMENTOVÁ, E. – ROŽNOVSKÝ, J. 2002. Vyhodnocení period sucha v časových řadách pražského Klementina a Hurbanova pomocí PDSI. In ROŽNOVSKÝ, J. – LITSCHMANN, T. (ed.) XIV. Česko-slovenská bioklimatologická konference. Lednice na Moravě, 2. – 4. 9. 2002, pp. 280–289. ISBN 80-85813-99-8. http://www.cbks.cz/sbornik02/Lit%2BKlem%2BRoz.pdf

LITSCHMANN, T. – KLEMENTOVÁ, E. – ROŽNOVSKÝ, J. 2001. Palmerův index závažnosti sucha a jeho použití v našich podmínkách. Poster in: transport vody, chemikálií a energie v systéme pôda-rastlina-atmosféra, Bratislava, 29. 11. 2001.

McKEE, T. B. – DOESKEN, N. J. – KLEIST, J. 1993. The relationship of drought frequency and duration to time scales. In Eighth Conference on Applied Climatology, 17.–22. January 1993, Anaheim : American Meteorological Society, pp. 179–184, https://pdfs.semanticscholar.org/c3f7/136d6cb726b295eb34565a8270177c57f40f.pdf

PALMER, W. C. 1965. Meteorologic Drought : Research Paper no. 45, Washington, D.C. : U.S. Weather Bureau, 58 p. https://www.ncdc.noaa.gov/temp-and-precip/drought/docs/palmer.pdf

PATASSIOVÁ, M. – KLEMENTOVÁ, E. – LITSCHMANN, T. – ČISTÝ, M. 2002. Výskyt sucha a analýza zrážok pri jeho výskyte v jarných mesiacoch. In Acta Hydrologica Slovaca, vol. 3, 2002, no. 1, pp. 94–101. ISSN 13356291. http://www.amet.cz/vyskytsucha.pdf

SPINONI, J. – NAUMANN, G. – VOGT, J. – BARBOSA, P. 2015. European drought climatologies and trends based on a multi-indicator approach, Global and Planetary Change, vol. 127, 2015, pp. 50–57. ISSN 0921-8181. https://doi.org/10.1016/j.gloplacha.2015.01.012

ŠŤASTNÝ, P. – TURŇA, M. 2013. Manažment sucha – Zhodnotenie rokov 2011 a 2012 podľa indexov sucha.

TALL, A. – GOMBOŠ, M. 2011. Aplikácia Palmerovho indexu pre hodnotenie sucha. In SALAŠ, P. (ed) Rostliny v podmínkách měnícího se klimatu. Lednice, 20. – 21. 10. 2011, Úroda, vědecká příloha, 2011, pp. 623-628. ISSN 0139-6013.

VALACH, J. – VIDO, J. – ŠKVARENINA, J. 2014. Zhodnotenie výskytu sucha použitím indexu SPEI v regióne Horného Požitavia. In BRYCH, K. – TESAŘ, M. (eds.): Hydrologie malého povodí 2014. 1st ed., Praha : Ústav pro hydrodynamiku AV ČR, v. v. i. a ČHMÚ, pp. 544–550. ISBN 978-80-02-02526-2 (Ústav pro hydrodynamiku AV ČR, v. v. i.). ISBN 978-80-87577-32-5 (ČHMÚ).

VICENTE-SERRANO, S. M. – BEGUERÍA, S. – LÓPEZ-MORENO, J. I. 2010. A Multiscalar Drought Index Sensitive to Global Warming: The Standardized Precipitation Evapotranspiration Index. In Journal of Climate, vol. 23, 2010, no. 7, pp. 1696–1718. ISSN 1520-0442. DOI: 10.1175/2009JCLI2909.1

VIDO, J. – VALACH, J. – ŠKVARENINA, J. 2014. Zhodnotenie výskytu sucha použitím indexu SPI v regióne Horného Požitavia. In ROŽNOVSKÝ – LITSCHMANN – STŘEDA – STŘEDOVÁ (eds.) Extrémy oběhu vody v krajině. Mikulov, 8. – 9. 4. 2014 [CD]. Praha : ČHMÚ, 2014. ISBN 978-80-87577-30-1.

VINIT K. JAIN – RAJENDRA P. PANDEY – MANOJ K. JAIN – HI-RYONG BYUN 2015. Comparison of drought indices for appraisal of drought characteristics in the Ken River Basin, Weather and Climate Extremes, vol. 8, 2015, pp. 1–11. ISSN 2212-0947. https://doi.org/10.1016/j.wace.2015.05.002

WHITE D. A. 2000. Drought as a natural hazard: concepts and definitions A. Donald, A. Wilhite (Eds.), Drought: A Global Assessment. Routledge, New York, vol. 1, 2000, pp. 3–18.

ŽALUD, Z. – TRNKA, M. – KAPLER, P. – SEMERÁDOVÁ, D. – DUBROVSKÝ, M. 2006. Sucho – problém současnosti i budoucnosti. In Kvasný průmysl, vol. 52, 2006, no. 7–8, pp. 203–234. http://kvasnyprumysl.cz/pdfs/kpr/2006/07/04.pdf

DOI: 10.2478/aree-2019-0009

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FINANCIAL AND PERSONAL ISSUES OF THE TRANSFERRED STATE ADMINISTRATION COMPETENCIES IN THE BUILDING PROCEDURE TO MUNICIPALITY OFFICES

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The aim of the paper is to draw attention to consequences of the transfer of competency at the level of the building procedure from state authorities to municipal offices in the Slovak Republic and the Czech Republic. The defined research objective was achieved firstly by conducting controlled interviews with representatives of the building offices in the Nitra Region and, secondly, by analysis of financing of this competency from the obtained data from publicly available sources in both states. Secondly, the paper includes a comparison of the financial management of the transferred competencies at the level of the building procedure between the Nitra Region (Slovakia) and the Pardubice Region (Czech Republic). By conducting controlled interviews in the Nitra Region, we came to the conclusion of the financial under-dimensioning of this competency. By comparing the amount of state subsidies provided for the building procedure in both regions, significant differences were found. Based on our research findings, we recommend reassessing the state subsidies for the transferred competency in the field of building procedure.

Keywords: transferred competency, building procedure, financial issues, personnel management

In the Slovak Republic, the local self-government structure is currently very fragmented, with a large number of small municipalities (2,927) (Báčik, 2019). "The average municipality population size in Slovakia is only 1,870 inhabitants" (Nemec, 2018). However, each municipality, small or large, has the same original and transferred competencies for which public resources are allocated. However, the amount of these resources is insufficient for municipalities. This creates the problem which needs to be solved. For objective reasons, for a small municipality it is not possible to provide the same services and needs for citizens as a large municipality. This claim is also supported by Matejová et al. (2017), adding that the existence of too small municipalities can lead to inefficient provision of public services.

Delegation of competencies from a higher level (state) to a local level (municipalities) brings many benefits; however, the scope and the way of performance of transferred competencies remain questioned (Fuka et al., 2016).

The performance of competency in the building procedure is one of the competencies which were transferred in Slovakia to the municipalities from the state administration bodies by the Act No. 416/2001 Coll. as amended.

The National Audit Office (NAO) of the Slovak Republic in its evaluation report for 2011-2013, published the result of the effectiveness and efficiency control in the managing of powers by the municipalities of the SR in the building procedure. Its conclusion was the affirmation that 58 per cent of municipalities had to contribute from their own resources to cover the transferred competency (NAO SR, 2014),

In the Czech Republic, the powers of state administration were transferred to municipalities by the Act No. 313/2002 Coll. as amended and at the same time, municipality powers were divided by the Act No. 314/2002 Coll. as amended among municipalities with delegated municipal powers and municipalities with extended powers (Černěnko, 2017). These municipalities receive state subsidies from the budget of the Czech Republic for transferred competencies at the level of the building procedure calculated on the basis of the size of the administrative units (MICZ, 2019).

In Slovakia, funding of this transferred competency regulated by the Act No. 50/1976 Coll. – building law, is financially costly. The law precisely determines the level of education of building office employees, whereby they are obliged to have a university degree and 3 years of professional experience in the field or secondary education and 5 years of the professional experience.

Concerning the financing of the transferred competency within the stipulations of the Decree of the Ministry of Transportation, Construction and Regional Development of the Slovak Republic from December 21, 2010, No 20786/2010-SRVS/z.5414-M, the state is obliged to contribute the sum of 1.11 € per inhabitant for the performance of transferred state administration at the level of the building procedure to each municipality (all municipalities are "Building Authorities" within the Section

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117 of the Act No. 50/1976 Coll. – building act as amended. However, as for the effective financial and personnel provision, subsidy of the transferred performance of state administration at the level of the building procedure to municipalities, is used in accordance with the law – Act No. 369/1990 Coll. as amended:

The Act No. 369/1990 Coll. on the municipal establishment states that municipalities can cooperate with each other on the basis of a contract, and mutual advantages, provided by the Section 20 of the Act.

Klimovský et al. (2014) consider cooperation between municipalities as the key tool to overcome the shortcomings associated with the fragmentation of municipalities. Bryson (2008) comments it also positively.

In the first part of this paper we explain consequences of that part of the reform of public administration in Slovakia (2000–2004) when more than 300 competencies (Marišová et al., 2016) from the state government were transferred to local self-government institutions. It was wide-scale decentralization (Buček, 2017). In this part of the paper, we also mention the transferred competencies from the state to municipalities in the Czech Republic. In the second part of the paper we describe samples of primary data concerning the current situation of voluntary cooperation among municipalities in the building procedure in the SR and in the Nitra Region (NR). In the third part we describe the state subsidy and personal management of the competencies in the building procedure in the SR and in the NR Region. In this section we also express the difference of the amount of the subsidy for the building procedure between the Nitra Region (SR) and the Pardubice Region (CZ). The paper also includes the opinions of employees of the building authorities in the NR Region. In the conclusion, we recommend to change the state subsidy policy in the Slovak Republic in favour of the competency in the building procedure sector.

Material and methods

The aim of the paper is to analyse the consequences of the decentralizastion process of public administration of the Slovak Repubic due to which a large number of state competencies were transferred to municipalities. We deal with the competency at the level of the building procedure – its financial and personnel provision. On the one hand, the paper contains information about the financing of competencies at the level of the building procedure in the SR and the requirements for the qualification skills of employees of building authorities. The paper also includes a comparison of the financial management of the transferred competencies at the level of the building acts between Nitra (SR) and Pardubice (CZ) Regions.

The paper is supplemented by data on the number (26) of joint building offices (JBO) and non-joint (11) building offices (NBO) performing competencies at the level of the building procedure separately in the SR and in the NR Region and about their financial issues. At the same time, the paper is supplemented by the data on municipalities (42) with delegated municipal powers and municipalities with extended powers in the building procedure sector in the Pardubice Region (CZ).

By means of qualitative research carried out in the municipalities of the NR Region, according to the Section 20 of Act No. 369/1990 Coll. as amended – on the municipal establishment, we came to the following conclusion: In the form of a contract at the level of the building procedure, municipalities created JBO (26) and the rest of them perform this competency independently – NBO (11).

We base our findings on the opinions of delegated employees of the building offices in the Nitra Region, on the financial and personnel management of this transferred competency. Primary information is obtained through controlled interviews with senior staff personnel of the building offices of the NR Region in the period from September 2018 to February 2019, supported by the opinions of authors dealing with identical issues. Among the identifiable quantitative data (obtained from publicly available sources) in the paper at the level of the NR Region, there are: the number of JBO, the number of NBO (source: Ministry of Interior of the Slovak Republic), the number of inhabitants living in municipalities with individual joint building offices (JBO) and non-joint building offices (NBO), (based on data from the Statistical Office of the SR), the number of operations of building offices and the amount of subsidies for the transferred competency of the building procedure for individual JBO and NBO in the NR Region.

The primary data for the Pardubice Region include the number of inhabitants living in the Pardubice Region, number of municipalities with delegated municipal powers and municipalities with extended powers falling under the building offices on the territory of the Pardubice Region (42) and the amount of the state subsidy for building procedure for building offices in the Pardubice Region (Pardubice Region, 2011).

The annual amount of the subsidies for the transferred state administration performance in Slovakia was expressed at the level of the building procedure for joint building offices and non-joint building offices by the following formula:

$$\textit{state subsidies} = \textit{population as on December } 31 \times 1.11\ €$$

1.11 € – inhabitant "Decree of Ministry of Transport, Construction and Regional Development of the Slovak Republic N. 20786/2010-SRVS/z.54145-M"

The amount of the total state subsidy for one act of operation of the building office:

$$\textit{subsidies for operation} = \frac{\textit{total state subsidy for a building office}}{\textit{number of operations of a building office/year}}$$

Results and discussion

During the Public Administration reform in 2000–2004, the Government of the Slovak Republic approved "The Conception of Decentralization and Modernization of Public Administration", by which more than 300 competencies were transferred from local state government (regional and district offices) to territorial self-government. This is the most difficult period of public administration development. The Act No. 416/2001 Coll., the so-called Small Competency Law, came to force (Marišová et al., 2016).

In the Czech Republic, similarly to Slovakia, a large number of competencies were transferred from the state government to municipalities by the Act No. 313/2002 Coll. as amended and at the same time the powers of municipalities were allocated by the Act No. 314/2002 Coll. as amended between municipalities with delegated municipal powers or municipalities with extended powers.

However, there is the following difference in the public administration reform, related to building competencies in Slovakia and the Czech Republic: In Slovakia, building competencies are performed by every municipal office, and in the Czech Republic, building offices are established in municipalities of II. and III. categories (municipalities with delegated municipal powers and municipalities with extended powers). Municipalities of the Czech Republic are divided into individual categories under the Act No. 314/2002 Coll. as amended (Černěnko, 2017).

The current problem of territorial self-government in the Slovak Republic is the lack of ability of some small municipalities to perform the competencies entrusted to them (Hvišč, 2017).

The requirement to solve this problem lies mainly in its impact on the efficiency and quality of the competencies carried out by self-governments as well as the financial under-dimensioning of the transferred competency.

According to the Section 20 of the Act No. 369/1990 Coll. on municipality establishment as amended, municipalities have the option, on a voluntary basis, to perform certain competencies within a contract of cooperation. Since 2002, 189 joint building offices (JBO) have been established, which covers 2,460 municipalites. The rest of Slovak municipalities (278) perform their competencies on their own (non-joint building offices) (Ministry of Interior of the SR, 2018). It is and example of joint building offices, operating on the basis of cooperation of municipalities within the understanding of the Section 20 of the Act No. 369/1990 Coll. on municipal establishment (Hrabánková et al., 2010).

The total number of municipalities in the Czech Republic is 6,257. The competency in the building procedure is implemented by 388 municipalities of II. category (municipalities with delegated municipal powers) and 205 municipalities of III. category (municipalities with extended powers) (MICZ, 2019). As for the Pardubice Region, there are in total municipalities (451), out of them 15 municipalies of II. category and 26 municipalies of III. category (Towns and Communities Online Portal, 2019).

The NR Region is specific, as 343 municipal offices belong to 26 JBO and only 11 perform the competency of building procedure individually – NBO (MISR, 2018). Thus, 96.89 per cent of the Nitra Region municipalities are part of joint building offices.

For the aim of the VEGA project, No. 1/0190/17, "Analysis of models of public services delivery in the field of construction order performance from the aspect of technical, size, and spatial allocation efficiency of local governments" and for the elaboration of the dissertation under the title:" Assessment of the competencies of municipal performance in the construction order sector", data on the amount of acts of individual offices were obtained from individual JBO and NBO of the NR region and within the frame of qualitative evaluation. Controlled interviews were conducted with staff members of joint building office (JBO) and non-joint building office (NBO): As many as 24 joint building offices (JBO) out of the 26 JBO and 9 building offices (NBO) out of the 11, which perform the competency at the level of the building procedure separately (NBO) in the NR Region, participated in the controlled interview.

Among the main reasons for merging offices in the sphere of building according to controlled interviews with staff members of building authorities in the NR, there were the following factors: size of municipalities, localization of municipalities, qualified personnel, and technical and material conditions of the authorities.

These are the factors that effectively influence the transferred competency performance at the level of the building regulations. Narbón Perpiña and DeWitte (2018) discuss them similarly in their study, complementing them by: population, complete infrastructure build-up, providing of public services, etc.

The JBO in the Nitra Region were asked the following questions:

1. Has your JBO been bound to recruit another employee to provide the acts of the building procedure?
2. Legislative regulation requiring law education of employees of the building offices, which was the subject of a draft amendment to the Act No. 50/1976 Coll. – Building Act, as amended, is still absent. Is law education of employees necessary?
3. Would you suggest the change of fixed rate of state subsidies?

The first question was answered by all 24 JBOs. Nine of them said "yes", that is, they had to recruit a new employee to perform acts of JBOs, and it was found that the main reason was the annual increase in the building office´s agenda and the demands of the state. However, this increase in the number of employees could only be realized after the approval by mayors of the municipalities that fall under the individual JBOs. At the same time, the offices should commit to finance jointly the monthly wages from their own resources because the state subsidy on transferred competency is insufficient.

Fifteen authorized employees of JBOs in the NR Region, who answered the identical question, replied that the number of employees of JBOs has not increased. However, the increase in the number of employees has not been realized, not because they would not need another employee, but because of financial incapability of JBOs to pay them. The employees, during the controlled interview, also pointed out to the the fact that young people who would have the qualification to fill a job at building office, are not interested in such a work because of financial under-dimensioning.

The Section 2a of the Act No. 50/1976 Coll. – the Building Act, as amended, stipulates that an employee of a building office can be a professionally qualified natural person who is irreproachable, has a higher eduation degree or a bachelor degree in the relevant field and at least three years of experience in the relevant field. Other possibility for an employee is to have :

– secondary education in the relevant field completed by a final exam,
– five years of experience in the relevant field,
– qualifying examination.

"Legislative regulation requiring law education of employees of building offices which was the subject of the draft amendment to the Act No. 50/1976 Coll. – Building Act, as amended, is still absent. Is law education of employees necessary?"

This 2nd question of the controlled interview was answered: Out of the nine, eight (NBO: Dvory nad Žitavou, Hájske, Ivanka pri Nitre, Klížska Nemá, Komoča, Močenok, Šaľa, Veľké Kosihy) answered the question, three of them said "yes", but the empolyee of an NBO in Komoča pointed out that to get a person with law education to the aforementioned position on the basis of the current inadequate financial motivation is very difficult. But the motivation of employees is very important.

Nowadays, Šafránková and Šikýř (2019) say that motivation is very important to staff. A motivated and satisfied employee is the basis for the aim of a public organization.

The employees jointly agreed that an employee of a building office should be skilled in legislation and should have knowledge of technical or construction direction; it is good to have a lawyer available at a municipal office.

The employees of the JBOs and NBOs were also asked about the financing of the transferred competency in the field of the building procedure.

According to the Act No. 523/2004 Coll. on budgetary rules of public administration and on amendments and supplements to some acts as amended, in accordance with the act on the state budget for a relevant financial year, municipalities and higher regional units get state subsidies for performance of transferred state administration.

In the section of the building procedure, it is about the amount of the subsidy determined in the frame of the Section 3 of the Decree of the Ministry of Transportation, Construction and Regional Development of the Slovak Republic No. 20786/2010-SRVS/ z.54145-M, which was 0.930 € per inhabitant. By the decree of the Ministry of Transport, Construction and Regional Development of the Slovak Republic dated March 16, 2018, the amount of this subsidy, in terms of the same decree, was replaced by the amount of 1.11 € per inhabitant.

The following table 1 shows the amount of the subsidy for the transferred competency of the state administration assigned to individual building offices in 2016 by regions.

The 3rd question of the controlled interview: "Would you suggest changing a fixed rate?" was answered by stuff members of building authorities of 24 JBOs and 9 NBOs. The answer was yes from all 24 JBOs and 7 NBOs. One employee of an NBO (Dvory nad Žitavou) said that he would not propose a change in the fixed rate and one employee said that he had not noticed a fixed rate yet.

The table 2 shows the following data: number of inhabitants falling under individual building offices as on December 31, 2015 – JBO/NBO NR region (column 3), number of building offices activities of the Nitra Region – JBO/NBO (column 4) for 2016 (total number: building permits (BP), certificates of occupancy (CO), territorial decisions issued (TDI), additional construction permissions issued (ACPI) and other decisions issued (OD). Column 5 shows the amount of state subsidy allocated to a particular building office for 2016. The last column of the table analyzes the state subsidy in 2016 for the number of legal activities (BP, CO, TDI, ACPI, OD) recalculated state subsidy per 1 inhabitant/year. The calculation of governmental subsidies is based on the amount of subsidy for one of the above mentioned activity from the building order.

The amount of the state subsidy for the transferred state administration performance in the area of the building procedure sector for the NR for 2016 amounted to 12.59 per cent of the total state resources for this competency. The maximum volume of funds within the NR was allocated to the JBO Nitra (14.02 per cent) and subsequently to the JBO Levice (10.21 per cent) and JBO Nové Zámky (8.18 per cent). At the JBO Nitra, the most activities of employees of the building offices in the NR were registered (1,904), followed by the JBO Nitrianske Hrnčiarovce (1,230) and the JBO Vráble (1,132). Based on the quantified amount of the state subsidy for individual building offices of the NR Region and the number of activities of employees of the building

Table 1 Subsidies for building regulations

Region	Population as of December 31, 2015	State subsidy for building regulations (€)
Bratislava	625,167	693,935.37
Trnava	558,677	620,131.47
Trenčín	591,233	656,268.63
Nitra	682,228	757,273.08
Žilina	690,449	766,398.39
Banská Bystrica	655,359	727,448.49
Prešov	819,977	910,174.47
Košice	795,565	883,077.15
Total	5,418 655	6,014,707.05

Source: Data-based processing by the Statistical Office of the Slovak Republic 2016 and data recalculated based on the "Decree of the Ministry of Transport, Construction and Regional Development the Slovak Republic N. 20786/2010-SRVS/z.54145-M"

Table 2 Financing of competencies in Nitra Region (year 2016)

Name of JBO/NBO NR Region	Category JBO/NBO	Population	Number of activities	State subsidy for building regulations (by population in €/year	Governmental Subsidies €/activity
Andovce	NBO	1,418	28	1,573.98	56.21
Bátorove Kosihy	JBO	9,131	203	10,135.41	49.93
Dvory nad Žitavou	NBO	5,131	67	5,695.41	85.01
Hájske	NBO	1,309	57	1,452.99	25.49
Hurbanovo	JBO	23,937	532	26,570.07	49.94
Ivanka pri Nitre	NBO	2,492	50	2,766.12	55.32
Jasová	JBO	2,795	19	3,102.45	163.29
Klížska Nemá	NBO	502	11	557.22	50.66
Kolárovo	JBO	18,005	251	19,985.55	79.62
Komárno	JBO	46,668	683	51,801.48	75.84
Komoča	NBO	940	17	1,043.40	61.38
Kráľová nad Váhom	JBO	9,976	577	11,073.36	19.19
Krušovce	JBO	3,089	110	3,428.79	31.17
Levice	JBO	69,669	578	77,332.59	133.79
Močenok	NBO	4,289	68	4,760.79	70.01
Mojmírovce	JBO	5,857	293	6,501.7	22.19
Nitra	JBO	95,619	1,904	106,137.09	55.74
Nitrianske Hrnčiarovce	JBO	34,481	1,230	38,273.91	31.12
Nové Zámky	JBO	55,802	888	61,940.2	69.75
Prašice	JBO	2,350	73	2,608.50	35.73
Solčany	JBO	13,054	376	14,489.94	38.54
Strekov	JBO	2,990	94	3,318.90	35.31
Svodín	JBO	16,278	450	18,068.58	40.15
Šahy	JBO	18,230	211	20,235.30	95.90
Šaľa	NBO	22,714	627	25,212.54	40.21
Štúrovo	JBO	14,930	337	16,572.30	49.18
Šurany	JBO	40,915	705	45,415.65	64.42
Tekovské Nemce	NBO	1,079	19	1,197.69	63.04
Tešedíkovo	JBO	14,225	69	15,789.75	228.84
Topoľčany	JBO	52,854	1,023	58,667.94	57.35
Veľké Kosihy	NBO	963	15	1,068.93	71.26
Veľký Lapáš	JBO	3,658	215	4,060.38	18.89
Vráble	JBO	25,849	1,132	28,692.39	25.35
Zemianska Olča	JBO	3,755	56	4,168.05	74.43
Zlaté Moravce	NBO	11,787	354	13,083.57	36.96
Želiezovce	JBO	24,975	578	27,722.25	47.96
Žitavany	JBO	20,512	339	22,768.32	67.16
TOTAL	37	682,228	14,239	757,273.08	53.18

Source: Data-based processing by the Statistical Office of the Slovak Republic 2016 and data recalculated based on the "Decree of the Ministry of Transport, Construction and Regional Development the Slovak Republic N. 20786/2010-SRVS/z.54145-M"and data form employees of building offices

Table 3 Financing of competencies in the Pardubice Region (year 2016)

Municipalities with buidling office	Population	State subsidies for building regulation (€)*
Tatenice	1,284	8,415.65
Výprachtice	1,674	10,950.05
Nasavrky	1,926	19,708.91
Sloupnice	2,126	13,878.52
Ronov nad Doubravou	2,470	16,101.61
Dolní Čermná	2,538	16,540.51
Dolní Dobrouč	2,588	16,863.13
Červená voda	3,068	19,955.68
Luže	3,079	20,026.45
Proseč u Skutče	3,379	21,955.21
Dašice	3,648	23,682.17
Seč	3,845	34,694.21
Bystré	3,906	25,336.44
Brandýs nad Orlicí	4,106	16,830.87
Městský úřad Slatiňany	4,191	27,161.53
Choltice	4,248	27,526.25
Březová nad Svitavou	5,612	37,277.67
Králíky	5,736	19,936.55
Chvaletice	5,948	38,364.57
Sezemice	6,233	40,174.55
Jevíčko	6,601	42,508.88
Skuteč	7,407	47,611.11
Jablonné nad Orlicí	7,680	49,336.15
Letohrad	8,251	52,939.26
Heřmanův Městec	10,045	64,218.66
Lázně Bohdaneč	11,579	73,074.42
Chrast	12,828	81,604.44
Žamberk	13,231	46,458.54
Choceň	13,831	78,272.05
Přelouč	14,409	49,561.89
Polička	15,688	54,184.75
Holice	17,473	61,340.34
Lanškroun	17,674	60,739.98
Vysoké Mýto	18,166	61,612.23
Česká Třebová	19,332	64,475.05
Moravská Třebová	19,911	68,502.91
Hlinsko	21,222	73,256.88
Ústí nad Orlicí	22,048	74,506.83
Litomyšl	24,307	83,922.40
Svitavy	25,543	85,607.62
Chrudim	31,663	104,448.69
Pardubice	105,829	319,208.21
TOTAL	516,323	2,152,771.84

Source: Czech Statistical Office, 2016; Ministry of the Interior of the Czech Republic, 2016
* the amount of the state subsidy calculated by the exchange rate NBS as of March 29, 2019; 1 € = 25.786 CZK

Table 4 Financing of competencies in Nitra and Pardubice regions

Region	Municipalities	Population	State subsidies (€)
Nitra	354	682,228	757,273.08
Pardubice	451	516,323	2,152,771.842

Source: Statistical Office of the Slovak Repubic, 2016; Ministry of the Interior of the Slovak Republic, 2018; Czech Statistical Office, 2016; Ministry of the Interior of the Czech Republic, 2016

authorities, the highest amount of funds per 1 activity was recorded at JBO Tešedíkovo (228.84 €) and subsequently at JBO Jasová (163.29 €) and JBO Levice (133.79 €). The lowest volume was found out in JBO Veľký Lapáš (18.89 €), JBO Kráľová nad Váhom (19.19 €) and JBO Mojmírovce (22.19 €).

It is clear from this analysis that the amount of the state subsidy is not fairly and proportionally divided into individual municipalities. Some building officies (Tešedíkovo) have a significantly higher volume of state subsidies than other municipal offices (Jasová, Levice).

In 2013, Ftáčnik from the Union of Towns and Cities of Slovakia pointed out at least a partial solution to the lack of funds in the area of building regulations by increasing fees (Act No. 145/1995 Coll, On Administrative Fees, as amended) for the acts of bulding authorities. The proposal was rejected.

The table 3 was prepared to compare the funding of transferred competencies at the level of the building procedure between the Slovak Republic and the Czech Republic. Table 3 contains data for the Pardubice Region (CZ). The column 1 contains the names of municipalities with the building authority in the Pardubice Region. The column 2 contains the population in the PR region based on data from the Czech Statistical Office. In the column 3, there is the amount of the state subsidy allocated to a specific building authority in the Pardubice Region (the amount of the subsidy is expressed on the basis of a specific methodological procedure for calculatiion of the state subsidy for the transferred state administration in CZ). Based on the availability of data, it was not possible to process the number of building offices activities in the Pardubice Region.

The population in the Czech Republic was 9,279,196 as of December 31, 2016 (Czech Statistical Office, 2016). The inhabitants lived in 6,257 municipalities. The total amount of state subsidy for building procedures in the Czech Republic was 37,955,259.09 EUR[1] (MICZ, 2016) The amount of state subsity for building procedures from the total state subsidy in the Czech Repulic for the Pardubice Region was 5.67 per cent. The maximum volume of funds within the PR of the Region was directed to the Pardubice building office (14.83 per cent) and subsequently to the following building offices: Chrudim, Svitavy, Litomyšl etc.

The table 4 shows the following sumary data: number of municipalities, population and state subsidy for competencies in the building procedure sector in € for Nitra and Pardubice Regions per year 2016.

From Table 4 we can identify the differences between the number of municipalities, the population and the amount of the state subsidy for the transferred competencies at the building procedure sector for 2016 for the Nitra and Pardubice regions. The Nitra Region had lower number of municipalities than the Pardubice Region but more population than the Pardubice Region. The comparative analysis showed that the Nitra Region performing the building procedure competency had by 64.82 per cent lower volume of state financial subsidy than the Pardubice Region performing the same competency.

Conclusion

The transfer of competencies from the central government to self-government has caused changes in its functioning. One of many of these competencies is the competency in the building procedure sector. This competency was transferred to municipalities from Slovak state administration bodies by the Act No. 416/2001 Coll. – Act on the Transfer of Certain Powers from State Administration to Municipalities and Higher Territorial Units, as amended.

The transfer of competencies of municipalities in the building procedure in Slovakia was carried out in two ways: at a municipal office as non-joint building office or at a joint building office.

In the Czech Republic, the powers of state administration have been transferred to municipalities by the Act No. 313/2002 Coll. as amended and at the same time the powers of municipalities were divided by the Act No. 314/2002 Coll. as amended between municipalities with delegated municipal powers and municipalities with extended powers.

The aim of this paper was to investigate the consequences of the process of decentralization of public administration, in which a large number of state competencies were passed to municipalities. At the same time, the research team of the project analyzed the facts and opinions of the employees of the building offices in the Nitra Region on the staff issues of building procedure. The research team also compared the amount of state subsidy for building procedure sector in the Nitra Region and in the Pardubice Region. The research stated a financial under-dimensioning of the transferred competency, based on the interviews with employees of the building authorities and based on the compared state subsidies between the Nitra Region (Decree of the Ministry of Transport, Construction and Regional Development the Slovak Republic N. 20786/2010-SRVS/z.54145-M") and the Pardubice Region (MICZ, 2016).

At the same time, the research came to the conclusion that the competency, which is also related to its insufficient personnel staffing, is financiallly under-compensated. For the future formation of building offices not only in the Nitra Region but also in the whole Slovakia, it would be effective to re-assess especially the state of financial subsidy for this transferred competency.

1 The amount of the state subsidy calculated by the exchange rate NBS as of March 29, 2019; 1 € = 25.786 CZK

References

BAČÍK, V. 2019. The Slovak Republic. Bratislava : UK. Online. Available on the Internet: http://www.sodbtn.sk/obce/index_kraje.php

BUČEK, J. 2017. Why and When Countries Implement Local Public Administration Reforms: A Long-Term View of Reform Dynamics in Slovakia, 1990–2015. In Local government and urban governance in Europe, Urban Book Series, 2017, pp. 30–70. doi: 10.1007/978-3-319-43979-2_3

BRYSON, P. J. 2008. "State administration" vs. self-government in the Slovak and Czech Republics. In communist and post-communist studies, vol. 41, 2008, no. 3, pp. 339–358. doi: 10.1016/j.postcomstud.2008.06.003

CZECH STATISTICAL OFFICE. 2016. Demographic and social statistics. Available on the Internet: https://vdb.czso.cz/vdbvo2/faces/cs/index.jsf?page=statistiky

ČERNĚNKO, T. a i. 2017. Skrytý podklad v samospráve – Alternatívne možnosti sústredenia výkonu správy v samosprávach. Online. Available on the Internet: http://www.finance.gov.sk/Default.aspx?CatID=11457

FTÁČNIK, M. 2013. Letter to the Minister. Bratislava: The Union of Towns and Cities of Slovakia. Available on the Internet: http://www.unia-miest.sk/assets/File.ashx?id_org=600175&id_dokumenty=4359

FUKA, J. et. al. 2016. Differences in Municipal Structure in Czech and Slovak Republic with Emphasis on Delegated Powers. Italy: 27th International Business Information Management Association Conference. Innovation management and education excellence vision 2020: from regional development sustainability to global economic growth, vols I–VI, 2016, pp. 252–261.

HRABÁNKOVÁ, M. et al. 2010. European Union Public Administration and Development Policies and Variations in V-4 Countries. Nitra : SUA, 2010. 221 p. ISBN 978-80-552-0341-6.

HVIČŠ, O. 2017. Local administration reform and principles of public administration reform. Košice : UPJŠ. Online. Available on the Internet: https://www.law.muni.cz/sborniky/Days-of-public-law/files/pdf/sprava/Hvisc.pdf

KLIMOVSKÝ, D. et al. 2014. Inter-Municipal Cooperation in Lithuania and Slovakia: Does Size Structure Matter? In Lex localis-journal of local self-government, vol. 12, 2014, no. 3, pp. 643–658. doi: 10.4335/12.3.643-658(2014)

MATEJOVÁ, L. et al. 2017. Economies of Scale on the Municipal Level: Fact or Fiction in the Czech Republic? In Nispacee journal of public administration and policy, vol. 10, 2017, no. 1, pp. 39–59. doi: 10.1515/nispa-2017-0002

MARIŠOVÁ, E. et al. 2016. Administrative Law. Nitra : SUA, 2016, 204 p. ISBN 978-80-552-1567-9.

MINISTRY OF INTERIOR THE SR (MISR). 2018. Overwiev of common municipalit 25y offices in the register of Ministry Interior of SR (as at 31 September 2018). Online. Available on the Internet: https://www.minv.sk/?prehlad_SOU

MINISTRY OF THE INTERIOR OF THE CZ (MICZ). 2016. Příspěvek na výkon státní správy. Online. Available on the Internet: https://www.mvcr.cz/clanek/prispevek-na-vykon-statni-spravy-prispevek-na-vykon-statni-spravy.aspx

MINISTRY OF THE INTERIOR OF THE CZ (MICZ). 2016. Online. Available on the Internet: https://www.mvcr.cz/clanek/privetivy-urad-obci-ii-typu-2016.aspx

THE NATIONAL AUDIT OFFICE IN THE SR (NAO). 2014. Protocol of Effectiveness and Efficiency of Performance Surveillance by tie Municipalities of the Slovak republic. Online. Available on the Internet: https://www.nku.gov.sk/documents/10157/6058fdaa-cf0b-4d4b-b8c9-7fac28257fe0

NARBÓN PERPIÑA, I. – DeWITTE, K. 2018. Local governments' efficiency: a system at icliterature review – part I. In International Transactions in Operational Research, vol. 25, 2018, no. 2, pp. 431–468. doi:10.1111/itor.12364.

NEMEC, J. 2018. Public Administration Reforms in Slovakia: Limited Outcomes (Why?). In Nispacee journal of public administration and policy, vol. 11, 2018, no. 1, pp. 115–134. doi:10.2478/nispa-2018-0005

PARDUBICE REGION. 2011. Obce Pardubického kraje – příslušný stavební úřad. Online. Available on the Internet: https://www.pardubickykraj.cz/stavebni-rad/31508/stavebni-urady-pardubickeho-kraje

STATISTICAL OFFICE OF THE SLOVAK REPUBLIC. 2016. Demographic and social statistics. Available on the Internet: http://datacube.statistics.sk/#!/lang/en

ŠAFRÁNKOVÁ, J. M. – ŠIKÝŘ, M. 2019. Principles of people management in public administration. Praha : College of Regional Development and Banking Institute – AMBIS, 2019.

TOWNS AND COMMUNITIES ONLINE PORTAL. 2019. Regions – Districts. Online. Available on the Internet: http://mesta.obce.cz/