Research report

National Research, Development and Innovation Office

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RESEARCH ON THE APPLICATION OF RENEWABLE ENERGY UTILIZATION AND LANDSCAPE PROTECTION ON SAMPLE AREAS OF HUNGARY

CHALLENGES AND PERSPECTIVES

Edited by Mária Szabó, Gergely Horváth, Gábor Csüllög, Béla Munkácsy & Gábor Michalkó

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Research on the application of renewable energy utilization and landscape protection on sample areas of Hungary – challenges and perspectives

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1. Aims, aspects and sample areas of the research

The research of the consortium consisting of the researchers of the Department of Environmental and Landscape Geography of the Institute of Geography and Geosciences of Eötvös Loránd University and the Geographical Institute of the Research Centre for Astronomy and Earth Sciences of the Hungarian Academy of Sciences encompassed the investigation of the impacts of the industrial and within that related energy production and mining processes on the landscape, on the other side the potential of certain renewable energies (e.g. solar energy and biomass), and finally the usability of these energy sources in the tourism in sample areas. Coming to the fore of the renewable energies became necessary due to the decrees of the United Nations and the European Union as well. Also in Hungary it is necessary changing the structure, which needs adequate legal background, longsighted complex planning and the investigation of the conditions taking into consideration the impacts on the landscape, specifically the utilization of the renewable energies and the requirement of the landscape conservation are often resources of conflicts. In addition, especially in economically undeveloped regions the alteration of the approaches of the local inhabitants relating to both the renewable energies and the landscape is also important; this was widely proved by the surveys made during the research.

For implementing the research programme three sample areas were chosen. The first area was stated in Komárom-Esztergom County, containing the districts of Komárom, Tata and Esztergom. These traditional, however, by now declined and in several places strongly degraded industrial regions provided an opportunity for surveying the regional structure of the sectors of industry and energy, for measuring their load on the landscape and for sizing up the recent situation of the economic utilization of the renewable energies. The second area was marked out in Nógrád County, Salgótarján town and its vicinity, the northern part of the Novohrad–Nógrád Geopark in the Hungarian side, which provided possibility for exposing the environmental problems caused by the mining and industrial activity and the landscape conflicts as their consequences; a question was what kind of new exploitable activities could be evolved and what kind of special perspectives would offer themselves for utilization of renewable energies. The third area was assigned in Borsod-Abaúj-Zemplén County, where several villages embracing the central part of the Bükk Mountains united in a LEADER group; this alliance of 48 settlements has already introduced a programme “1 village – 1 MW” focusing on renewable energies and began to implement small-size energy producing systems for local communities.

2. Results

2.1. Quantitative assessment of landscape load

2.1.1. Landscape load in Komárom-Esztergom County

The aim of the investigations was to quantify the landscape conflicts caused by industrial and mining activities on the sample areas and to represent them by GIS methods. On the first sample area (Komárom-Esztergom County) – an area which has been considerably industrialized for approximately 150 years – this was approached by the aspects of landscape sensibility, landscape load and industrial influence. The industrial landscape conflicts have been visualized using elaborated methods and geoinformatical models, which exceeded the object-level environmental approaches formerly used in most cases (TAMÁS, L. et al. 2016 a). The methodological base of the investigation of the industrial pressure on the landscape was carried out with regard to the specific characteristics of the Hungarian industry. During modelling the main emphasis was laid on studying the aspects, how industrial processes appear in the landscape, encompassing both linear and patch-like elements.

For determining the delimitation of the industrial objects three methods were applied: taking data from official state databases; using photo interpretation; and going-over on field. In all the three cases it has been an important effort for collecting as much data as possible and for creating a unitary data structure. Such a sample area was chosen that contained both natural and anthropogenic elements in variegated extent and on which the perception of the industrial impact on the landscape, which is the condition of modelling the impacts, was obvious.

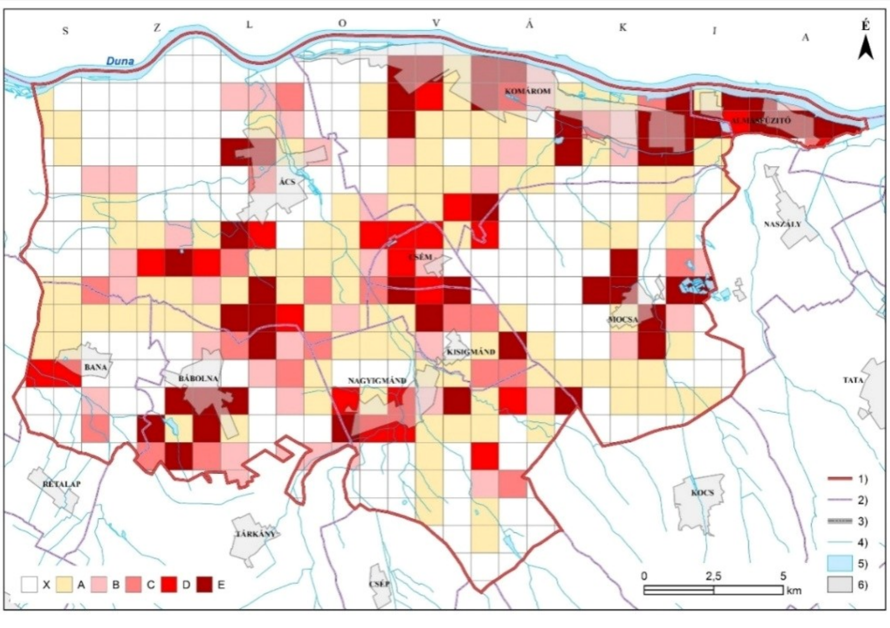

Figure 1. Industrial influence indices in Komárom District (ed. by TAMÁS, L. & CSÜLLÖG, G.). Legend: 1 = border of the investigated area; 2 = administrative borders of the settlements; 3 = state border; 4 = rivers; 5 = lakes; X = no influence; A = low influence; B = moderate influence; C = medium influence; D = above the average influence; E = high influence

For measuring industrial influence indices, 441 cells was created, each of them 1x1 km^2, and these cells totally covered the 379 km^2 area of Komárom District. The number of the investigated industrial objects was 329, and more than half of the cells, 248 contained industrial objects, the extent of which is altogether 4.7% of the district's total area (*Figure 1*). Thus, both the territorial extent and the distribution prove considerable industrial existence (TAMÁS, L. et al. 2016b, 2017).

Investigating the landscape conflicts it was stated that there are 135 cells which are touched by conflicts of different level from the critical mass to the low force (*Figure 2*). Beyond the 5 main types also 24 subtypes of the intensity were determined. By determining these different types concrete landscape-managing recommendations can be worked out, taking into consideration the aspects of landscape rehabilitation, too. The intensity degree of the conflict marks – from point of view of the environment – the deteriorative localities, or even the advantageous developing trends (TAMÁS, L. et al. 2017).

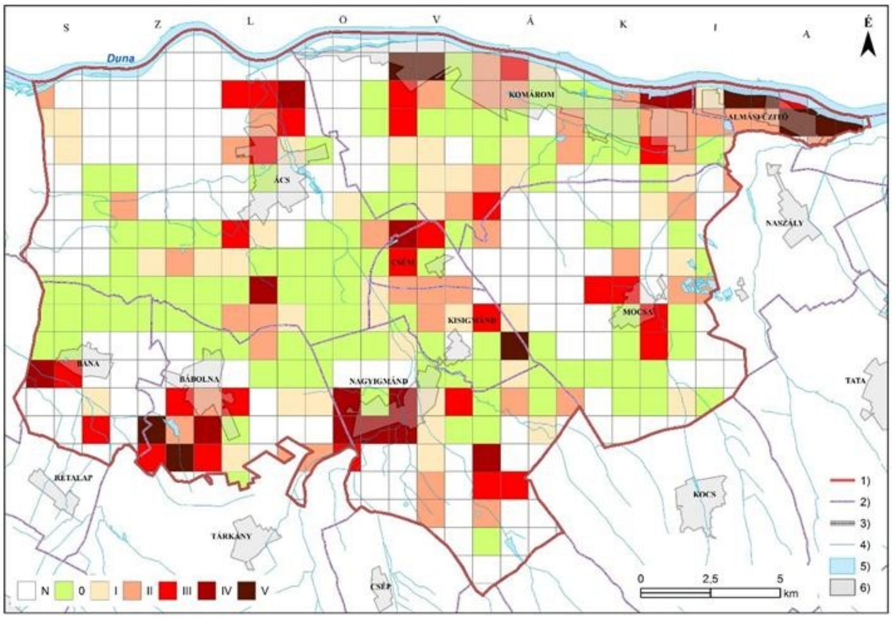

Figure 2. Spatial model of the industrial landscape conflict in Komárom District (ed. by TAMÁS, L. & CSÜLLÖG, G.). Legend: 1 = border of the investigated area; 2 = administrative borders of the settlements; 3 = state border; 4 = rivers; 5 = lakes; 6 = central inner part of the settlements; N = no measured conflicts; 0 = identification of conflicts is not reasonable; I = low level; II = moderate level; III = medium level; IV = high level; V = critical level of conflicts

Of course, elements of the type V (critical level of landscape conflicts) mean the greatest problem in the district. Such areas can be found altogether in 10 cells, reaching about 3% of the total district. Although this rate is low, however, landscape elements of this critical level have high landscape sensibility, like the floodplain of the Danube, the areas of water protection, certain sensible rock strata or semi-natural habitats surrounded by areas of high industrial influence.

The main result of the investigation is the method worked out for quantitative determination of the industrial landscape load. It can contribute to considerable extent on the one hand to the rational survey of the state of the environment of the given area, taking into consideration the interdependences in the landscape, on the other hand to the activities on regional planning and regularization like selection of areas for re-use and reclamation, planning of environmental reconstruction, eventual new mine openings etc. Some results, including recommendations can be seen in *Figure 3*.

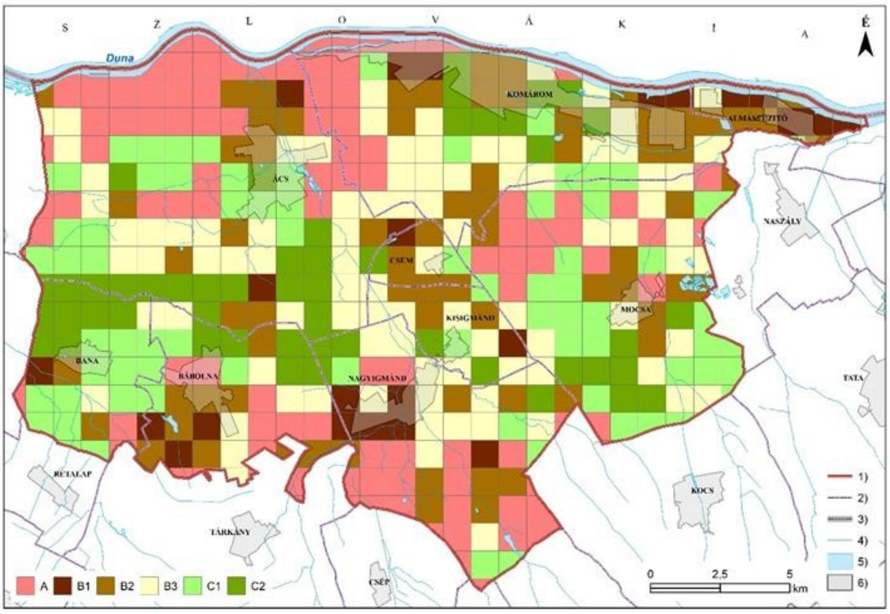

Figure 3. Possibility of industrial locations depending on the load on landscape in Komárom District (ed. by TAMÁS, L. & CSÜLLÖG, G.). Legend: 1 = border of the investigated area; 2 = administrative borders of the settlements; 3 = state border; 4 = rivers; 5 = lakes; 6 = central inner part of the settlements; A = encouragement of industry-proof semi-natural landscape management; B1 = only industrial landscape reclamation can be recommended; B2 = only expansion within the site can be recommended; B3 = only settling of industrial objects of low landscape load and small extent can be recommended; C1 = only settling of agrarian objects of low landscape load can be recommended; C2 = settling of new industrial objects can be recommended

2.1.1. Landscape load in Nógrád County

On the other sample area, the northern part of the Novohrad–Nógrád Geopark in Nógrád County other types of landscape conflicts have to be solved. The geopark, established in 2011 has considerable geoheritage and advantageous landscape potential (HORVÁTH, G. & CSÜLLÖG, G. 2011, 2013). Nevertheless, it has also a less advantageous feature in correspondence with the strong anthropogenic effects, which has been increased at the end of 19th and during the 20th century due to the considerable mining and industrial activity. The landscape constituent effect of the former, by now abandoned mines (*Figure 4*) and the mostly also abandoned industrial sites determine the character of the landscape, both in direct and indirect manner (HORVÁTH, G. & CSÜLLÖG, G. 2012a).

For implementing the investigation on the sample area – having proceeded from the quantitative database of the mining claims and landfills –, mining landscape load indices have been elaborated, on the one hand to quantify their impacts on the landscape, on the other hand determining the mining load index of certain geographical landscape units (CSÜLLÖG, G. et al. 2017). On the basis of the indices, the impacts and consequences could be ranked, and it was also possible to compare the impacts of different mining claims and waste deposits in three different landscape categories. With the main result of our examination, this will make it possible to investigate concrete problems and landscape conflicts caused by the landscape use of mining or its aftermath in different landscape units with a high load index.

It can be stated, that this sample region belongs to those areas which have high mining landscape load (*Figure 5*) and within the region in great extent can be found degraded natural and cultural landscapes with high rate of non-exploited areas. The local authorities and the management of the protected areas of the region make great effort for decades to find new forms for utilizing the former mining areas (HORVÁTH, G. et al. 2012b). Examples from abroad focus mostly on settling systems and edifices of renewable energies as well as on development of ecotourism.

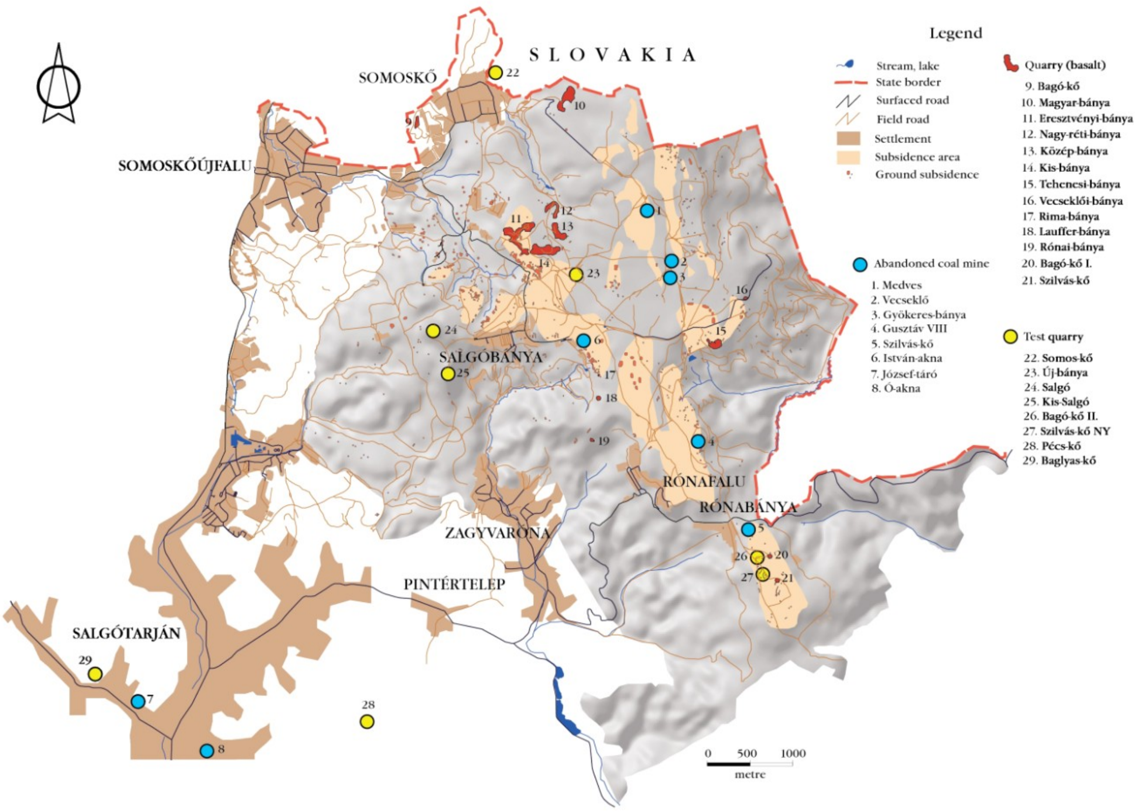

Figure 4. Abandoned mines within the sample area (ed. by KARANCSI, Z.)

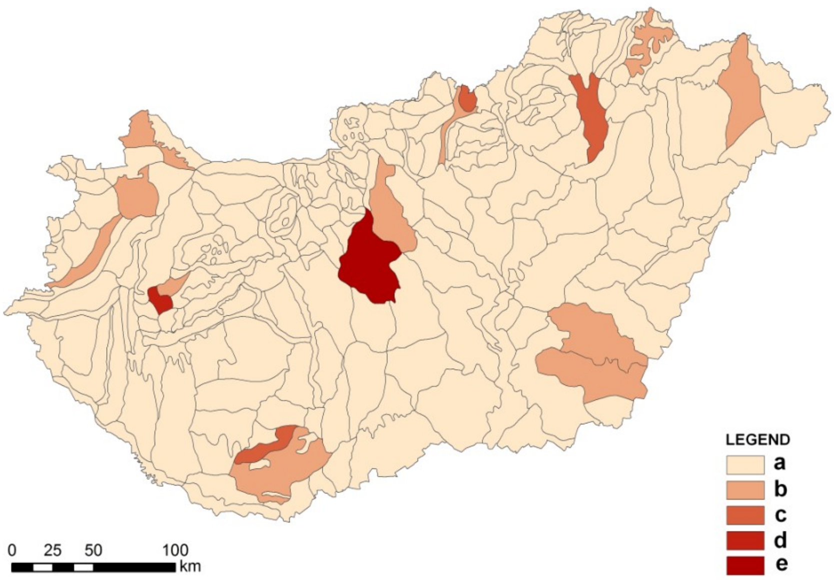

Figure 5. Array of mining claims on the basis of landscape load indices (ed. by TAMÁS, L. & CSÜLLÖG, G.). Categories: a = <480; b = 481–960; c = 961–1439; d = 1440–1919; e = 1920–2300

It can be stated, too, that in the sample area the rate of the degraded areas is high, referable to the former mining activity and its abandonment. Of course, the level and the extension of these areas is different within the sample area, however, in certain landscape parts its occurrence is rather dense (*Figure 6*).

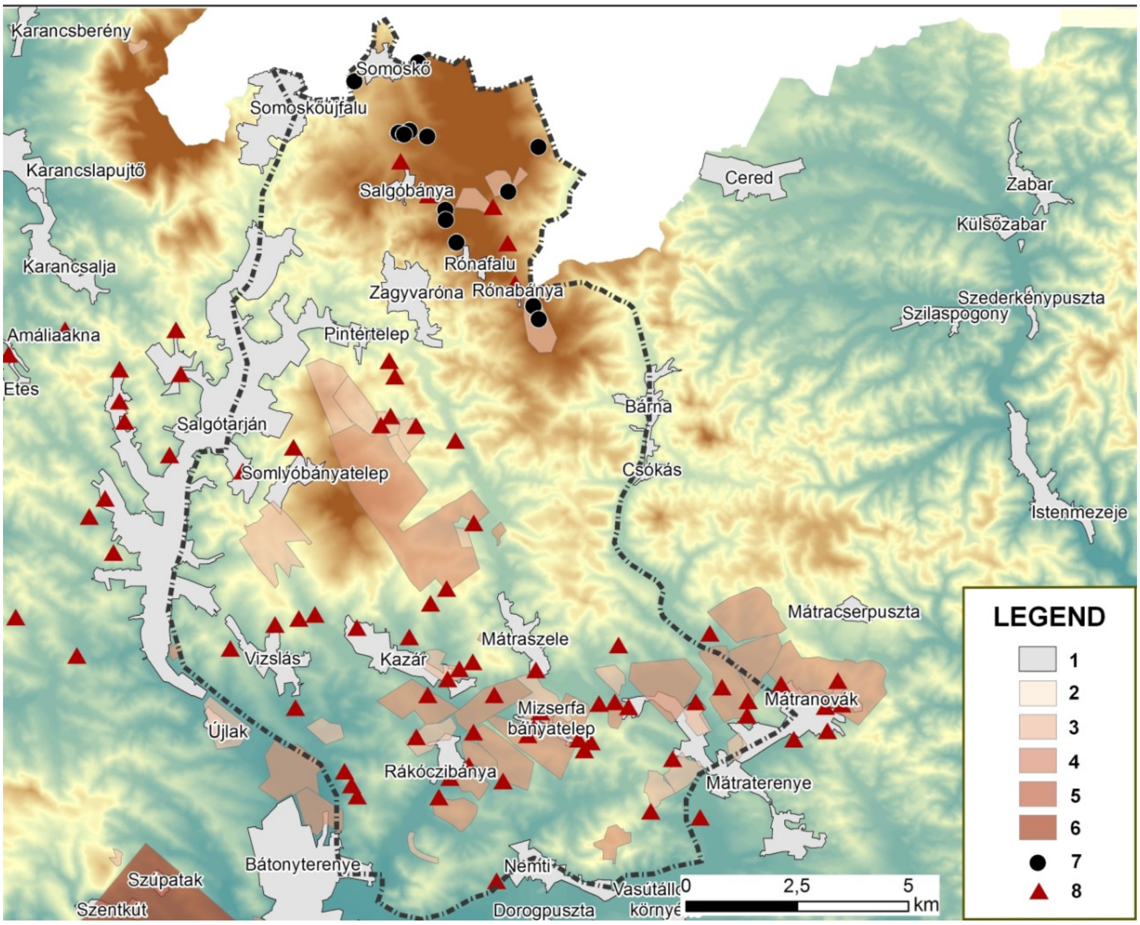

Figure 6. Mining landscape load and landscape degradation level of the mining claims in the sample area (ed. by T*AMÁS, L. &* C*SÜLLÖG, G.). Legend: 1 = central inner part of the settlements; 2 = low level; 3 = moderate level; 4 = medium level; 5 = high level; 6 = critical level; 7 = basalt mines; 8 = abandoned mining landfills*

Based on the mining load indices and landscape characters, those degraded surfaces in the sample area can be determined of which new forms of utilization is inevitable. If appropriate survey was taken place, appropriate database was collected and objective evaluation is available, it can constitute a basis for the future plans concerning to the area. These plans have to take into consideration also the landscape-determined interdependences. The utilisation of the abandoned mining regions and an environment-friendly realisation of the present mining activities are important tasks not only because of the serious environmental and economic problems, but also because a degraded landscape with its unattractive image affects everyday life as well. It is very important to change this image in order to achieve a more positive view of mining and a successful reclamation of the landscape.

Because of their different character the utilization can be distinct. Former mines are also part of the geoheritage, and taking into consideration that the sample area is part of the geopark, geotourism (educational trails with interpretive tables, organized geotours, etc.) is a perspective usage manner (HORVÁTH, G. & CSÜLLÖG, G. 2012b, HORVÁTH, G. et al. 2012a). However, other parts are waiting for new ideas of the utilization. Regarding the waste dumps and slag cones – as deposition of the waste of a former mine, power plant or iron works – and other mining landfills, in addition open-air mining areas settling of different types of energy production – e.g. solar and biomass facilities, pumped-hydro energy storage – should be expedient utilization. Within that, detailed research was accomplished regarding the pumped-hydro energy storage in the sample area and in its bigger vicinity (see detailed in 2.3.3.). The research established the conclusion that decentralized energy storage can be a realistic alternative, even under the somewhat unfavourable conditions found in Hungary (SÁFIÁN, F. & MUNKÁCSY, B. 2015). Beyond the benefits to be expected at the level of energy policy in a strict sense, this has two additional reasons: on the one hand, the emergence of new water habitats can lead to positive changes from an ecological point of view; on the other hand, in conjunction with the rehabilitation of strip pits, pumped-hydro energy storage structures can positively impact the landscape as well.

2.2. Analysis of the condition of the landscape

At the third sample area – villages belonging to a LEADER group at the foot of the Bükk Mountains (in what follows: Bükkalja) in Borsod-Abaúj-Zemplén County – investigation of the perspectives for settling renewal energies was the main task, which needed the investigation of the condition of the landscape as well. Is spite of its minor extension, there are several dissimilarities within the investigated region both in potential and usage of the landscape. According to the map of general land-use of Bükkalja (*Figure 7*) considerable differences can be seen within the landscape (SZABÓ, M. et al. 2017). At the rim of the mountain the capacities for intensive agriculture are essentially contrary; at the peripheries of the settlements forests are dominant; and the position of the grounds and lanes aligns itself with the valleys growing narrow. Only functions related to tourism and recreation can offer factors for the regional development.

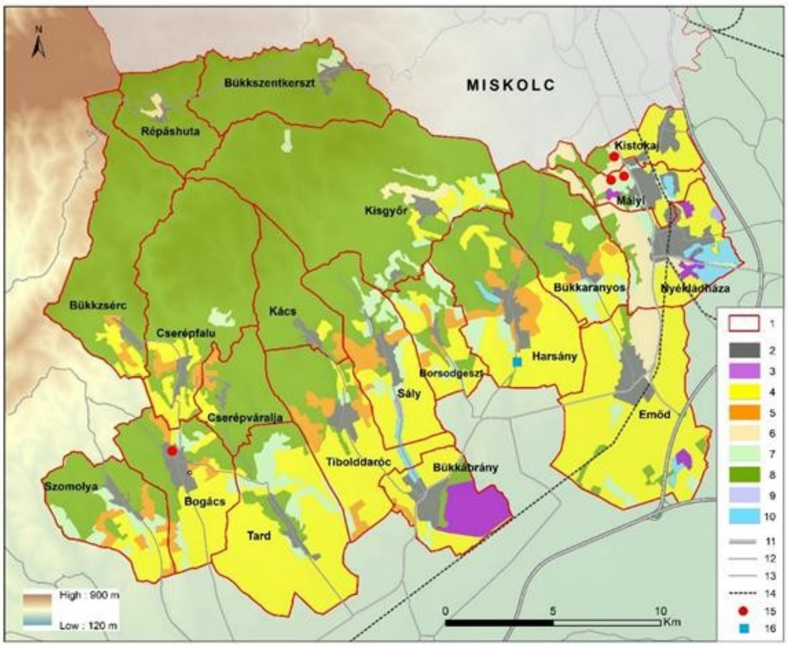

Figure 7. General land-use of the Bükkalja area (sources of data: CLC 2018, SRTM). Legend: 1 = administrative border of settlements; 2 = interior area of settlements; 3 = mineral extraction and dump sites; 4 = agricultural cultivation; 5 = vineyards; 6 = garden-plots; 7 = pastures; 8 = forests; 9 = inland marshes; 10 = water bodies; 11 = motorways; 12 = main roads; 13 = secondary roads; 14 = railways; 15 = geothermal wells; 16 = biogas plant

Where the lower bajadas (glacis) meet the lowlands, parallel to them main roads formed, squaring with the valleys running down; in their node came into being the important settlements, and the main land-use of their vicinity is arable land. Between these two landscape types, along the broader valleys and on the gentle interfluves the land-use of the settlements because of the conditions is much more complex. Former land-use activities have been abandoned, resulting in considerable landscape degradation, only scare land-use can be observed at the outskirts of the settlements, and there are opposite interests of land-using stakeholders (forestry, environmental protection and nature conservation versus local farmers). The underdeveloped and bad-quality infrastructure hinders the optimal land-use as well. There are also several unhusbanded landscape parts, unfortunately especially in the vicinity of landscape values (like beehive stones).

According to the investigations the causes of the recent landscape conditions are owing not only to the demographic and economic troubles of the settlements but also to the "vanishing" of the landscape from the everyday life. Contrary to the former complex utilization, nowadays – depending also on age, occupation, social status – only one or two functions, like dwelling or economic activity can be observed. Another problem is that the co-operation between neighbouring villages in several cases has essentially broken off (SZABÓ, M. et al. 2017).

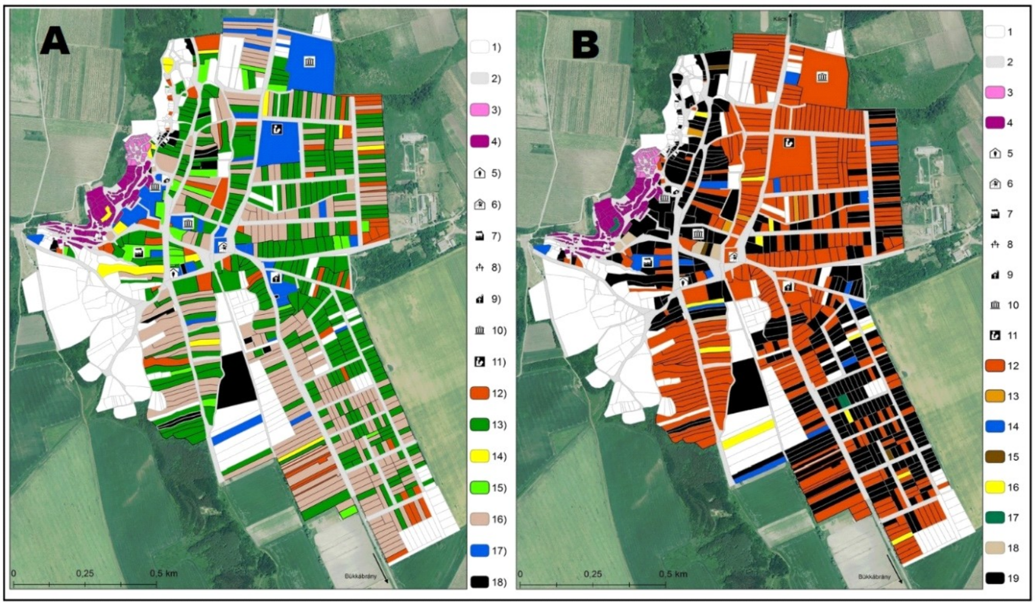

Figure 8. (ed. by CSÜLLÖG, G.) A) Utilization functions linking to certain grounds in the interior of Tibolddaróc village. Legend: 1 = not surveyed ground; 2 = road, public domain; 3 = cave dwelling; 4 = cellar; 5 = parish hall; 6 = community centre; 7 = sparkling champagne factory; 8 = cemetery; 9 = church; 10 = mansion; 11 = school; 12 = function indeterminable; 13 = only dwelling function; 14 = only recreation function; 15 = only economic function; 16 = mixed (dwelling and economic) functions; 17 = other function; 18 = no data; B) Utilization functions at the outskirts linking to certain grounds in the interior of Tibolddaróc village. Legend: 1 = not surveyed ground; 2 = road, public domain; 3 = cave dwelling; 4 = cellar; 5 = parish hall; 6 = community centre; 7 = sparkling champagne factory; 8 = cemetery; 9 = church; 10 = mansion; 11 = school; 12 = no outskirt ground; 13 = horticulture; 14 = vinery; 15 = horticulture and vinery; 16 = arable land; 17 = forestry; 18 = mixed functions; 19 = no data

As a typical example, a survey in Tibolddaróc village has been carried out about the land-use on the grounds of the inhabitants (SZABÓ, M. et al. 2016), among others investigating for what functions are utilized the grounds both in the village and in the outskirts. As it can be seen in *Figure 8A*, dominant usage (317 cases) is only dwelling (in some cases completed by olericulture) and on 260 grounds can be found mixed usage (dwelling and husbandry, however, the latter mostly marginally). There are only 51 grounds, to which belongs also any husbandry belongs – almost only vinery – somewhere in the outskirt. Thus, from economic point of view most of the inhabitants have only a few linkage to the surrounding landscape (*Figure 8B*).

A step ahead from these conditions can be rebuilding the connection between landscape and settlement by optimal exploitation of the landscape capacities and building up economic functions adjusting to the market relations and to the legal regulations. Relating to that, liquidation of the degraded landscape elements, enhancing of local energy production based on the renewing sources of the landscape and establishing of a local economy system for merchandizing local products are inevitable. Fulfilment of utilization of the non-economic landscape values, including the unique landscape features and the aesthetics of the landscape, in addition the traditions would be important as well as strengthening the role of the local authorities as stakeholders and involving the local people based on its capacities and resources.

According to the evaluation of the survey and the data it can be stated that the contraction and the role loss of the local, inner system is the basic problem – nevertheless, not only in this region, but also in almost all small settlements in Hungary. Unfortunately, in general also the state does not care fairly the landscape, there is a lack of intention for managing it (both from legal, institutional and financial aspects), although the landscape is the fittest framework for a complex management of the problems related to settlement, demography, economy and environment. It can be hoped that the new Hungarian Landscape Strategy, which attaches significance to the recognition of the condition, characteristics and problems of the landscape, to the conservation of its values and to building its balance, brings gradually positive changes.

A summary of the landscape status at the sample area in the vicinity of Tibolddaróc village – in the form of a SWOT analysis – can be read in *Table 1*.

Table 1 SWOT analysis of the landscape status at the sample area

Strengths	**Weaknesses**
Complexity of the landscape constituent elements	Arable land cultivation is the dominant use
Advantageous geographical location, gently dismembered relief	Rate of degraded surfaces is considerable
Existence of a peculiarly usable geological capability (dominance of rhyolite tuffs) and the edifices joining to it	Low level connection between landscape and settlements, a few forms for utilizing the landscape, mostly no utilization of the outer peripheries
Favourable agrarian potential of the plain surfaces	Considerable rate of degraded surfaces remaining from the socialist era
Continuity of the historical land-use, existence of land-use traditions	Lack of harmonized plans for landscape management and also of farmers thinking holistic manner
Dynamic local society, virulent communities	Opposite interests of land-using stakeholders (forestry, environmental protection and nature conservation versus local farmers)
	Optimal land-use impediment under-

	developed infrastructure

Threats	Opportunities
Lack of correlation between the demand of the land-use and the perspectives given by applications	Further strengthening of undertaking the role of the local authorities: appointing aims, elaborating plans, solving organizational tasks, submitting applications etc.
Unsuitable expenditure of assistances	Thinking and activity on unity of landscape and settlement, especially regarding the chain of manufacturing and treatment of the products
Further degradation of the connection between landscape and settlements	Establishing and strengthening local systems and manufacturing local products, involving the inhabitants by their ability and human capacity
Enlargement of degraded surfaces	Establishing economic functions aligning themselves with the capacities, market and regulations, by terminating the abandoned, degraded surfaces and by enhancement of energy production based on renewable resources of the landscape.
Increasing the intensity of the viniculture and arable land cultivation can result in raising disadvantageous environmental impacts on landscape (water-household, soil erosion etc.)	Presentment of the settlements as a “product”, qualitative raising of the physiognomy of the settlements by several developments, assisted by heavy settlement-marketing
Deterioration of the quality of the forests	Establishing and operating ground-level tourism infrastructure
Spreading, becoming dominant of the invasive species on degraded surfaces	Utilization of certain landscape values, including the unique landscape features, the landscape aesthetics and the traditions
	Establishing strong co-operation among the neighbouring villages
	Common planning and operating greenways, thematic routes
	Elaborating plans of a future nature park

2.3. Perspectives of energy usage on different sample areas

The databases reflecting geographical aspects and the spatial models can be utilized in several manners during arrangements of spatial planning and regional development. Based on the data, proposals and recommendations can be drawn up for the planning and the eligibility for certain development in different landscape units is statable. An especially acute problem is the energy production, which should be changed because of the challenges of our age. It is inevitable to re-structure both the energy production and consumption, which must be built on the local renewable resources, however by such manner and localization which does not increase excessively the landscapes’ load.

As a first step, the assessment of the current energy management has been featured. In the different sample areas different approaches were applied. The most complex investigation was accomplished in the Bükkalja region. During the research period energy survey of 24 settlements including more than 1200 households were implemented. Regarding these households, the heating solutions and habits were on the focus, because this was the major part of the total energy consumption and unfortunately the most significant source of air pollution.

Also the most important local power or heat production plants were visited, including most of the solar and biomass facilities (which were financed by the LEADER initiative). Besides this focus, the biogas plant in Tarján and the geothermal wells in Kistokaj, as well as the 500 kW solar photovoltaic system in Tibolddaróc were explored. As for the energy storage, all the battery storage and electric car charging station sites (24) were mapped. Surprisingly, most of these charging stations were never used properly. Also the small scale pumped hydroenergy storage potential was investigated by GIS methodology.

2.3.1. Biomass

As regards the investigation and survey of the household level energy consumption, it can be stated that in this rural area principally firewood and lignite are the general resources, moreover household plastics and any other wastes, which leads to environmental and health problems caused by, for example, the increased concentration of PM10 (HORVÁTH, GÁ. et al. 2018). Usage of the lignite is understandable, taking into consideration that the biggest lignite mine of Hungary can be found at Bükkábrány at the southern part of the Bükkalja region (Figure 7), and like several parts of the landscape are covered by forests, promoting the usage of firewood. Thus, recently the biomass is the most important renewable energy source in the region and according to the investigations its utilisation is closer to its potentials (HARMAT, Á. et al. 2018).

Therefore, the renewable energy potential analyses were focused mainly on biomass. This analysis carried out applying strong sustainability criteria. Since the two main solid biomass fuels in Hungary are forestry biomass and agricultural biomass, these two sources were in the focus. Regarding the energy potential from the plough land, the method of humus balance was used, developed by WEISER, C. at al. (2014).

As a first step, the theoretical potential was calculated. Subtracted the need of animal feed, bedding, material demand and the lost from the harvesting resulted in the technical straw potential. To calculate the amount of straw which is needed for the soil fertilization, humus balance was calculated in a 1x1 km grid basis, while agricultural data were available in this structure. As a result, the aggregated sustainable straw potential was around half of the theoretical 100–120 PJ/year, however, the geographical differences are significant.

Based on the spatial analysis, the biomass potential in the Bükkalja sample area is over average, however, there are significant dissimilarities due to the differences of the land-use and the population density (*Figure 9*). In particular, having completely different capabilities and resources, a sharp southwest–northeast boundary can be identified between the mountainous and the plain areas. The northern part belongs to the Bükk Mountains; there wood is the main energy source, as mainly forestry dominates, although its major part being part of the Bükk National Park is under protection with logging restrictions. In contrary, in the southern part of the region, which belongs to the Great Hungarian Plain, farming is the typical land-use, therefore, mainly cereal straw can be found.

The potential of forestry biomass was calculated not only for the sample area but also for the whole Borsod-Abaúj-Zemplén County. Significant difference can be observed regarding the volume of its utilization depending on the different kind of sources and calculation method for the county, as the lowest value is 450,000 m^3, and the highest is 730,000 m^3. Nevertheless, the available firewood was calculated using GIS method, and for an average year it is only 281,000 m^3. It is likely that the usage of the firewood is overestimated, however, its utilization can not be increased further due to environmental concerns (HARMAT, Á. et al. 2016, 2018).

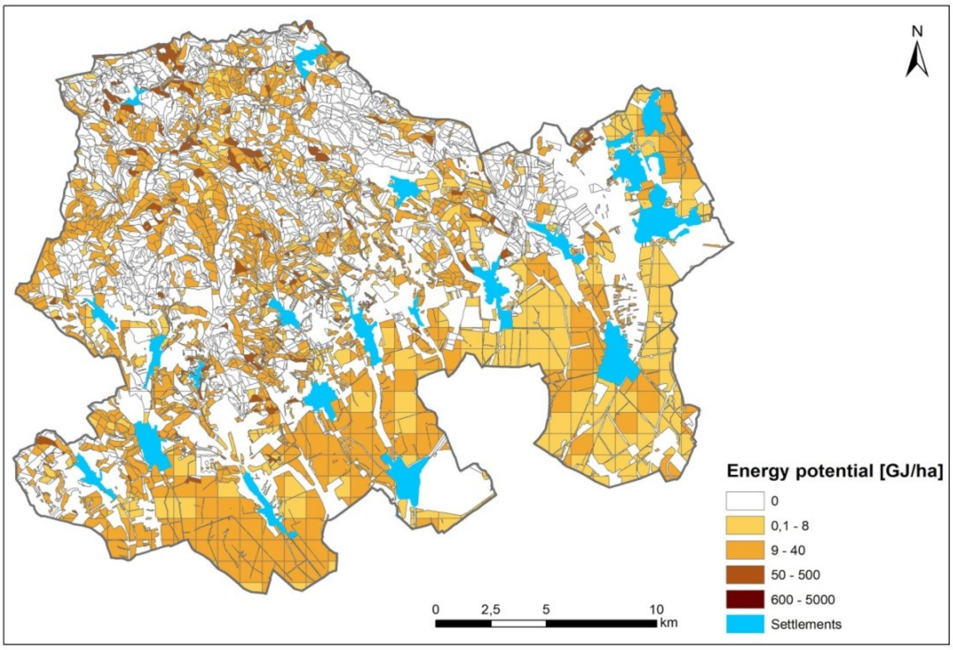

Figure 9. Available biomass energy in the Bükkalja area (ed. by HARMAT, Á.).

On the basis of all three available methodologies it can be stated that the amount of firewood used exceeds the quantity of harvested firewood counted in the county. If the industrial utilisation is also included, the final result will be higher than the current annual increment. It means that the current level of timber harvesting already threatens the renewable capacity of our forests. According to the European Union Timber Regulation (EUTR) introduced last year (which orders e.g. stricter administration and more intensive monitoring) it is expected to reduce the amount of illegal timber on the market. In addition, according to the new "Renewable Energy Directive" (RED II), it is expected that only that forest biomass can be considered as a renewable energy source which has been proven to have originated from a sustainable production.

Within the framework of this research, the technical biogas potential was also investigated. The main goal was mapping the potential for the utilization of biogas from a) livestock manure, b) wastewater sludge and c) plant by-products in Komárom-Esztergom County. Based on statistical data sources, a geospatial database was built. It contains the quantity of environmentally sustainable biomass from the three main source groups. These values were supplemented with technical criteria for production and use. Thus, a fairly accurate picture of the technical biogas potential of Komárom-Esztergom County (BUDAI, E. et al. 2016) was outlined. As a final result it can be stated that if an 800–1000 kW biogas plant were established at all the livestock farms within the 500 m buffer zone of an existing gas pipeline, road network and electricity grid, a total of 50–62.5 MW power capacity could be created. With 1000 m buffer distance a 65–81 MW capacity could be allocated in the county. With these developments it would be possible to cover the electricity demand of a) in the first case: 400,000–500,000; b) in the second case: 520,000–650,000 average consumers in the county (BUDAI, E. et al. 2016).

2.3.2. District heating

District heating (DH) technology can be one of the most energy-efficient ways of the production of heat and domestic hot water (LUND, H. et al. 2018a). There were four major steps in the evolution of DH technology (LAKE, A. et al. 2016; LI, H. & NORD, N. 2018). In the case of the first and the second generations, the flow temperature is over 100 °C, which causes significant heat loss and the consumer-side heat controllability is almost impossible. However, the emergence of the 3rd generation, the so-called Scandinavian type, is common in the states of Northern and Western Europe. In this level, the flow temperature is less than 100 °C, which provides higher energy efficiency and the heat consumption can be controlled by the households (LAKE, A. et al. 2016). After substantial technological developments the scientific dispute is focusing on the introduction of 4^{th} generation district heating systems. This state-of-the-art solution will be based on low-temperature surface heating, pre-insulated pipes and the usage of an optimal mixture of locally available renewable energy sources (e.g. biomass, solar thermal and ambient heat, as geothermal) or excess heat (LUND, H. et al. 2018b). The combination of different resources in one system is called hybrid (SCHMIDT, D. et al. 2017) or multi-source district heating (VESTERLUND, M. et al. 2017).

Having built international good examples in our research, especially the Danish hybrid solar district heating methodology, it was worth focusing on the potential analyses of solar thermal technology in the case of Esztergom and Dorog, which belong to the sample area in Komárom-Esztergom County. In addition, a small town in Pest County, Veresegyház was also involved into the investigations; this settlement has a matured geothermal district heating system which could be developed further easily by solar collectors mounted on brownfields. Due to the yearly fluctuation of solar radiation, the implementation of seasonal heat storage (hot water pit) was also investigated (CSONTOS, Cs. et al. 2018). The Dorog–Esztergom district heating area is still based mainly on fossil fuels but this city has huge spare brownfield areas, too (PAPP, L. et. al. 2018). The investigation resulted in that in the case of two major cities, Dorog and Esztergom it would be a realistic opportunity to expand significantly the district heating service. Suggested is the hybrid operation of the district heating system involving brownfield sites, up to 0.76 km^2 with the development of a solar collector field, which would be able to supply the heat demand of the connected customers by about 33% (PAPP, L. et al. 2018).

Moreover, district heating can be tightly linked to the electricity grid in the near future. The increasing development of heat pumps brings up new perspectives in the energy sector, which means a widespread use of demand-side management techniques, Furthermore, seasonal storage applications can also be linked to the electricity grid via heat pumps. This technology reduces heat losses and makes demand-side management possible at the same time (GALINDO FERNÁNDEZ, M. et al. 2016; MANGOLD, D. & DESCHAINTRE, L. 2015). It is worth continuing the research on this topic.

2.3.3. Energy storage

Several medium and large-scale energy storage technologies (namely pumped-hydro, power-to-gas, compressed air and liquid air energy storage) and their adaptation possibilities were investigated for the Bükkalja study area (MUNKÁCSY, B. et al. 2017). One of them, the pumped-hydro energy storage (PHES) proved to be very promising, since this is the most mature technology and all the study areas can be described as mountainous regions with good terrain conditions, therefore it got special focus in later research.

Our results demonstrated, by using GIS applications it is possible to identify ideal water reservoir sites effectively, due to raster-based remote sensing and other vectorized data. Moreover, modelling different versions it was stated that not only all of the three sample areas but also other Hungarian middle-mountain areas offer significant amount of suitable sites for small scale pumped-hydro energy storage water reservoirs (SOHA, T. et al. 2017a). Despite the high amount of protected natural areas, there are enough sites for such facilities. It also means that the site selection proved to be much easier in the case of smaller scale projects. Furthermore, thanks to the limited area demand, negative environmental impacts could be minimised. The small scale pumped-hydro energy storage seems to be a proper solution for the integration of intermittent renewable energy sources, such as wind and photovoltaics.

According to the geospatial analysis, 24 decentralised water reservoirs could be formed, with a total area of 264.3 hectares. Regarding all the three sample areas, it would be the simplest task to establish pumped storage projects, considering all the protected natural areas. To the opinion of the research group it could be carried out also from the point of view of the landscape protection as well, and – apart from the western edge of the area, which is affected by visibility problems from the castle of Hollókő – would not disturb the aesthetics of the landscape.

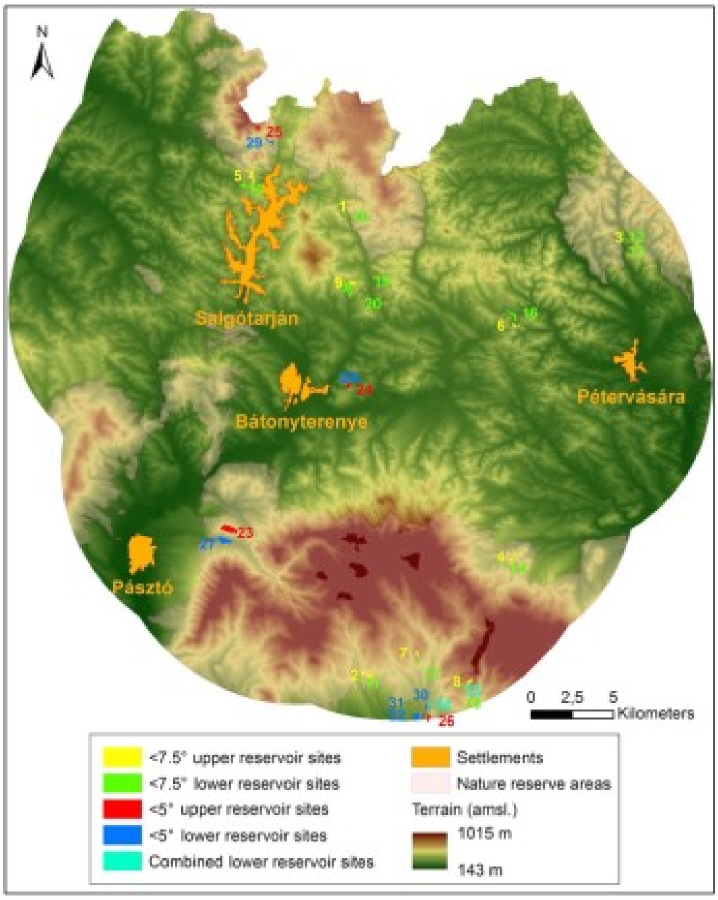

Figure 10. The potential locations for pumped-hydro energy storage on the enlarged sample area (ed. by SOHA, T. et al)

A detailed survey was made on the Nógrád sample area, that is, on an enlarged sample area of 1,324 km^2. According to the results, a minimum of 1,590 MWh and a maximum of about 1700 MWh of electricity could be stored over a total of 15 upper reservoirs (*Figure 10*). In terms of the analysis including both the upper and lower basins, their average surface area would amount to 7.85 ha, which is definitely a low figure is considering current technological practices (SOHA, T. et al. 2017b). This would ensure that systems could be incorporated in the landscape much more smoothly, which is fundamental given the fact that the entire area under consideration is classified as protected landscape either at the national or the county level. Another essential factor that needs to be considered is that among the 19 possible PHES basin connections, only 3 are not under nature conservation. From general point of view, turning the mining lots with a poor ecological value into a "water habitat" – as an option for reclamation – can clearly be regarded as a great step forward.

2.3.4 Prediction of possible landscape effects of the alternative power management system

One of the most important parts of the research was the software-based energy modelling, creating long term scenarios by 2050. According to the results of the alternative scenarios it is important to underline that the future energy demand can be decreased significantly. It also means that the existing landscape effects can be diminished or even terminated.

In the case of „BAU" model, there will be no significant intervention to the recent tendencies. In contrast, the „Green" model assumes considerable investments to the energy efficiency improvements of buildings and their space heating systems. In this scenario the total space heating demand is provided by renewable energy resources. Our hypothesis is that in the future firewood will play an important role, and the share of electricity will be increased, thanks to the spreading of heat pumps. District heating systems (geothermal, biomass) also need to be developed in the studied area. Using the currently available technology, the energy autonomy could be achievable. However, without the appropriate support and regulation system, only a modest shift would be expected (HORVÁTH, GÁ. et al. 2018).

3. Renewable energies in the tourism with respect to the landscape

It is well known that in our age the importance of tourism is enormous, and the number of tourists is increasing year by year exponentially. Of course, tourism as part of the economy and as an impact on the ecology is investigated from several points of view. Regarding our project, it was a new approach to research how renewable energies can be involved in and connected to the tourism (BECKEN, S. et al 2003, CEROVIĆ, L. & DRPIĆ, D. 2014). In the interest of creating a theoretical background for this aspect, at first investigations were made for elaborating the international literature on the relationship between renewable energy and tourism, and a literature review has been compiled (ÁSVÁNYI, K. et al. 2017).

Further investigations were focused on the supply of the tourism destinations especially on the hotel sector. Based on the homepages of local governments, all tourism attractions which can play any role in the development of the investigated settlements were involved and categorized. The tourism attractions was aggregated by genesis (nature-based and cultural) and potential (functioning or need development). The tourism statistical data were elaborated in all of the three sample regions. In the course of this task the features of tourism market were evaluated in 153 cities and villages (BALIZS, D. & MICHALKÓ, G. 2017).

Strengthening the symbiosis between the tourism and the usage of renewable energies is a desirable international development trend. Unfortunately, in Hungary still only a few examples of it can be seen. However, the region of the Novohrad-Nógrád Geopark managing the present economic and social problems – building on the great extent of forests (with considerable living wood stock, *Figure 11*), on the landscape capacities and on the perspectives of the agrarian sector – could successfully rely upon the supply of the tourism, respectively upon the utilization of the alternative energies for the inhabitants, for the communities and for tourism. Taking into consideration the resources of the region, the recently increase of the use of the solar energy seems to be a real target.

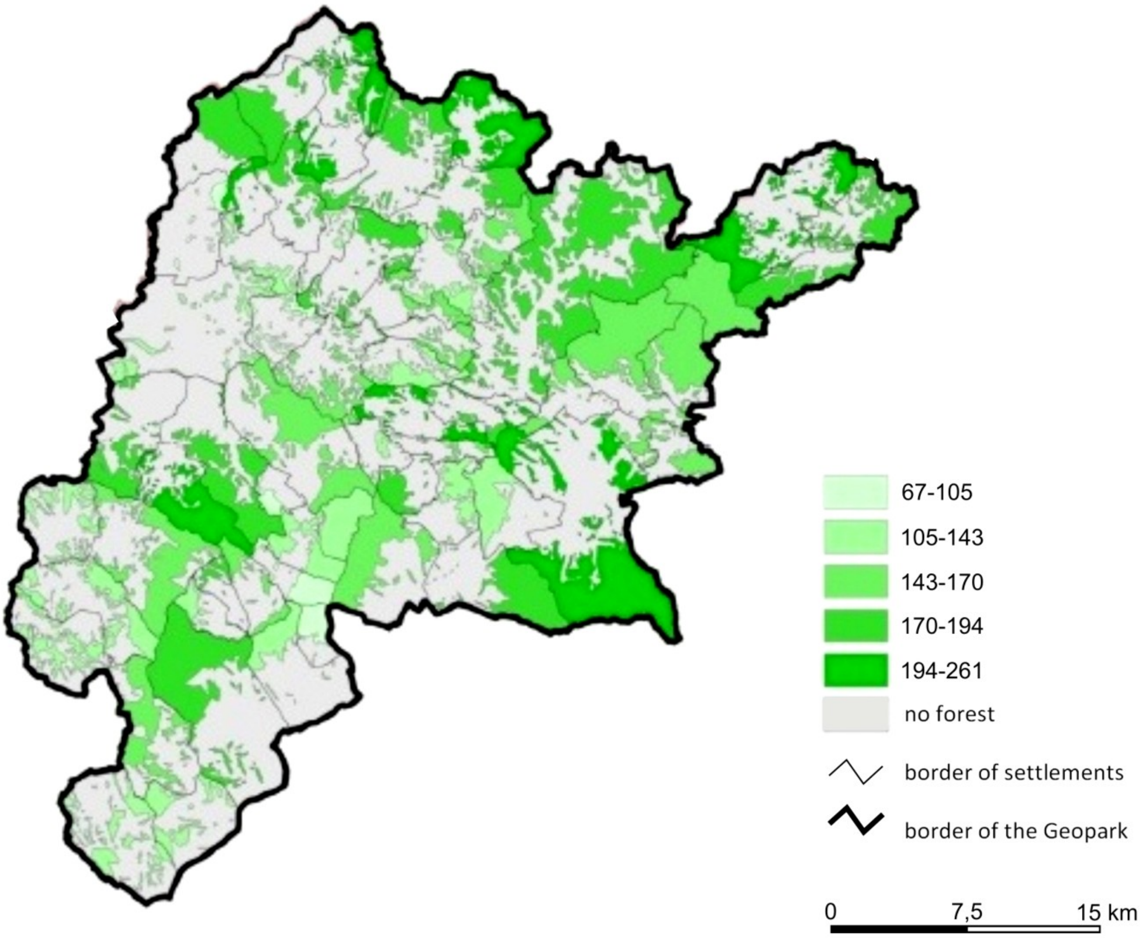

Figure 11. Living wood stock (m^3/ha) in the area of the Hungarian part of the Novohrad–Nógrád Geopark (ed. by BALIZS, *D. after* KORENCSÁK, *I. et al 2016)*

In the Bükkalja sample area, in Tibolddaróc village a quantitative research project was implemented for querying the opinion of local population about relationships between tourism and renewable energy. Altogether 280 households were asked to fill in our questionnaire personally focusing on their attitude (MICHALKÓ, G. et al. 2017a). It can be stated that the efforts for utilizing renewable energies resulted in an initial modernization in Tibolddaróc, especially due to the investments of the Mezei Vinery. The attained results reinforce the feasibility of the aims for developing the tourism based on the local values. The inner and outer marketing-communication of the local governments strengthens the message to the inhabitants that the utilization of the renewable energies can form the village to a liveable, up-to-date settlement and it will be worth visiting and investing into the village. In general, building up a system of renewable energies suggests to the stakeholders of the tourism industry that for the village the environmental problems, the sustainability and the conscious consumption have priority, which can be seen as a fine-sounding buzzword on the tourism market.

Also an online survey by questionnaires with participation of 114 hotel managers has been carried out. The survey focused on the attitudes of the managers and on the practice of the given hotels concerning the renewable energies. It has been stated that there is lack of information and the interest in the topic is low. Nevertheless, the managers know the importance of the “green” image, which can be used in the marketing. Also a second online survey by questionnaires has been carried out, targeting the hosts of lodges (not hotels) in the countryside. They are ready for using renewable energies; however, the investment costs are very high for them. The mostly used tools are sun collectors (JUHÁSZ-DÓRA, K. et al. 2016; MICHALKÓ, G. et al. 2017b).

Nowadays it can be observed that in parallel to the constantly increasing number of online touristic service orders also the number of online feedback and reviews by the consumers is increasing on the social media platforms. Therefore, it is already possible and worth implementing the scientific analysis of these reviews. An important question was whether the equipment of the renewable energies can be interpreted as landscape values or just a contrary? The Instagram is one of the most popular photo-sharing applications, which allows the users to upload and share their experience with the online community (consisting of mainly other tourists), allocated with different short tags (hashtags). With the co-operation of the students of Corvinus University of Budapest, almost all photos uploaded on the website of Instagram application were collected and systematized regarding the 184 investigated settlements. The dominant landscape elements were recorded according to the different locations and the conditional appearance of the equipment generating renewable energy were revealed. The analysis and the evaluation were carried out on the sample of Komárom-Esztergom County (MICHALKÓ, G. & JUHÁSZ-DÓRA, K. 2017, MICHALKÓ, G. et. al 2019). As a result of the analysis it was stated that most of the photos imaged the person who made it (and his or her relatives, acquaintances), however, based on the background the supply or the potential of the tourism of the destinations could be determined. On the other hand, also photos depicting different types of equipment or constructions applied for the generation of renewable energy were available in different settlements. Among them in this sample area wind turbine has only become a dominant element of the landscape at one specific settlement (*Figure 12*), in the case of other towns and villages iconic touristic attractions were dominant.

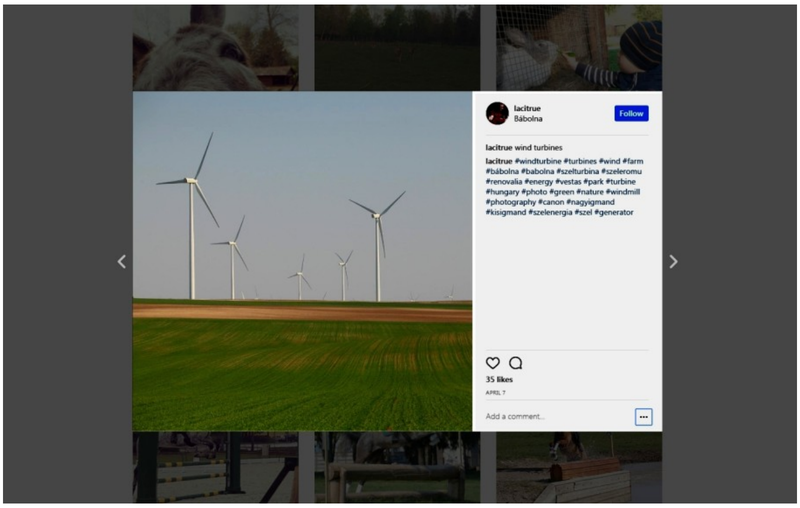

Figure 12. Landscape picture illustrating wind turbines with #Bábolna hashtag on the Instagram (MICHALKÓ, G. & JUHÁSZ-DÓRA, K. 2017)

Hiking is one of the most popular leisure activities of the Hungarian population. Despite the fact that the motivation for hiking is reasonably complex, it can be assumed that the participants are more sensitive to environmental problems than the average, they are more eco-conscious. Eco-consciousness is a multidimensional concept that includes the usage method of energy. The commitment to the use of renewable energy is an indicator of the attitude that supports the enforcement of the sustainable development principle. It has been proved by a questionnaire survey among the hikers, made by visiting the Pilis Parkerdő Zrt. with the assistance and contribution of the students attending the University of Debrecen, Department of Landscape Protection and Environmental Geography. Altogether 673 questionnaires have been evaluated, and based on the results it has been stated that the respondents are aware of the key role of renewable energy in environment protection and in the enforcement of sustainable development principle, they show much higher acceptance of solar-powered structures (solar panels) compared to wind energy (wind turbine) structures. The respondents disagreed whether the renewable energy structures can be interpreted as tourist attractions, and they disagree with the integration of renewable energy structures into landscape.

Another interesting approach is the preference of the consumers, which has been assessed as well. It is obvious that the creation of tailor-made supply elements, the emphasis on unique selling proposition (USP) and the globally heightened competition in the tourism market have become increasingly significant. The tourism service providers have the opportunity to increase their competitiveness by the means of supply element development. Tourism service providers who rely on the susceptibility to innovations that fit into the trend of environmental awareness can strengthen their market position through the usage and implementation of renewable energy. Therefore, a research question was put by a questionnaire (conducted on a convenience sample – 15–39 years old) with the cooperation and assistance of the students attending Corvinus University of Budapest: to what extent the utilization of renewable energy contributes to the increasing demand for tourism services?

Based on the results of the 2546 questionnaires processed and evaluated, the followings was concluded. At first, the respondents identified the utilization of renewable energy on the penultimate place among the 18 pre-defined factors during the assessment of the supply elements of tourism services. Cleanliness and orderliness, guest-centeredness and good value for money are the most significant factors in the success of touristic services, and the role of renewable energy utilization is less significant. During the evaluation the direct service environment is in the forefront of the enforcement of sustainable development principle. Secondly, as a result of the application of Pearson's correlation calculation method it was outlined that among the respondents who consider the utilization of renewable energy as an important tool for success, the role of pet-friendly attitude and accessibility is a priority. Therefore it can be stated that emotional control (love centricity) is the ”node” that supports the physical environment, animals and people with disabilities, regarded from the aspect of defencelessness.

Summary

As it can be seen, the research program was quite arborescent, and also the results can be used in several fields. Picking out some elements, the elaborated landscape load indices – together with the tools of geoinformatics – are useable among others in the industrialization, in the regional planning (e.g. for applying renewable energies) and especially in the environmental protection for the landscape reclamation. The investigation of the degraded landscapes can contribute to an advantageous utilization of the abandoned mining areas e.g. by settling renewable energy facilities (biomass plants, solar photovoltaic systems, pumped-hydro energy storage) or by planning ecotourism. The results can help also to find new functions for the land-use in those abandoned landscape parts which were earlier locale of considerable agricultural activity. The results of the investigations on the potentials of utilization of renewable energies can contribute to break out from the underdeveloped, peripheral condition of several settlements, which will not be rejected according to the attitude-investigations. Although it needs still further research, it can be stated that the application of energy planning software created substantial energy planning scenarios for any regions and based on them recommendations were drawn up for optimizing the regulations. Last, but not least the research flashed a beam of light on the perspectives of applying renewable energies in tourism; also in that case according to the attitude-investigations it seems reassuring that there is an adequate readiness for its acceptance.

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