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VSEBINA – CONTENTS

MATERIAL RESPONSES TO NATURAL HAZARDS IN 16TH AND 17TH CENTURIES: CASES FROM PRESENT-DAY SLOVENIA AND ITS SURROUNDINGS

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Abstract
Material responses to natural hazards threatening agricultural land and dwellings in princely seigneuries and urban settlements included cooperation between central agencies, regional and local level – in some cases leading to efficient measures. Examples of reactions of provincial estates, non-princely seigneuries and neighbours are also given. Historical knowledge contributed to risk mitigation. Artificial interventions in landscape due to flood hazard affected also flood safe locations.

Key words: natural disaster, environmental history, Early Modern Period, Slovenia, Carniola, Styria, Carinthia, Inner Austria, archival sources

STVARNI ODZIVI NA NARAVNE NESREČE V 16. IN 17. STOLETJU: PRIMERI Z OZEMLJA DANAŠNJE SLOVENIJE IN NJENE OKOLICE

Izvleček
Stvarni odgovori na naravne nesreče, ki so ogrožale kmetijska zemljišča in bivališča v deželnoknežjih gospostvih in urbanih naseljih, so vključevali sodelovanje centralnih organov, regionalne in lokalne ravni. V nekaterih primerih so omogočili učinkovite ukrepe. Navajam tudi primere odzivov deželnih stanov, nedeželnoknežjih gospostev in sosedov. Poznavanje zgodovine je prispevalo k zmanjševanju tveganja. S poplavami povezani človeški posegi v pokrajino so spreminjali tudi poplavno varna območja.

Ključne besede: naravne nesreče, okoljska zgodovina, zgodnji novi vek, Slovenija, Kranjska, Štajerska, Koroška, Notranja Avstrija, arhivski viri

1 INTRODUCTION

'Disasters /…/ have two historical trajectories, one "natural" and the other societal. They are "historical" in the sense that both forces change over time' (Bankoff, 2007, p. 104).

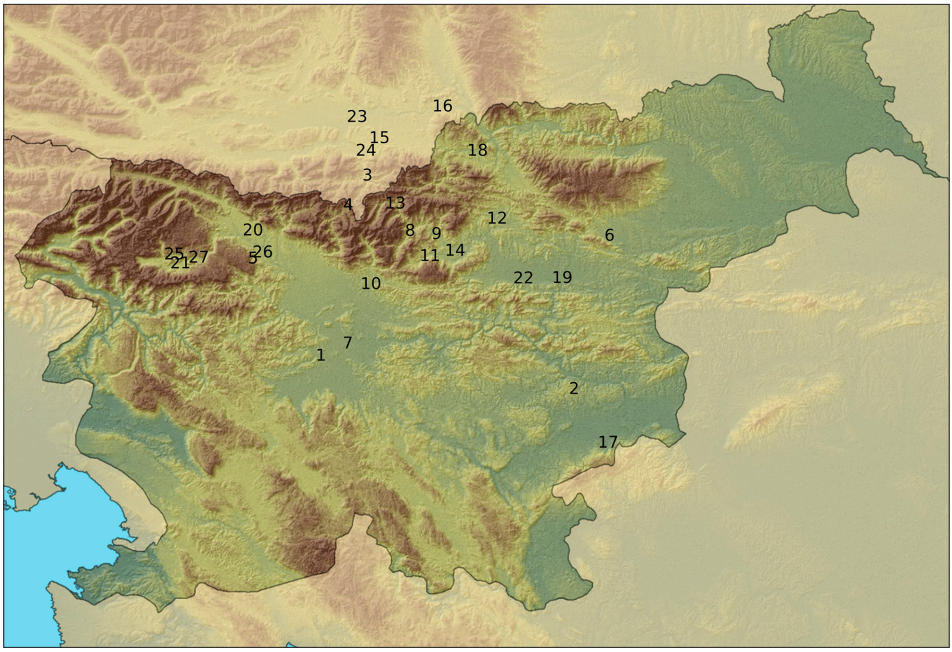
The article concentrates on the period from mid 1560s to the late 17th century. In the observed timeframe, great majority of people here lived on the countryside as tenants of various seigneuries. The state and transformation of cultural landscape as results of interrelated ever changing natural conditions and processes on the one hand, and varying human interventions on the other hand were often much different from the present ones. The braided rivers, for instance, heavily transformed during the further course of history, must already in the observed timeframe be interpreted as socio-natural sites, although human interventions were in general not comparable with the ones from industrial period (Winiwarter et al., 2013).

The main emphasis is placed on case studies (Fig. 1) from the territory which was at that time part of three provinces belonging to the Inner Austrian group – Carniola, Styria and Carinthia (Spreitzhofer et al., 1988). Inner Austria had its own central agencies in its capital Graz. Whereas court's treasuries in Vienna were responsible for the Inner Austrian territory until 1564 (Inventar …, 1951), the court's treasury and the Lower Austrian court's treasury were founded in Graz in that year (Spreitzhofer et al., 1988; Vilfan, 1996). The majority of archival sources of central agencies from the period 1564–1625, used in this article, are preserved in the chronological series from the collection *Archive of the Inner Austrian court's treasury* in Styrian provincial archives, thus they are results of operation of the court's treasury in Graz, not of the Lower Austrian court's treasury situated there (Puschnig, 1959). Division of work between both court's treasuries in Graz changed more than once until 1625 when they were united into the Inner Austrian court's treasury. These court's treasuries were responsible for princely property until the end of the observed period (Spreitzhofer et al., 1988), which suggests that they were actively involved in material responses to natural hazards and disasters.

On the provincial level, two parallel but partly overlapping administrative systems coexisted, the princely one and the one of the Estates of each province. Central authorities from Graz cooperated with the princely ones. In the observed timeframe and in the observed provinces, *Vîztums* were officials administrating the princely property on the province level or at least on the level of a very considerable part of the province as in the case of Styria. One of the most important fields for which Estates of the provinces were competent and which is important for this article was the administration of taxes from non-princely seigneuries based on revenues from land in possession of tenants (Spreitzhofer et al., 1988; Vilfan, 1996; Golec, 2011), thus they were also actively involved in material reactions to natural disasters.

By analysing archival sources from the archives of the court's treasury in Graz, the Inner Austrian court's treasury, the Estates of the provinces of Carniola and Styria, the *Vîztum* of Carniola and selected seigneuries, the article, firstly, provides a new basic insight in the administrative as well as not formally organized material responses to natural hazards within the specified timeframe and area, and secondly, discusses artificial interventions into environment related to natural hazards with an emphasis on floods. Within the cultural landscape, the article focuses on agricultural land and banks of watercourses.

Figure 1: Important locations for understanding the case studies. For easier orientation, state boundaries are represented in their present-day outline. Background: Relief map of Slovenia
Slika 1: Lokacije, pomembne za razumevanje študij primerov. Za enostavnejšo orientacijo so prikazane današnje državne meje. Ozadje: Relief map of Slovenia



1 Kozarje; 2 Primož, Osredek pri Hubajnici, Dolge, Gornje Impolje, Dolnje Impolje, Dolnje Orle; 3 Eisenkappel/Železna Kapla; 4 Jezerski vrh/Seebergsattel; 5 Kropa; 6 Slovenske Konjice; 7 Mala vas, Stožice; 8 Luče ob Savinji; 9 Ljubno ob Savinji; 10 Kamnik; 11 Gornji Grad; 12 Šoštanj; 13 Solčava; 14 Pobrežje; 15 Gösselsdorf/Goselna vas; 16 Schwabegg/Žvabek; 17 Kostanjevica na Krki; 18 Ravne na Koroškem; 19 Celje; 20 Nova vas, Dvorska vas; 21 Savica, Brod; 22 Šešče, Vrbje, Spodnje Roje; 23 Stein/Kamen, Seidendorf/Ždinja vas, Piskertschach/Piskrče; 24 Winkel/Kot; 25 Studor; 26 Otoče, Globoko; 27 Nomenj

2 FROM CENTRAL AUTHORITIES TO LOCAL RELIEF: BASIC LEVELS OF MATERIAL RESPONSES TO NATURAL DISASTERS

2. 1 The levels of Inner Austria and its provinces

Environmental historian Christian Pfister (2009) divides activities during and after a natural disaster into phases of emergency, damage compensation and reconstruction. According to him 'under the ancient régime, local officials waited for instructions from the prince and his cabinet in the wake of a disaster' (pp. 25–26) and only later, e.g. in the late

18th century when the initiative of the local level increased, 'local officials reported their observations to higher levels of administration and made recommendations on how best to manage the emergency phase' (p. 26). In the damage-compensation phase 'disaster-stricken communities usually received some support from the territorial ruler or his surrogate' (p. 27). The provinces could reduce or free the disaster-stricken population from taxes (Pfister, 2002a) and it was for instance typical for reconstruction following disastrous floods, the phase succeeding the emergency and damage compensation, that prior to the 19th century adaptation and flood risk mitigation were matters of local communities in the Western Europe (Pfister, 2009). On the observed territory, the system functioned in a slightly different way. According to the following case studies, central agencies took very important final decisions in the phases of damage compensation and reconstruction, but before that they had received the information from the local level, they had checked it and had asked for advice at the regional, mainly provincial level.

The instructions from 1498 already ordered the provincial administrator of princely property (*Viztum*) in Carniola to provide a report on damage, caused by natural disasters to the land in possession of tenants from **princely seigneuries**, to the central agency existing at that time (Žontar, 1966). How did the information from princely seigneuries reach the central authorities in the 16th and 17th centuries? The example of princely tenants from the small seigneury of Kozarje, spatially concentrated mainly in the village Kozarje (Fig. 1; no. 1) from the late 16th century is representative of many similar cases. **First**, the court in Graz in Styria, at that time the capital of Inner Austria, received a letter written by tenants or on behalf of them, e.g. by a person with pledge right on the affected princely seigneury. In the case of Kozarje, it says that severe winter and cold weather in 1586, the subsequent frost but most of all hailstorms in 1588 caused great damage to cereals and fruits to eight princely tenants there which turned them to poverty and caused 'severe famine'. The letter was written not earlier than in 1589. Tenants asked for release from their debts caused by taxes and dues from years 1586 to 1588. The letter did not forget to stress also that they lived close to the city of Ljubljana, the provincial capital, where their compulsory labour presented a source of workforce for the administrator of the princely possession (*Viztum*) (ARS, 1589). Taking into account the fact that the purpose of such documents was releasing of burdens, many such sources present the devastation in an exaggerated way. Comparison of preserved draft and final version of a record from 1654 on damage caused to agricultural land and forest by fluvial erosion and deposition can demonstrate it. According to the (impartial or already exaggerated?) draft, up to five days had formerly been needed to plough the devastated fields and 112 carts of hay had been cut on destroyed meadows, what turned to many days of ploughing and many hundreds of carts in the final version (ARS, 1654a, b, d). Thus, **second**, trying not to be misled, the court's treasury ordered the provincial administrator of the princely property to provide a report on the situation containing also the advice, what the adequate measures would be for the central authority to take in the case of Kozarje; it dates from March 6, 1589. **Third**, the *Viztum* answered confirming the truthfulness of causes for the existing poverty announced by tenants. He suggested releasing them from debts in taxes and dues at least for the year 1588 if not for all the three years they had asked for, or for two of them. To

increase the possibility for his proposal to be accepted, he also emphasized that the occasional compulsory labour of these tenants in Ljubljana or in freight transport reduced the expenditures for workforce (ARS, 1589) – one of the factors which could lead to potential untruths in his report. **Fourth**, on April 22, 1589, the court's treasury from Graz decided to release these tenants from the whole tax and dues for 1588 (ARS, 1589).

The central agency thus took into account the potentially reliable advice from the regional level. The procedure took a couple of months, thus it was completed relatively quickly, which was not always the case. For instance, the letter from the princely seigneury of Teriška vas/Ruckenstein was sent to Graz before August 25, 1570, stating that fields of 29 listed tenants in eight settlements, e.g. Primož, Osredek pri Hubajnici, Dolge, Gornje Impolje, Dolnje Impolje and Dolnje Orle (Fig. 1; no. 2), were entirely devastated by a hailstorm in the same year. It immediately followed the previous food shortage, thus the tenants would not subsist there unless they were released from taxes for 1570. The order to the provincial administrator of princely property to inform the central agency on the actual circumstances and to propose the adequate measures was written in Graz on August 29. Almost half a year later, before January 30, 1571, the seigneury sent a reminder to the court's treasury in Graz that as far as it knew the case was still not solved and on February 4, the central agency issued a reminder to the provincial *Viztum* as they were still waiting for his report (ARS, 1570–1571). The field work had by that time already been carried out – not by *Viztum* himself, but by a nobleman from the vicinity whom *Viztum* had ordered to conduct it. His report to *Viztum*, dated November 16, 1570, more or less confirmed the statements of the seigneury of Teriška vas/Ruckenstein. Due to the previous food shortage, the majority of tenants stricken by hail in 1570 already had to borrow, buy or beg for seed for 1570 harvest; also the seigneury helped them with release from dues and with seeds.

In 1570, hail destroyed the majority of those cereals with high grain volume weight and grapes to tenants listed by the seigneury as well as to two nearby hides in Prevoje. In the villages Gornje Impolje, Dolnje Impolje and Dolnje Orle harvest of cereals with high grain volume weight and grapes was completely destroyed. *Viztum* sent his report to the court's treasury only on September 8, 1571. He proposed to help the affected tenants with a tax release and reduced dues, especially for those whose crops were entirely destroyed. However, he stated that according to the trustworthy information he had received, the main reason for the poverty of these tenants was extremely low wine and must prices paid to the tenants by former seigneurial economic officials. The *Viztum* did not know whether this was also the case with the economic official of the time but he proposed to make sure that such exploitation would not continue. On November 19, 1571, the court's treasury proposed the prince to reject the tax release due to the usury of seigneurial economic officials as well as to force the noblewoman with pledge rights on this princely seigneury to pay the debts in taxes instead of the tenants and to make sure that the usury of economic officials would not continue. Five days later, more than a year and a quarter after the beginning of the procedure, the prince rejected the tax release and ordered the mentioned noblewoman to make sure that the usurious wine prices would not continue (StLA, 1571).

Recommendations from provincial level were thus not always respected by central authorities as demonstrated even more clearly by an application for a three-year tax

release of burghers from the alpine market town of Kappel/Kapla (now Eisenkappel/Železna Kapla) (Fig. 1; no. 3). The subsequent letter from Graz to the agency of the provincial administrator of princely property and, in this case, also to the representative of the office between the prince and the Estates of the province (*Landeshauptmannschafft*; on this agency, see Spreitzhofer et al., 1988) dates from April 11, 1572. The involvement of the instance between the prince and the Estates is here probably the consequence of the reported fact that burghers of Kappel/Kapla had unsuccessfully tried at first to receive aid from the Estates of the province. The *Viztum* who inspected the situation there and a representative of the office between the prince and the Estates recommended a two year tax release (a year less than the burghers had asked for) because of damage caused by water due to abundant precipitation and harvest failure(s). To increase the possibility of a favourable answer, they emphasized that this market town was also in charge of repair works on a section of the important Alpine route over the Jezerski vrh/Seebergsattel Pass (Fig. 1; no. 4). At that time, it was in very bad condition thus the investment of traffic-related incomes of the market town would not make the repair works possible. The tax release would lead also to improved traffic infrastructure, what would have broader beneficial economic consequences. The central agency proposed prince to reject this tax release but stated that he could per chance allocate another kind of relief to the burghers of this market town. Considering the finances of the state, this solution could not only be beneficial in this case but would also discourage similar applications for tax releases in the future. On December 21, 1572, the prince ordered the court's treasury to reject the tax release in order to avoid other similar cases but ordered the court's treasury to impose on the provincial *Viztum* to deliver this market town the relief of 50 Gulden in each of the two following years. This sum corresponded to about a quarter of the taxes paid by burghers of this market town in two years (StLA, 1572a, b). Further research will be needed to prove, whether this case in reality had any broader impact.

In the case of a disastrous flood in Kropa (Fig. 1; no. 5) in the autumn of 1625, there is clear evidence that after the measures recommended by provincial *Viztum* were rejected in Graz, he was ordered to propose a more acceptable solution (StLA, 1626). Kropa, situated in a narrow valley, was in the 17th century very important center of iron extraction and forging, many devices were driven by waterwheels (Valvasor, 1689). The provincial *Viztum* ordered the visitation of the devastated Kropa. It confirmed the truthfulness of the report which had arrived from Kropa to Graz stating that 'the smithies, charcoal sheds, road[s?], squares, ore, charcoal, wood and others' needed for iron extraction and forging as well as 'houses, fields, gardens, bridges and mills' were so much swept away or devastated that it was impossible to recognize, where they had been situated. As means of damage compensation the *Viztum* supported the proposal from the application sent from Kropa to Graz to allow a tax free sale of as many nails as 500 horses could carry. The recommendation was rejected in Graz but the provincial *Viztum* was ordered again to propose an acceptable solution. It was a flood relief of 200 Gulden, a half of it for the local church whose dues collected from people in possession of ecclesiastical pieces of land disappeared because the plots were annihilated by erosion and deposition, the other half for the blacksmiths. According to the estimation it only amounted to less than a third

of sum of taxes for trading in nails which 500 horses could carry and the court's treasury was not against the new proposal from provincial level (StLA, 1626).

Also **non-princely seigneuries** could apply for tax releases due to natural disasters. In February 1654, the provincial diet of Carniola confirmed a considerable tax release of 200 Gulden to a seigneury due to the damage caused by hail (ARS, 1654c). In some cases, detailed lists of devastated holdings were added. This is most probably the reason why a source listing more than 40 tenants possessing vineyards subservient to three small ecclesiastical seigneuries with seigneurial seats in the parish of Konjice (now Slovenske Konjice) (parish seat Fig. 1; no. 6) who were affected by hailstorm in 1700 is preserved in the archives of the provincial Estates. Its reliability is suspicious, it is not based on inspection of affected territory but on questioning the affected. The landlord listed there for how much the 1700 wine harvest of each of those tenants exceeded the tithe and dues, for 13 tenants the source says that it did not exceed them at all, also the amount of harvested seigneurial wine is mentioned. Shares of destroyed cereals are not listed although the source mentions that also they were severely stricken (StLA, 1701).

The application to the Estates of the province of Carniola from 1654 for tax reductions for tenants from various seigneuries due to fluvial erosion and deposition at villages Mala vas and Stožice (Fig. 1; no. 7) calls for inspection of circumstances (ARS, 1654a, d) thus at least in some cases visitations were carried out before the answer was provided. Further investigation of tax reductions and relief involving the Estates of provinces will be needed.

2. 2 Seigneuries, help among neighbours and relatives

If we move further towards the local level, **seigneuries** were important actors in material responses to natural disasters. In some cases detailed reports on such disasters or increased environmental dynamics of less than disastrous extent are preserved in their archives, e.g. the report of seigneurial official on flood in the Upper Savinja Valley in late autumn 1625 whose addressee was the bishop of Ljubljana as important landlord there. The official, who had just returned from the flooded area, reported that snow cover formed in the mountains as well as in the valleys in late November or in early December; a rainy interval followed, so that there were up to 12 successive days of precipitation. It rained incessantly at least in the night and the day before the report was written. In the administrative unit of Luče (almost corresponding to the present-day municipality; central village Fig. 1; no. 8), all the paths along the Savinja River were washed away. In Ljubno (Fig. 1; no. 9), the new bridge and two dams were destroyed, one of the dams was entirely washed away. The source describes in detail the damage caused to the new bridge across the Savinja River on an important way from Kamnik (Fig. 1; no. 10) via Gornji Grad (Fig. 1; no. 11) towards Šoštanj (Fig. 1; no. 12), where the river severely stroke the pillars and caused collapse of one of the arches. The source reveals also the awareness of the fact that damage was not caused only by water but also by wood and other material carried by the swollen river. The main emphasis is thus placed on infrastructure but even here the report is evidently not exhaustive. For instance, there were about 120 isolated farmsteads on the

slopes above Luče, according to a source from 1581 about every fourth of them possessed a small mill on an nearby alpine brook but no such damage is reported in the source in question. From the great majority of those mills no dues were paid to the seigneury which could be the reason why they are not mentioned in the report (Zwitter, 2013; 2014a).

There is evidence that **seigneuries took a variety of measures** to help tenants after natural disasters and also less destructive adverse nature-induced events. Seigneuries e.g. (a) allowed a temporary or permanent reduction of tenants' burdens (cf. Pfister, 2002a) – those delivered annually and/or occasional ones (Zwitter, 2014b; 2015). Seigneuries (b) permitted intensification of land use in limited parts of forests or pastures in order to compensate for the flood-inflicted damage and also (c) ordered works in stream beds (see below). On the one hand, there is evidence that a seigneury (d) cared for attachment of extant agricultural land of an abandoned holding to another farm which was severely damaged by fluvial lateral erosion in order to improve its economic situation (Zwitter, 2014b). On the other hand, seigneuries (e) cared for incorporation of agricultural land that remained from the former farms abandoned due to natural disasters (e.g. floods) to the existing holdings, e.g. of remnants of three out of nine hides in Otoče in the 15th century (Fig. 1; no. 26) which were subservient to the seigneury of Radovljica or of the only field that after the flood remained of one out of three hides of the same seigneury in the nearby village Globoko. Some seigneuries (f) enabled a different, more favourable form of dues, e.g. pecuniary ones instead of dues in agricultural products of tenants from four or five hides subservient to the same seigneury in Otoče in the 15th century – in four cases explicitly as adaptation to flood-inflicted damage (ARS, 1498). Alpine farmsteads in the seigneury of Gornji Grad (seigneurial seat Fig. 1; no. 11) delivered barley instead of rye in 1602 (Zwitter, 2014a). Both species do not tolerate the same hazards equally and they are exposed to weather in different parts of the year. E.g., barley has a very short growing season, rye, if autumn-sown, is among all cereals most prone to damage by long-lasting snow cover (Pfister, 1984). As mentioned, seigneuries (g) were often involved in correspondence with higher authorities applying for tax reductions. Seigneuries (h) influenced on adaptation to conditions after a disaster and on the vulnerability also through court rulings (Zwitter, 2014b). In some seigneuries, (i) tenants in severe economic difficulties, potentially caused by natural disasters, were allowed to pawn a part of their farms for a limited period, e.g. for up to three years (ARS, 1571), which, in general, improved subsistence possibilities by borrowing money or property without a long-term deterioration of economic situation of holdings. On the territory of isolated farmsteads above Solčava (Fig. 1; no. 13), an area where impartibility of farms was a rule, the seigneury (j) allowed a tenant to sell a third of the isolated farm in 1627 after the hailstorm had devastated it (Zwitter, 2013). Seigneuries (k) served as important creditors of tenants at least in terms of tolerating accumulation of tenants' arrears (Zwitter, 2015), and (l) some tenants were forgiven a part of their debts by the seigneury due to natural disasters (Zwitter, 2014b).

Exceptionally, landlord (m) provided a relief that was not expected to be returned. Seigneuries thus occasionally helped already in the emergency phase. So, the landlord approved the application for the famine relief in cereals (rye) – which was not expected to be returned – for a drought stricken family of his severely ill tenant from Pobrežje or its hilly southern

surroundings (Fig. 1; no. 14). Tenant's wife provided an application to the landlord stating that extreme summer heat and drought as well as hoar frost in autumn caused very severe harvest failure of cereals, cabbage and turnips on their holding and in its surroundings in 1669 (it is not clear if in the previous years as well). She stated that they were dependent on relief received from neighbours and relatives (NŠAL, 1670; localisation based on comparison with NŠAL, 1723). Comparison with other sources reveals that husband's severe illness contributed to the positive answer (NŠAL, 1579). Due to the closeness of seigneurial seat, the listed arguments are most probably real although the entire economic effects of severely adverse natural conditions on this holding could be reported in an exaggerated way. In the case that not a single but consecutive harvest failures are mentioned, the information corresponds with the documented crop failures in the region of Solčava (Fig. 1; no. 13) in the second half of 1660s caused by frost (Zwitter, 2015). Further investigations will be needed to prove whether the fact that this landlord was a bishop contributed to the positive answer.

Ties between people in areas affected by natural disasters strengthened and multiplied. The aid was usually a combination of institutionalized and not formally organized one. On the **local level** it comprised e.g. relief campaigns organized by church or various kinds of help provided by relatives, neighbours and other locals (Pfister, 2002a; 2002b; 2009). It is typical that the source from Pobrežje documents that neighbours and relatives were the first to help, higher institutional levels were only activated when help between relatives, neighbours and other villagers did not suffice (cf. Pfister, 2002b). Results, referring to the time from the late 19th century on but in many aspects relevant for our topic, stress that main motives for this first help, activated already during the emergency phase and continuing throughout the forthcoming phases, were compassion, religious grounds and also awareness that a household could reckon on help if it also offered it. This awareness played an important role although former disputes could be overcome due to a disaster in a considerable number of cases (Makarovič, 1979). Also credit networks existed in the countryside in the observed timeframe (Zwitter, 2015).

3 ACTIVE HUMAN INTERVENTIONS IN THE ENVIRONMENT RELATED TO NATURAL DISASTERS

Despite the importance of religious interpretation of God punishing human sins by disasters, preventive measures taken were 'more than just religious observances'. Devastation caused by natural disasters presented an incentive to think of risk mitigation or even prevention during reconstruction (Pfister, 2009, p. 27). Whereas the previous chapter focused on institutionalized as well as not formally organized ways of relief, this one concentrates on artificial interventions in the environment related to natural hazards as far as they are reported in the listed sources. Most of them refer to flood hazard. Learning in the case of natural disasters 'is geared either toward prevention of or adaptation to catastrophes' (Pfister, 2009, p. 20). In this chapter, we will go step by step from riverscapes towards areas distant from watercourses but severely impacted by artificial interventions related to natural disasters.

3. 1 Riverbeds

The awareness that regular **stream cleaning activities** contribute to risk mitigation was at least partially present. The brook Suha/Sucha rises in the Alps to the north-east of Eisenkappel/Železna Kapla. Due to seepage into the ground, there used to be no surface flow in the final part of its bed close to Gösselsdorf/Goselna vas prior to the recent regulation (Fig. 1; no. 15). However, when its water level rose, the surface water flow lengthened and the debris from this flooding caused e.g. abandonment of a meadow in possession of a tenant from Gösselsdorf/Goselna vas as recorded in mid 1660s. At that time, the seigneury of Eberndorf/Dobrla vas cared for cleaning up the creek bed of the Suha/Sucha. Details were not reported, but removal of a fence reaching into stream bed thus increasing flood risk could be a part thereof. The seigneury of Eberndorf/Dobrla vas also warned the seigneury of Sonnegg/Ženek to clean its part of the bed by compulsory labour of tenants to mitigate flood risk. Not far from there, villagers from Schwabegg/Žvabek (Fig. 1; no. 16) were obliged to clean up the bed of another brook or mill race every year as reported by the source from 1664/65 (Zwitter, 2014b & author's fieldwork in 2015).

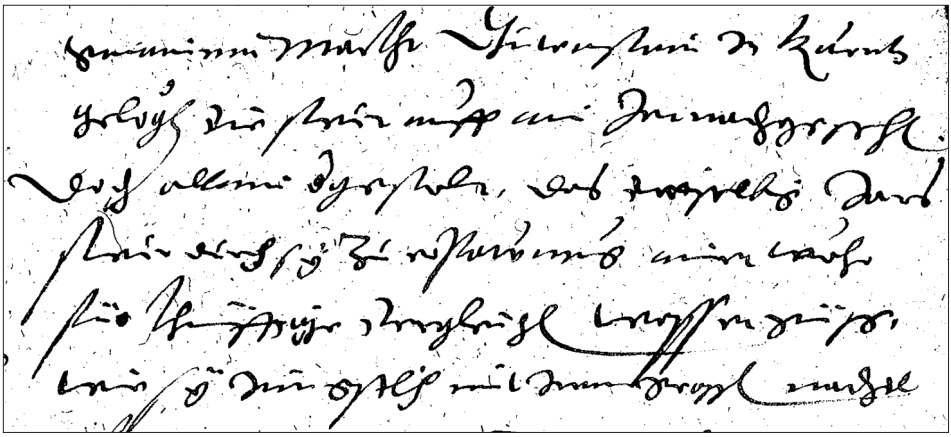
One of the measures of stabilizing the river banks in the observed timeframe was **reforestation** (Pfister, 2009). The town Kostanjevica (now Kostanjevica na Krki) (Fig. 1; no. 17), situated on a low island within the floodplain of the Krka River (Komac, Natek, Zorn, 2008) offers an example of afforestation and further measures to prevent fluvial erosion. The island was considerably narrowed by lateral erosion between the 17th and early 19th century. From 1691 a record is available, not only mentioning erosion of river banks but also ordering its prevention. Every burgher had to plant ten poplars and willows, which were not allowed to be cut for heating, no tree was permitted to be cut for charcoal and it was prohibited to dig holes for fishing (Golec, 2014). The ordinance thus reveals not only understanding of bank-protective role of roots and prescribes to plant appropriate tree species for moist soils but proves also the awareness of anthropogenic stimulation of erosion by digging the holes.

Building of wooden constructions to protect river banks or erection of dams in rivers or streams was another way of mitigating the risk of lateral erosion (Pfister, 2002b). Traditional constructions from wood, stone and some iron elements added for stability are at present recognized as good, sustainable practices of water management and of impeding slope processes. Their building is promoted (Repnik Mah et al., 2013). We shall realize that very similar constructions have already been built in the 16th century.

The market town of Guštanj (now Ravne na Koroškem) (Fig. 1; no. 18) is situated in an alpine valley near the Meža River. On the slopes above the urban settlement, made of impermeable bedrock, there have been extensive permanent forest clearings. Additionally, temporary clearings existed there in the observed timeframe due to the presence of swidden cultivation. These are some of the factors causing floods in the market town (Komac, Natek, Zorn, 2008; swidden cultivation: Makarovič, 1982; Zwitter, 2014a). In the late 1560s or in the early 1570s, this princely market town was stricken by flood, the burghers asked the Inner Austrian court to release them from their debts in taxes. According to the previously discussed procedure, the court's treasury ordered *Viztum* in May 1572 to provide a

report containing also the advice which measures to take. By accident, *Viztum* had already personally visited the affected territory in 1571. In his report to the central agency from November 1573, he suggested releasing the burghers from tax for at least one year but only on condition that they invested the capital saved by tax release into the riverbed, probably by stabilizing the banks, so that a future flood would not cause a repeated devastation. The court accepted this suggestion and on November 25, 1573, a one-year tax release was issued on the aforementioned condition (Fig. 2; StLA, 1573; translation that it refers to the banks by comparison of StLA, 1588, and Franz, 1998). Such preventive measures from the 16th century are interesting in a Middle European context; it has been stressed for the Ill River close to Strasbourg, that contemporaries had already clearly connected its regulation in 1531 with prevention of future damage (Schenk, 2012).

Figure 2: A section from the source confirming tax release for Guštanj (Ravne na Koroškem) on condition that preventive works in the riverbed are carried out (StLA, 1573)
Slika 2: Izsek iz vira, ki potrjuje davčno olajšavo za Guštanj (Ravne na Koroškem) pod pogojem, da bodo izvedli dela v strugi vodotoka (StLA, 1573)



The town of Celje (Fig. 1; no. 19) is situated in the floodplain, there are confluences of the Savinja and the Ložnica as well as the Savinja and the Voglajna rivers in the immediate vicinity (Fig. 3). In the course of centuries, the urban area was often stricken by floods (Komac, Natek, Zorn, 2008). At least in a part of the observed timeframe, mill dams increased the flood risk as reported for the 1651 flood. In the centuries preceding the observed period, at least from the late 15th century on, works in the river are known to have been carried out (Orožen, 1971; Bizjak, 2014).

Riverbed of the Savinja shifted towards the Ložnica creek above their confluence upstream from the town Celje in the second half of 1580s (Fig. 3). Consequently, only a very narrow belt divided the two streams. Contemporaries realised a serious risk that the majority of water from the Savinja would find its way into the riverbed of the Ložnica, severely increasing the flood threat to the main road, the nearby common land and the town castle. It

would cause also other devastation. The commission whose part was also the official of the administrator of princely property called for the necessary erection of constructions on two locations of severe lateral erosion to strengthen the banks and prevent the progression of the Savinja (*Sann Fluss* in Fig. 3) towards the Ložnica (*Bach Losniz* in Fig. 3). They stated that one of the two had to be particularly strong, built from oak timber (StLA, 1588). Wood of some oak species belongs to the best choices for such constructions due to its slow decomposition and resistance to fungi (Repnik Mah et al., 2013). The commission proposed the strengthening of the latter construction by timber framework filled with stones. Official of the *Viztum* recommended to build another timber skeleton filled with stones for strengthening the bend of the river near the castle (*Schloss* in Fig. 3). The commission also called for people skilled in protection against fluvial erosion to inspect this area but due to the severe risk of the Savinja reaching the Ložnica soon, they were afraid that this commission would arrive too late. On December 20, 1588, the court decided not to wait. It allowed to cut the requested oaks in the princely forest near Celje; during the tree felling caution had to be taken to make the least possible damage to forest and game (StLA, 1588). However, the risk was mitigated but the Savinja River was not tamed in the observed timeframe. For instance, disastrous flood in August 1651 destroyed a small section of town wall and eroded an extensive area of town's common; works to mitigate the risk were ordered (Orožen, 1971). If not earlier, the swollen river caused damage there again in 1656. It harmed the so called old construction considerably and lateral erosion appeared at another site where it had not represented a problem before. The *Viztum* stated that four new skeletons would have to be

Figure 3: The hydrological situation near Celje in 1780s provides a basic context to interpret the situation in 1580s despite the naturally and socially caused changes in the meantime (Slovenia …, 1763–1787, 5, section 193)
Slika 3: Hidrografske razmere v bližini Celja v 80. letih 18. st. predstavljajo osnovo za razumevanje dogajanja v 80. letih 16. st. navzlic naravno in družbeno povzročenim spremembam v vmesnem času (Slovenija …, 1763–1787, 5, sekcija 193)

erected there and that only oaks were appropriate for such constructions. The court's treasury agreed with it and ordered to take the oaks from the princely forest again (StLA, 1656).

Due to high population density, the issues of natural disasters affecting urban areas are different from those in the countryside (Bankoff, 2007). However, mitigation or prevention of lateral erosion by stabilizing river banks were not characteristic only for urban areas. In 1558, a new renter of the seigneury of Bled was installed, who was given a list of ordinances (Wallner, 1889). Accompanied by specified persons he had to inspect the damage caused by lateral erosion of watercourses in two villages, most probably Nova vas and Dvorska vas (Fig. 1; no. 20) but per chance the information refers to Savica and Brod (Fig. 1; no. 21). He was obliged to enable the affected tenants to gain some uncultivated land and intensify its land use as compensation for the agricultural land devastated by fluvial erosion but he was at the same time obliged to order these tenants to strengthen the river banks to prevent future lateral erosion there (Innstruction …, 1558).

In some cases **artificial channels were dug** to mitigate flood risk at a certain site, which could have downstream effects. The rural and urban areas in the Lower Savinja Valley at the end of the 17th or at the beginning of the 18th century offer examples of both. The Savinja River near Šešče and the neighbouring villages to the east (Fig. 1; no. 22) was a braided river (Slovenia …, 1763–1787, 5, map of the section 174). At that time, its riverbed moved northwards there, towards some villages and the main road, thus artificial channels were dug, e.g. near the mentioned village, shortening the riverbed. This measure mitigated lateral movement of the river, but on the other hand, the straighter bed caused disputes over accelerated erosion downstream as the contemporaries perceived it. Another artificial channel was dug for the lowest course of the Ložnica in 1690s. Some bushes which had formerly grown on the path of this new channel were foreseen to serve as material to strengthen the embankments (Orožen, 1971) – a common sort of raw material for such constructions at that time (Winiwarter et al., 2013). Similarly, a channel was dug to change the course of the Sava River not far from the village Mala vas near Ljubljana (Fig. 1; no. 7) in 1707 but due to the dispute it is not yet clear whether the water was redirected to it or not (ARS, 1707).

3. 2 Agricultural land, forests and settlements

In the wake of a hailstorm and heavy rain having caused disastrous flood, tenants of St. Lambrecht's abbey in Upper Styria asked their landlord to apply at the provincial Estates for tax release, so they would be able to subsist there and **turn the devastated agricultural land again into fruitful area**. They stated that the disaster not only destroyed their crops in fields, but it also devastated a lot of agricultural land. It swept away a very considerable extent of fields and meadows, some of them were covered with debris and years of work would be needed to make the land suitable for cropping again (StLA, 1611). Despite the possible exaggerations, the source proves that in certain cases, definitely more frequently than shown in the preserved written sources, such adaptive interventions were also carried out, e.g. by removing the unproductive debris which covered fertile land. However, it was certainly often not the case. For instance, a source

from 1707 says that former meadows – partly eroded and partly covered with debris by the Sava River not far from Mala vas (Fig. 1; no. 7) and the neighbouring villages to the west – were abandoned and overgrown by bush (ARS, 1707).

Investigation of **local knowledge about natural hazard adaptation and mitigation** belongs to desiderata of environmental history (Schenk, 2014). The lawsuit between the village communities of Stein/Kamen, Seidendorf/Ždinja vas and Piskertschach/Piskrče (Fig. 1; no. 23), situated above the Drava River in Jauntal/Podjuna, over enclosing the common land reveals preventive importance of local long-term knowledge. The ruling from July 1615 observed local knowledge emphasizing the importance of taking into account decades old historical experience of problems caused to animal husbandry, when a year of extreme drought was followed by a year of extreme flood, in order to mitigate the forthcoming vulnerability related to droughts and floods. Both extreme weather conditions destroyed grass on the common of Stein/Kamen, both natural hazards also threatened the common of Seidendorf/Ždinja vas, thus it was essential for both villages to have access to the common of the neighbouring Piskertschach/Piskrče, where on the one hand, there were water springs mitigating the drought threat, and on the other hand, this common was situated higher, thus the flooding Drava River did not reach it. The ruling from 1615 made sure that the communities from these three villages were allowed to graze the animals on all the three commons. However, every village community had to keep or restore the good quality of grassy pastures it was in possession of – by uprooting the thistle, thorny bushes and coniferous trees. This task represented the largest burden to the village Piskertschach/Piskrče because their common was the most overgrown by thornbush, spruce, fir and pine trees. Additionally, since there was wetland, this village was ordered to dig drainage ditches. The fact that the common of Piskertschach/Piskrče was the most overgrown one proves that by ordering its clearing and draining the seigneury wanted to assure larger extent of productive land than needed in most years to prevent lack of fodder as a consequence of extreme drought or flood event (Zwitter, 2014b).

It was common to **compensate the agricultural land devastated by lateral erosion by intensifying the use of some previously uncultivated land** – forest or pasture. As revealed already by the aforementioned lawsuit, flood damage caused also artificial interventions and environmental change in parts of cultural landscape away from the flood area. Sources from the seigneury of Eberndorf/Dobrla vas reveal conversion of forest or pasture into fields at the village Winkel/Kot in Jauntal/Podjuna due to fluvial erosion (Fig. 1; no. 24) (Zwitter, 2014b). The ordinance of the deputies of the bishop of Brixen/Bressanone in Tyrol as landlord of the seigneury of Bled from 1558 contains the same instruction for tenants from the already mentioned two villages, most probably Nova vas and Dvorska vas (Fig. 1; no. 20) or, due to the already mentioned uncertainty, maybe from Savica and Brod (Fig. 1; no. 21) (Innstruction …, 1558). A land register of the seigneury of Radovljica from 1579 ordered such compensation of flood damage for two farmers from the village Studor (Fig. 1; no. 25) after the village community had confirmed the truthfulness of the devastation. The seigneury stressed that the extent of the new clearings would have to correspond with the extent of the lost agricultural land which the affected tenants had possessed and also boundary stones would have to be erected in order to

prevent uncontrolled further clearing or other disputes. The dues, tithe and taxes of the flood-stricken tenants would thus not be reduced (ARS, 1579).

However, the extent of forests and pastures and the geopolitical situation did not allow to take such measures everywhere. According to the same source, the seigneury of Radovljica at the same time reacted to river-induced damage to the tenants from the village Otoče situated near a bend of the Sava River (Fig. 1; no. 26) only by releasing them from a considerable part of dues in cereals and by noting that also their pecuniary dues and their taxes would in the course of time have to be reduced because the river was causing further damage and hardly anything was left from two of the eight farms from this seigneury there (ARS, 1579). Moreover, the inclination to this kind of intensification of land use also varied in time within the same seigneury and considering tenants from the same settlements. The land register of the same seigneury from 1498 proves that the compensation of flood damage to a tenant in Studor (Fig. 1; no. 25) was not carried out by allowing such an intensification of land use but, instead, by reduction of tenant's dues (ARS, 1498). At the village Savica, situated near the bend of the Sava Bohinjka River (Fig. 1; no. 21), 17 out of 33 holdings of tenants who delivered the tithe to the seigneury of Radovljica were deprived from very considerable extent of arable land devastated partly by lateral erosion and partly by deposition during floods. The devastation took place at unspecified occasions before the land register was written in 1579. In some cases it caused abandonment of a half of the fields from which the tithe was collected by the seigneury of Radovljica. The extent of two holdings in the nearby village Nomenj (Fig. 1; no. 27) was also reduced during floods, leaving to one of them only roughly one third of the fields (ARS, 1579).

Changing of riverbed's position was due to geomorphic factors, weather and climate characteristic for many sections of rivers in the middle and lower course. It was also the case with the Sava River to the north of Ljubljana, e.g. near the villages Stožice and Mala vas (Fig. 1; no. 7). Despite it, there were many factors promoting land use in parts of some floodplains, which was for that time intensive. Such factors were the influx of nutrients where deposition of nutrient-rich mud was the prevailing process during flood events, vicinity of potable water, possible income and transport possibilities provided by the adjacent river (Winiwarter et al., 2013).

However, the environment has been changing considerably since the medieval colonisation. The Sava River was not navigable near the villages Mala vas and Stožice in the late Middle Ages (Kosi, 1998) and also not in the 17th century (Valvasor, 1689). It was a braided river (Slovenia …, 1763–1787, 2 & 4, maps of sections 177, 190). In this area, sources from mid-17th century reveal fluvial erosion and deposition of sand and pebbles on fertile land, e.g. on fields and meadows (ARS, 1654a, b, d). Therefore, there is clear evidence that increased soil fertility was not the case here. Land use became inappropriate due to the changing location of riverbed which posed increased threat not only to agricultural land but also to villages. Extensive floods lasted there for five to six days every spring according to data from the second half of the 18th century which surely does not correspond entirely with conditions a century and a quarter earlier (Slovenia …, 1763–1787, 4). According to the source from 1654, the river in previous decades devastated very considerable parts of

holdings in possession of 19 tenants from Mala vas and Stožice. It was destructing parts of arable land, meadows, common land and bush, in some places by erosion, in others by deposition. The extent of affected fields is not expressed in precise units but up to five days were reported to have formerly been needed to plough the devastated land. According to the same source, more than a hundred carts of hay had been harvested from the devastated meadows. The bush and the common where trees for timber had been cut were reported to have been damaged. The source says that most of 19 listed tenants from the villages Mala vas and Stožice will have to abandon their houses because the riverbed moved too close to them (ARS, 1654b, d).

Another source from the mid-18th century proves that this statement was truthful – these **villages were displaced to flood safe locations** (Fig. 4). At that time, two meadows, each of them a part of another holding from Stožice, were called '*Na starem selische*' meaning 'On the site of the former homestead' (ARS, about 1750a), thus at least some of the sites of former homesteads in the floodplain were used as meadows. It is also

Figure 4: The flood safe location of the old farmstead in the now urbanized village Mala vas on the terrace is not a result of a cautious selection of settlement area, taking into account long-term environmental change already in the Middle Ages. It is a consequence of historical adaptation in the forthcoming centuries. After the artificial transformation of the riverscape, e.g. the channelisation, the former floodplain below the village is not threatened any more, not even by a 500-year flood (for present flood hazard see Environmental atlas …, 2014). (photo: Ž. Zwitter, 2014)

Slika 4: Poplavno varna lega stare kmetije v dandanes urbanizirani Mali vasi na terasi ni rezultat pazljive srednjeveške izbire prostora za naselje, ki bi upoštevala dolgoročne okoljske spremembe. Je posledica historične prilagoditve v sledečih stoletjih. Po umetnem preoblikovanju rečne pokrajine (regulaciji) nekdanja poplavna ravnica danes ne šteje več med ogrožene niti zaradi poplav s 500-letno povratno dobo (o današnji poplavni nevarnosti gl. Environmental atlas …, 2014). (foto: Ž. Zwitter, 2014)

explicitly reported for Stožice in the same source that some of the homesteads had to be displaced due to fluvial dynamics but the homesteads of villagers persisting on old locations were threatened (ARS, about 1750a). The fact that the village was formerly located below the terrace and its present-day location is a consequence of fluvial dynamics is preserved also in local tradition, at least in the case of Stožice (Škerl, 1987) but it was not known before this investigation whether it was true or false and when it had happened. By the mid-18th century, the Sava River also entirely eroded a big meadow in possession of a tenant from Mala vas. This meadow had been called '*vass*' (ARS, about 1750b), 'The village' – evidence that by the mid-18th century the riverbed moved or extended to the location where at least some homesteads from the village Mala vas were previously standing.

There are also other examples of villages in the observed timeframe displaced to safe, higher locations due to fluvial dynamics, e.g. Vrbje and Spodnje Roje (Fig. 1; no. 22) in the Lower Savinja Valley at the end of the 17th or at the beginning of the 18th century (Orožen, 1971).

4 CONCLUSIONS

In Inner Austria, central authorities, especially the (Inner Austrian) court's treasury played an important role in material responses to natural disasters in 16th and 17th centuries. They checked the information received from local level at regional, mainly provincial level, and asked the latter also to propose adequate measures for central authorities. It made possible potentially highly efficient measures, e.g. to approve relief for damage compensation only on condition that preventive measures would be taken. However, proposals from regional level were in some cases accepted, in others they were rejected leading either to decisions without further consultations with regional level or to repeated ordering provincial administration to propose acceptable measures. Duration of such procedures varied but, characteristic of that time, it did not allow a reaction in the emergency phase at least for short-lived emergencies. Regarding non-princely seigneuries, provincial Estates were involved in responses to natural disasters.

Seigneuries not only reduced or accustomed tenants' burdens, they could also allow tenants to pawn or sell parts of their holdings in order to improve their economic situation, seigneuries attached or incorporated abandoned holdings to the remaining ones, seigneuries functioned as tenants' creditors, forgave a part of tenants' debts, at least exceptionally they even approved the relief to affected tenants and did not expect them to return it. They were involved in responses to natural disasters also through court rulings. Seigneuries thus influenced on adaptation to conditions after natural disasters and similar less destructive events, but they were in some cases also actively involved in risk mitigation. They could be involved in all three phases of activities during and after a natural disaster – emergency, damage compensation and reconstruction. It is important to stress that not all the listed measures were taken in every seigneury.

Mentioned institutions only reacted when help of relatives and neighbours did not suffice. There were many institutionalized and not formally organized measures which could be taken but the effectiveness of the whole system is yet to be assessed.

Artificial interventions in cultural landscapes related to floods took place on the one hand in riverbeds and on the threatened lands, e.g. by cleaning up riverbeds, strengthening river banks with wooden skeletons filled with stone or through reforestation as well as by digging new channel to divert a section of a river or a creek into it. On the other hand, artificial interventions also affected flood safe environments, e.g. by clearing forest to compensate for lost agricultural land or by displacement of villages.

Local traditions in the Early Modern Period in some cases included knowledge of historical natural disasters as well as an enviable rate of awareness how important it was to take such data into account during decision-making process in order to reduce vulnerability to future extreme nature-induced events.

(Translated by the author)

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STVARNI ODZIVI NA NARAVNE NESREČE V 16. IN 17. STOLETJU: PRIMERI Z OZEMLJA DANAŠNJE SLOVENIJE IN NJENE OKOLICE

Povzetek

Članek obravnava stvarne ukrepe, povezane z naravnimi nesrečami na Kranjskem, Koroškem in Štajerskem v 16. in 17. st. Metodološko predstavlja analizo primarnih pisnih virov iz arhivov graške dvorne komore, notranjeavstrijske dvorne komore, vicedomskega urada za Kranjsko, kranjskih in štajerskih deželnih stanov ter izbranih zemljiških gospostev. Sinteza temelji na rezultatih študij primerov. Razprava po eni strani nudi temeljni vpogled v stvarne ukrepe, povezane z naravnimi nesrečami, po drugi strani pa obravnava človeške posege v okolje, ki so bili povezani s poplavno nevarnostjo in dejanskimi poplavami. Znotraj kulturne pokrajine se osredotočam na kmetijska zemljišča in naselja.

V deželnoknežjih gospostvih, mestih in trgih je prošnja za pomoč po naravni nesreči, npr. za davčno olajšavo, z lokalnega nivoja potovala neposredno na sedež notranjeavstrijskih centralnih uradov v štajerskem Gradcu. Pred odgovorom pošiljatelju na lokalni nivo je (notranjeavstrijska) dvorna komora kot centralni organ, pristojen za deželnoknežje premoženje, iz Gradca naslovila dopis na regionalnega predstavnika – vicedoma, ki je bil pristojen za deželnoknežje premoženje v deželi ali v njenem obsežnem delu. Vicedom je moral v Gradec poslati svoje poročilo o naravni nesreči, s čimer si je dvorna komora zagotovila zanesljivejše informacije od tistih, ki jih je prejela s strani prizadetih. Poleg tega je moral vicedom dvorni komori predlagati ustrezne ukrepe. Takšen postopek je omogočal učinkovito ukrepanje, denimo davčni spregled v času sanacije po poplavah, a le pod pogojem, da bodo tako prihranjena sredstva vložili v sanacijo struge vodotoka, kar so leta 1573 določili od poplav prizadetemu trgu Guštanj (Ravne na Koroškem). Poudariti je potrebno, da so v Gradcu le občasno udejanili ukrepe, ki jih je priporočil vicedom. V nekaterih primerih so ravnali po svoji presoji, v nekaterih drugih pa so vicedomov predlog ocenili kot neustrezen in ga pozvali, naj predlaga novo, sprejemljivo rešitev. Trajanje takšnih postopkov ni bilo enotno, vendar pa vsaj v primeru tistih naravnih nesreč, kjer so izredne razmere kratkotrajne, ni omogočalo ukrepanja že v času trajanja naravne nesreče. V nedeželnoknežjih gospostvih so bili v ukrepanje po naravnih nesrečah vpleteni deželni stanovi.

Zemljiška gospostva niso ukrepala le tako, da so (a) po naravni nesreči zmanjšala podložniška bremena ali (b) spremenila obliko dajatev v ugodnejšo. Med nadaljnje gospoščinske ukrepe so sodila dovoljenja, da so podložniki (c) zastavili ali (d) prodali del podložne posestne enote, da bi izboljšali svoj gospodarski položaj, gospostva so (e) ohranjene dele kmetij, ki so propadle zaradi naravnih nesreč, priključila preostalim kmetijam in obratno – (f) obstoječa kmetijska zemljišča opuščenega posestva je gospostvo priključilo kmetiji, ki je ostala naseljena, čeprav so ji naravni dogodki uničili obsežen del kmetijskih zemljišč. Zemljiška gospostva so poleg tega (g) dovoljevala urejanje nadomestnih obdelovalnih zemljišč namesto tistih, ki so jih uničile poplave, in sicer z intenzifikacijo rabe tal na ozemlju gozdov ali pašnikov, in (h) odrejala sanacijo strug vodotokov. Gospostva so bila vpletena v odzive na naravne nesreče tudi (i) prek razsodb patrimonialnih sodišč. Poleg tega so (j) podložnike kreditirala, zaradi naravne nesreče so (k) podložnikom lahko odpisala del dajatev, v izjemnih primerih so (l) podložnikom namenila tudi brezplačno pomoč, ki je ni bilo potrebno vrniti. V kontekstu naravnih nesreč so bila vključena tudi v (m) dopisovanje z nadrejenimi organi. Zemljiška gospostva so torej vplivala na prilagajanje razmeram po naravnih nesrečah, v nekaterih primerih pa je njihova dejavnost vplivala tudi na zmanjševanje tveganja. Zemljiška gospostva so lahko sodelovala v vseh treh stopnjah ukrepanja po naravni nesreči – v času izrednih razmer, nadomestila škode in obnove. Vendar v vseh gospostvih niso izvajali vseh navedenih ukrepov, v različnih delih istega gospostva so lahko hkrati ukrepali na različne načine, tudi znotraj istega gospostva so v istem kraju lahko ob različnem času ukrepali različno – denimo enkrat z odpisom podložniških dajatev, drugič z dovoljenjem za ureditev nadomestnih zemljišč po poplavah.

Navedene ustanove so se vključile v odzive na naravne nesreče, kadar pomoč sosedov in sorodnikov ni zadoščala. Obstajali so raznovrstni institucionalno in neformalno

organizirani ukrepi, ki jih je bilo mogoče uvesti, vendar pa stopnja raziskav še ne omogoča ocene učinkovitosti celotnega sistema.

S poplavami povezani posegi v pokrajino so po eni strani potekali v strugah vodotokov in na poplavno ogroženih območjih, po drugi strani pa tudi v poplavno varnih legah. Strugam so utrjevali bregove z gradnjami iz lesa in kamna – tako so pri poplavno ogroženem Celju v 80. letih 16. st. skušali preprečiti prelitje Savinje v strugo Ložnice – ali s pogozdovanjem. Poleg tega so kopali umetne struge, da bi vanje preusmerili vodotoke, in odstranjevali med poplavami odloženo nerodovitno plavje. Blizu Ljubljane so tako leta 1707 izkopali kanal, da bi vanj preusmerili Savo. Na poplavno varnih lokacijah so okoljske razmere spreminjali denimo z urejanjem nadomestnih obdelovalnih zemljišč ali s prestavitvijo vasi. Spreminjanje savske struge je med sredino 17. in sredino 18. st. zahtevalo prestavitev večine domačij Stožic in Male vasi na višji, poplavno varni mesti. Kjer je nekdaj stala Mala vas, je sredi 18. st. tekla Sava, nekdanja zemljišča dela stoženskih domačij pa so tedaj uporabljali kot majhne travnike.

Zgodnjenovoveško lokalno znanje v nekaterih primerih ni vsebovalo le poznavanja naravnih nesreč v preteklosti, ampak tudi zavidljivo stopnjo zavedanja, da je za zmanjšanje ranljivosti v tedanjem času in v prihodnosti pri načrtovanju pomembno upoštevati te podatke. Razsodba v sporu glede ograjevanja gmajn med tremi podjunskimi vasmi iz leta 1615 je upoštevala pričevanja, ki so trdila, da mora paša ostati nerazmejena, saj je historična izkušnja leta z izredno sušo, ki mu je sledilo leto z izrednimi poplavami, dokazala, da je to za lokalno živinorejo zaradi škode, ki sta jo oba dogodka povzročila travi, ključnega pomena. Ena od treh gmajn je namreč ležala više, tako da je niso dosegle dravske poplave, hkrati pa so ravno na njej ležali izviri, ki so zmanjševali tudi nevarnost suše. Največja zaraščenost te gmajne med vsemi dokazuje, da so bile tamkajšnje pašne obremenitve v običajnih letih zmerne. Z razsodbo, da jo je potrebno očistiti trnovega grmovja, smrek, borov in jelk (z vidika živinoreje neproduktivne in moteče rastline!), hkrati pa izboljšati kakovost pašnika še z izkopom drenažnih jarkov v močvirju, je gospostvo ukazalo, da je tam potrebno vzdrževati obsežnejše pašnike, kot so bili potrebni v običajnih letih, da bi zmanjšali okoljsko ranljivost tamkajšnje živinoreje v sušnih poletjih in ob poplavah.

THE PROBLEM OF DISSOLUTION DOLINE DEFINITION

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Abstract
Dolines are regularly referred as diagnostic karst landforms, as their formation is usually attributed to chemical weathering or dissolution, which is the most typical karst process. In this paper, we re-evaluate the formation of the two most typical dissolution dolines, provided by Cvijić. Within this study, we stated that both cases, which constitute the foundations of interpretation of dissolution dolines formation, are actually not caused by dissolution of the surface. The purpose of the article is to provide a doubt about the understanding of formation of the most common karst landform.

Key words: geomorphology, karst, doline, dissolution, ERI (electrical resistivity imaging), Dinaric karst, Slovenia

PROBLEM DEFINICIJE KOROZIJSKIH VRTAČ

Izvleček
Vrtače so najbolj pogoste kraške oblike zmerno toplega pasu, saj njihov nastanek navadno pripisujemo kemičnem preperevanju oziroma koroziji, ki je najbolj tipičen proces na krasu. V članku smo ponovno ovrednotili nastanek dveh najbolj tipičnih primerov korozijskih vrtač, ki jih je podal Cvijić. V raziskavi smo ugotovili, da oba primera, ki predstavljata temelje korozijske razlage nastanka vrtač, pravzaprav nista nastala s korozijo površja. Namen članka je podati dvom o razumevanju nastanka najbolj tipičnih kraških oblik.

Ključne besede: geomorfologija, kras, vrtača, korozija, ERI (električna upornost tal), dinarski kras, Slovenija

1 INTRODUCTION

Dolines are small to middle-sized closed depressions of various shapes. They are the most typical unit landform in the temperate latitude karst since they are giving the relief distinctive pitted character. The term *doline* was first used by Austrian geologists in the middle of 19th century (Šušteršič, 1994; Gams, 2003) while studying the Classical karst in Carniola. At that time a number of different typologies of dolines appeared. Scholars recognized several different types according to their morphographic and morphometric properties. On the other hand, there was extensive disagreement about morphogenesis of dolines, whether they form by a collapse of cave chamber ceiling or predominantly by a dissolution action on the surface. The oldest description introduced by early researchers of the Classical karst in Carniola connected the doline origin to a collapse (Cvijić, 1893). They recognized the role of dissolution action on the surface mostly in a role of doline slope remodeling. Other group of scientists supported the findings of Cvijić (1893) who claimed that middle-sized surface depressions are formed solely by surface dissolution. They supported his statements with variety of examples from different karst environments, which were confirming dominant role of dissolution in a dolines formation.

The most influential karstologic publication written by Cvijić at the end of 19th century was the monograph titled *Das Karstphänomen* (1893). Among other topics, he discussed morphogenesis of dolines in detail. He claimed that although dolines might be formed by other mechanisms, the most characteristic dolines are formed by the action of dissolution (Cvijić, 1893). He listed a number of examples from the Dinaric karst but he presented only one example of a doline cross-section profile. This example was the evidence of a fractured zone that is contributing to a concentrated runoff of rainwater and consequential accelerated dissolution on which he explained the morphogenetic formation of all dissolution dolines. This illustration of a dissolution doline cross-section became one of the most reproduced in all geomorphologic literature. Cvijić did mention a number of areas where comparable examples of dissolution dolines appear. Among other examples of such areas he specified only one location where typical examples of dissolution dolines are situated. This is an area named Skalčen kamen close to Logatec, Slovenia.

The aim of the article is to re-evaluate classical examples of dissolution dolines provided by Cvijić (1893). The first objective is to discuss and re-evaluate morphogenesis of the doline cross-section that became classical example of dissolution doline presented by Cvijić (1893). Morphogenesis of this doline at Logatec train station will be established through earlier findings recorded in a literature. The second objective is a geomorphologic analysis of the doline in the Skalčen kamen area. It will be studied through morphographic and sediment analysis as well as by application of electrical resistivity imaging (ERI). The results of the article will not present a new proposal of doline morphogenesis mechanism. However, it will bring to focus reasonable doubt about contemporary understanding of dissolution doline formation.

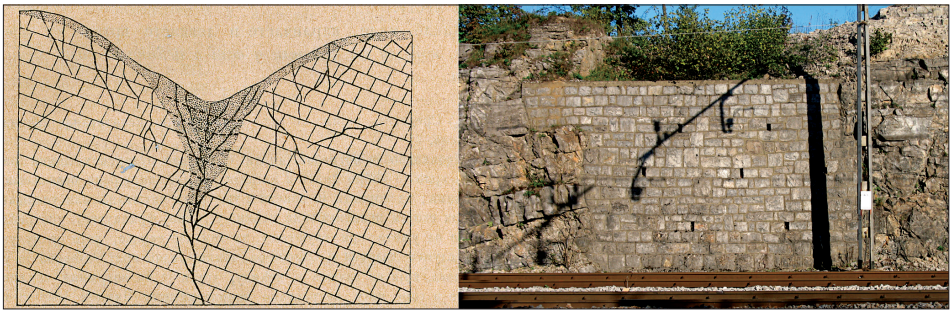
2 THEORETICAL CONCEPTS OF DISSOLUTION DOLINES

Contemporary understanding of dissolution doline formation dates back in the end of 19th century. The monographs *Der Karstphänomen* in German language, followed by a slightly updated version with title *Karst* in Serbian language, both written by Cvijić (1893; 1895) have had great impact on karstology as a science. Among many karst phenomena, he discussed in detail geomorphologic properties of dolines. He recognized a couple of doline forming processes but he finally concluded that the most common dolines are formed by dissolution and he even terms them as *true dolines* (in German: die echte Dolinen; Serbian: лраве вртаче) (Cvijić, 1893; 1895). He explained them as the places of more intensive dissolution lowering of the surface, which is controlled by bedrock fractures.

Cvijić (1893) even proposed several arguments and evidences against theories of collapse origin of dolines. He stated that there are no reliable reports in the literature in which a bedrock doline would be disturbed by a collapse. In addition, he claimed that majority of typical bowl- and funnel-shaped dolines are not connected to caves. Even if dolines lead to caves that does not mean that they are automatically to be explained as a product of collapse. In addition, existence of detritus cones and other debris in the caves does not justify the conclusion that dolines are sited over them. Such accumulations may be formed for a variety of reasons (Cvijić, 1893). On the other hand, Cvijić offered detailed reports about bedrock dolines from various parts of the Dinaric karst. He claimed that those examples are a proof that majority of dolines are surface features formed by dissolution. The presented examples have no connection with subsurface cavities since bedrock strata beneath them are not repositioned. Additionally, bedrock beneath them is fractured by numerous cracks that are enlarged by dissolution and filled by terra rossa and fragments of limestone.

Though Cvijić presented many areas where dissolution dolines appear, he offered only one example of doline cross-section as an explanatory model of dissolution doline formation. The example is positioned within a railway cut at the Logatec train station, Slovenia. This doline cross-section has become the most reproduced figure of doline cross-section in the following literature (Fig. 1).

Figure 1: Original sketch of the cross-section of a dissolution doline (Cvijić, 1893, p. 63) (left) along with photo of present situation of the railway cut (right) (photo: U. Stepišnik)
Slika 1: Izvirna skica profila korozijske vrtače (Cvijić, 1893, str. 63) (levo) s fotografijo današnjega stanja železniškega useka (desno) (foto: U. Stepišnik)



By this cross-section example Cvijić (1893) noted that there is no evidence of underlying cavity, since all underlying strata are undisturbed. Nevertheless, the bedrock is intensively fractured directly under the lowest point of the doline. An area of limestone fragments is positioned just below the doline floor in a shape of a wedge (on Fig 1 left marked with dotted lines). The wedge is completely fractured and limestone fragments are embedded in terra rossa (Cvijić, 1893; 1895).

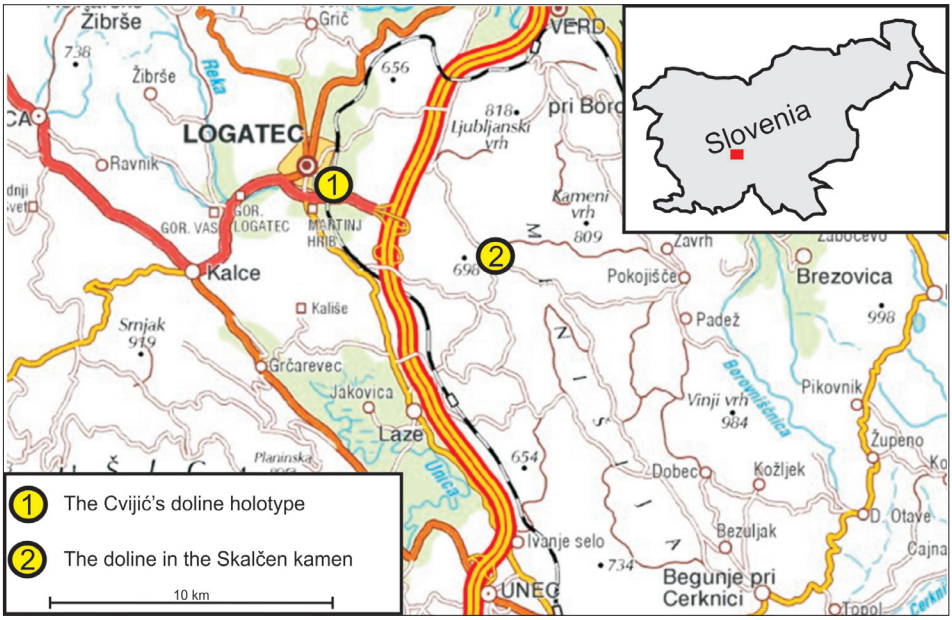
The definition and cross-section sketch of dissolution dolines provided by Cvijić (1893) had a tremendous impact on subsequent theories about doline morphogenesis. Following literature did not question the presented dissolution morphogenesis but it was more concerned with distribution and morphometry of dolines. Even contemporary literature (e.g. Gams, 2000; Sauro, 2003; 2012; 2013; Williams, 2003) defines dissolution dolines following theoretical background of Cvijić (1893) as closed surface depressions which were formed in the areas of focused chemical attack on bedrock.

Modern interpretations of dissolution dolines morphogenesis were summarised by Sauro (2012) into three types. The first type is a point-recharge doline which is strongly connected to outflow of surface streams into karst subsurface. The second type is a drawdown doline. The formation of later is result of focusing of the dissolution inside the water infiltration zone of the rock through centripetal convergence of the mainly subsurface water held inside the epikarst. This type of morphogenesis exactly corresponds the dissolution dolines proposed by Cvijić (1893). The third type is an inception doline that also originates from the centripetal convergence of water; this occurs inside a pre-existing hydrogeological structure and is triggered by a change of hydraulic conductivity due to lithological and structural factors.

The cross-section of the doline at the Logatec train station was partially destroyed and built up by a protective wall, so cross-section is not visible any more. But according to Šušteršič (1994), who studied morphometry of the surrounding area in detail, the doline ground plan is not circular but it is rather lengthened depression along a tectonic crushed zone. Therefore, the basic example of the doline cross-section is accordingly not a doline but preferably a type of a karst channel termed bogaz (Šušteršič, 1994) or karst corridor (Tîrlă, Vijulie, 2013). It means, that most cited and reproduced example of dissolution doline is not a dissolution doline at all.

Since the structure presented by Cvijić is not a doline, a new holotype of a dissolution doline was required. Cvijić did mention numerous areas where similar examples of dissolution dolines appear. Among a large number of general locations, he specifically noted the area of typical dissolution dolines in the Skalčen kamen about 6 km southeast of Logatec, Slovenia. The area is densely covered by dolines of various shapes so it was not completely clear which doline Cvijić specifically mentioned. Detailed morphometric analysis of dolines in the area was performed by Šušteršič (1994). One doline that is positioned closest to the road crossing at the Skalčen kamen with study name SK-022 was determined as the most typical and was defined as a new holotype of the dissolution doline (Šušteršič, 1994).

Figure 2: Location of the doline cross-section in railway cut in Logatec (1) and doline SK-022 in the Skalčen kamen area (2)
Slika 2: Lokacija profila vrtače v useku železnice v Logatcu (1) in vrtače SK-022 v Skalčnem kamnu (2)



Source/Vir: GURS, 2015

3 RESEARCH METHODS

Morphometric analysis of the doline in Skalčen kamen with study name SK-022 provided by Šušteršič (1994) was used to prepare cartographic background for further morphographic survey. Morphographic analysis included identification of micro-scale features, types of slopes (Stepišnik, Kosec, 2011) as well as identification of the sediments exposed on the surface.

Since the formation of the dissolution doline cannot be interpreted solely by surface morphology, the geophysical method of electrical resistivity imaging (ERI) was applied to identify the subsurface structures. The SuperSting R1/IP Earth resistivity meter developed by Advanced Geosciences Inc. was used for the data collection. The survey was conducted with a dipole-dipole array and 20 electrodes were used simultaneously with alternation of two currents and two potential electrodes. The data were processed to generate two-dimensional resistivity models, using EarthImager 2D resistivity inversion software developed by Advanced Geosciences Inc. The root-mean-square (RMS) error quantifies the difference between the measured resistivity values and those calculated from the true resistivity model. A small RMS value indicates small differences. The

minimum RMS error in the survey was 5.8%, and the maximum error was 13.56%. The method turned out to be appropriate for subsurface tomography of karst terrains where significant differences of electrical resistivity values of material within the profile exist (Stepišnik, Mihevc, 2008; Kaufmann, Deceuster, Quinif, 2012; Mihevc, Stepišnik, 2012; Yeboah-Forson, Comax, Whitman, 2014).

4 GEOMORPHOLOGIC ANALYSIS OF A DISSOLUTION DOLINE

Within our study we performed detailed geomorphologic analysis of the doline SK-022 in the area of Skalčen kamen, which was defined as the new holotype of dissolution doline (Šušteršič, 1994). The doline is positioned in the northern part of an extensive levelled karst area named Logaški ravnik that is morphogenetically interpreted as corrosion plain or a relict polje (Šušteršič, Šušteršič, 2003; Šušteršič, 2004). The whole area is levelled at elevation of about 530 m. The doline is positioned in close proximity of the only road crossing in the area of Skalčen kamen at coordinates 45.883° N 14.296° E (WGS 84).

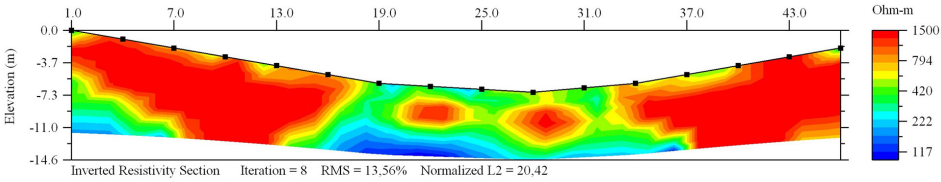
Figure 3: The doline SK-022 in the Skalčen kamen area from the southwest (photo: U. Stepišnik)
Slika 3: Vrtača SK-022 v Skalčnem kamnu od jugozahoda (foto: U. Stepišnik)

Detailed survey of the doline revealed that the doline longer axis is 50 m and shorter axis 45 m. The depth of the doline is 7.5 m and it covers an area of about 8000 m^2. The doline is positioned completely within Upper Jurassic limestone with dip of strata about 30 degrees towards east. Slopes of the doline are mostly balanced (Stepišnik, Kosec, 2011) with inclinations up to 20 degrees. Only southern slopes are steeper, with inclination up to 30 degrees and covered by coarse material which is prone to limited mass wasting. On the southern slope, there is a section with about 1.5 m high vertical wall. Loamy material is exposed in the lower sections of the northern slope as well as in the floor of the doline.

Within loamy material fragments of flowstone and up to fine pebble size grains of bauxite are to be found.

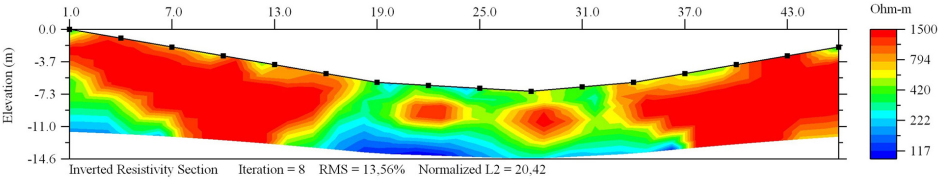
Two ERI profiles were measured through the doline. The first profile (Fig. 4) was conducted approximately along east-west axis across the lowest point of the doline floor. The azimuth of the profile was 260 degrees. Results from the electrical resistivity imaging, with electrodes at 3 m spacing, exhibited subsurface resistivity values on the slopes of more than 1000 ohm-m. The floor of the doline and its subsurface has resistivity values less than 500 ohm-m to a depth of 8 m and more. Below the floor in depth of about 3 m there are two circular structures with a diameter of 4 to 5 m and resistivity more than 1000 ohm-m (Fig. 5).

Figure 4: The first ERI profile of the doline SK-022 in east-west direction
Slika 4: Prvi ERI profil vrtače SK-022 od vzhoda proti zahodu



The second ERI profile (Fig. 5) was conducted approximately across south-north axis across the lowest point of the floor. The azimuth of the profile was 170 degrees. Electrical resistivity imaging profile was conducted by electrode spacing 3 m. The southern and the upper section of the northern slope have resistivity values higher than 1000 ohm-m. The same values are in the subsurface below them. Lower section of the northern slope and the floor along it exhibit resistivity vales lower than 500 ohm-m. The depth of low resistivity structure below it is at least 8 m (Fig. 6).

Figure 5: The second ERI profile of the doline SK-022 in south-north direction
Slika 5: Drugi ERI profil vrtače SK-022 od juga proti severu



5 DISCUSSION

Dolines are natural enclosed depressions of different shapes and sizes found in karst landscapes. They are considered a diagnostic karst landform. We recognize several different types of dolines, but the most common are formed due to dissolution, so they are

termed dissolution dolines (Ford, Williams, 2007). They are believed to have a similar function to the drainage basin in fluvial landscape. Dolines are discharging rainwater into underground via enlarged fissures in the lowest point of the doline (Williams, 2003). This interpretation was initiated in 19th century understandings which were summarized in work of Cvijić (1893). Contemporary literature recognises several types of dissolution dolines (e.g. Gams, 2000; Williams, 2003; Sauro et al., 2009; Sauro, 2012; 2013) which have foundation in definition provided by Cvijić (1893).

The doline morphometry at Skalčen kamen was initially well documented by Šušteršič (1994). We conducted morphographic analysis, which revealed that southern slope is active while other slopes are balanced. The floor and lower sections of northern slopes are covered by loamy material. Within the loamy material fragments of flowstone and up to fine pebble size grains of bauxite are to be found. Flowstone in the local climate cannot be generated on the surface, but only in cave environment. Bauxite deposits were not formed in situ. Their only location in the area is about 15 kilometers towards southeast in the watershed of the Cerkniščica River (Šušteršič, Šušteršič, 2003). Bauxite is being transported into karst aquifer by the Cerkniščica River from the area of the Cerkniško polje. The only spots where bauxite-derived deposits can be found in the area are fillings of caves and denuded caves (Geršl, Stepišnik, Šušteršič, 1999; Šušteršič, Šušteršič, 2003). Therefore, sediments fill analysis suggests that the doline is filled with sediments which are typical for caves in the area (Šušteršič, 2004). Those kinds of sediments are typical for cave environment and could not be formed inside a dissolution doline that is functioning as a vertical drainage for rainwater.

ERI profiles exhibit two different sets of electrical conductivity in the doline subsurface. Bedrock has resistivity values higher than 1000 ohm-m while loamy material and weathered or fractured bedrock has values lower than 500 ohm-m. Lower resistivity values are located beneath the floor of the doline as well as beneath lower sections of the northern slopes exactly where patch of loamy sediment is positioned on the surface. Therefore, we know that subsurface profile values with resistivity less than 500 ohm-m are as well of loamy material. Slopes as well as subsurface in those sections are built of limestone bedrock which exhibits resistivity values higher than 1000 ohm-m. Consequently, we assume that subsurface structure with those values is relatively undisturbed bedrock. Span of those two electrical resistivity values sets are comparable to previous applications of this method in various karst surface features on the Slovenian karst (Stepišnik, 2007; Stepišnik, Mihevc, 2008; Stepišnik, 2009). Earlier applications of the method revealed that the resistivity value for carbonate rock exceeds 1000 ohm-m. Soil and weathered bedrock exhibit the resistivity values between 200 and 1000 ohm-m. Loamy material has resistivity values lower than 500 ohm-m (Stepišnik, 2007; Stepišnik, Mihevc, 2008; Stepišnik, 2009).

The depth of loamy material below the doline in the Skalčen kamen area is well exhibited on both ERI profiles and it exceeds 8 m. Loamy material is not positioned only below the doline floor but also beneath a part of its northern slope. Thickness of this loamy fill is preventing vertical runoff of rainwater, thus the investigated doline cannot be a result of accelerated dissolution due to concentrated vertical runoff.

6 CONCLUSIONS

Most of the karstologic literature explains formation of dolines through dissolution effects of rainwater discharge via fissures in the lowest point of the doline (Williams, 2003; Ford, Williams, 2007). It is the most obvious deduction since the dominant process on karst is dissolution. Contemporary understanding of doline formation originates from a century old theories. Therefore, the aim of the article was to revaluate morphogenesis of the most common examples of dissolution dolines. The main objective of the article is not to propose new explanation of doline morphogenesis but to put focus upon understanding of dissolution doline formation.

A dissolution doline holotype introduced by Cvijić (1893) which became a basis for understanding dissolution formation of dolines as well as famous for its cross-section reproduced by many authors, turned out not to be a dissolution doline at all (Šušteršič, 1994). Since the first example of doline was recognized to be an elongated tectonic depression termed bogaz or corrosion corridor, another example of Cvijić (1893) was defined as a dissolution doline holotype (Šušteršič, 1994). The new holotype is positioned in the area of Skalčen kamen close to Logatec, Slovenia, and became a focus of our geomorphologic survey.

Morphographic analysis of the doline in the Skalčen kamen area revealed that a patch of loamy material is covering the floor and lower sections of the northern slope. This loamy material would not be uncommon if accelerated corrosion in the doline floor would result in formation of insoluble infill (Gams, 2003). Nevertheless, within the loamy material pebble size bauxite clasts as well as pieces of flowstone are found which are typical cave sediments in the area (Geršl, Stepišnik, Šušteršič, 1999; Šušteršič, 2004). Excessive amount of loamy material below the doline floor revealed by application of ERI also implies that it could not be solely a residual of a chemical weathering. Consequently, vertical runoff through the doline floor is not possible due to impermeable loamy material. Therefore, we must conclude that another holotype of a dissolution doline is rather a denuded cave (Mihevc, Slabe, Šebela, 1998; Mihevc, 2007).

Technically speaking, we do not have any particular example of a dissolution doline for which it was proven that it was formed by a process of dissolution. Furthermore, we do understand that epikarst zone seepage concentrated in a vadose zone is forming shafts (e.g. Ford, Williams, 2007). Enlarging of fissures in the subsurface beneath dissolution dolines would eventually lead to opening of the shaft. Since we have almost no examples from any karst area, where shaft entrances in doline floors would be common, we can conclude that it is highly unlikely that dissolution dolines would be formed by accelerated focused corrosion of epikarst.

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PROBLEM DEFINICIJE KOROZIJSKIH VRTAČ

Povzetek

Vrtače so majhne do srednje velike kraške kotanje različnih oblik. So najbolj tipična oblika krasa zmerno toplega podnebja. Začetek znanstvenega preučevanja vrtač sega v sredino 19. st., ko so različni krasoslovci pričeli s prvimi opisi in tipizacijami vrtač na osnovi njihovih morfografskih in morfometričnih značilnosti. Hkrati so se že takrat pojavila prva nesoglasja glede morfogeneze te najpogostejše kraške oblike. Najstarejše razlage pripisujejo nastanek vrtač procesu udiranja jamskih stropov. Učinek korozije so videli le v preoblikovanju vrtač in ne njihovem nastanku (Gams, 2004). Kasneje je Cvijić zavrnil udorni nastanek vrtač in zaključil, da nastanejo izključno z delovanjem površinske korozije (Cvijić, 1893). Njegovo interpretacijo je sprejela cela vrsta krasoslovcev v drugi polovici 19. st. (Cvijić, 1893).

Najpomembnejše delo iz konca 19. st., *Das Karstphänomen*, je objavil Cvijić (1893). Med drugimi oblikami in procesi se je Cvijić (1893) podrobno ukvarjal tudi z nastankom vrtač. Priznaval je, da lahko vrtače nastanejo na različne načine, tudi z udorom, daleč najpomembnejši in najpogostejši proces oblikovanja vrtač pa je po njegovih ugotovitvah korozija. Ta tip vrtač je Cvijić (1893) poimenoval *korozijske vrtače* oziroma celo *prave vrtače* (nemško *die echte Dolinen*). V svojem delu je navedel celo vrsto primerov korozijskih vrtač iz dinarskega krasa, vendar je predstavil le en primer prečnega profila vrtače (slika 1). V tem profilu, ki se nahaja v useku železniške postaje Logatec, je pod vrtačo jasno vidna zdrobljena cona, ki naj bi delovala kot zbiralec koncentriranega odtoka padavinske vode v podzemlje in posledično tudi pospešene korozije (Cvijić, 1893). Skico tega profila danes najdemo skoraj v vseh krasoslovnih knjigah in učbenikih. Cvijić je v svojih delih omenil številna območja, na katerih se pojavljajo podobni primeri vrtač, ampak je posebej imenoval le vrtačo v Skalčnem kamnu na Logaškem ravniku kot tipičen primer korozijske vrtače (Cvijić, 1893).

Šušteršič (1994) je podrobno preučil profil vrtače pri logaški železniški postaji in ugotovil, da opisana oblika pravzaprav ni vrtača, ampak podolgovato znižanje v reliefu, ki je nastalo ob tektonsko zdrobljeni coni. Torej, največkrat navajan primer profila korozijske vrtače pravzaprav ni vrtača. Šušteršič (1994) je tako za nov holotip korozijske vrtače predlagal vrtačo v Skalčnem kamnu, ki jo je omenil že Cvijić (1893).

Naša geomorfološka analiza vrtače v Skalčnem kamnu je pokazala, da sta njeno dno in del severnega pobočja prekrita z zaplato ilovnatega materiala. Prisotnost ilovic ni nič nenavadnega, saj naj bi v dneh vrtač zaradi pospešene korozije ostajal netopni material (Gams, 2003), vendar so v ilovnatem materialu prisotni tudi posamezni manjši prodniki boksita in kosi sige. Tako smo lahko zaključili, da sediment v vrtači najverjetneje ni netopni ostanek, pač pa alogeni material, značilen za jamska polnila na celotnem območju Logaškega ravnika (Šušteršič, 2004; Geršl, Stepišnik, Šušteršič, 1999). Pri analiziranju zgradbe vrtače pod površjem, ki smo jo opravili z metodo električne upornosti tal (ang. *electrical resistivity imaging*; ERI) smo ugotovili, da je ilovnati sediment v dnu vrtače in pod severnim pobočjem globok najmanj 10 metrov. Takšna količina ilovnatega sedimenta ne more biti netopni ostanek kemičnega preperevanja, saj hkrati preprečuje odtok padavinske vode skozi dno vrtače v podzemlje. Zaključili smo, da je drugi, novi holotip korozijske vrtače najverjetneje brezstropa jama (Mihevc, Slabe, Šebela, 1998).

Kljub temu da razumemo nastanek vrtač kot rezultat korozije kraškega površja in dela epikraške cone, nimamo primera, ki bi nedvomno dokazoval ta proces. Poleg tega sodobno krasoslovje razume funkcijo epikraške cone kot območje združevanja razpršenih vodnih curkov, ki vodi v oblikovanje vertikalnih votlin vadozne cone oziroma brezen. Ker pa so primeri, kjer bi bili v dneh vrtač vhodi v brezna, izredno redki, lahko zaključimo, da je malo verjetno, da bi vrtače nastale s korozijo površja oziroma s točkastim raztapljanjem razpoklinskih območij epikrasa.

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ASSESSING URBAN HEAT ISLAND IMPACT ON LONG-TERM TRENDS OF AIR TEMPERATURES IN LJUBLJANA

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Abstract
The paper presents an assessment of urban heat island (UHI) impact on air temperature trends in Ljubljana. The assessments are based on the comparison between the long-term air temperature trends in Ljubljana and Zagreb. Meteorological station Zagreb-Grič operated on the hill in the city centre since its establishment in 1862, while the Ljubljana station changed its location several times. The analysed UHI effect on the measurements of air temperature in Ljubljana gradually increased, especially after 1950.

Key words: urban heat island, climate change, instrumental period, temperature trends, Ljubljana, Zagreb

OCENA VPLIVA MESTNEGA TOPLOTNEGA OTOKA NA DOLGOROČNE TRENDE SEGREVANJA OZRAČJA V LJUBLJANI

Izvleček
V prispevku je ocenjen vpliv mestnega toplotnega otoka (MTO) na trende segrevanja ozračja v Ljubljani. Ocene temeljijo na primerjavi dolgoročnih trendov temperature zraka v Ljubljani in Zagrebu. Meteorološka postaja Zagreb-Grič deluje od ustanovitve leta 1862 ves čas na griču v središču mesta, medtem ko se je ljubljanska postaja večkrat selila. Analizirani učinek MTO na trende temperature zraka v Ljubljani se je postopoma povečeval, zlasti po letu 1950.

Ključne besede: mestni toplotni otok, spreminjanje podnebja, instrumentalno obdobje, temperaturni trendi, Zagreb, Ljubljana

1 INTRODUCTION

In the last 25 years the science dedicates a lot of attention to so-called historical climatology, which is engaged in researching past climate. Among the main reasons for the increased attention are certainly contemporary global and regional climate changes and fluctuations, which are manifested in several ways. In Slovenia for example, with the emergence of green and mild winters followed by very hot and dry summers at the end of the 1980s, and recently with the universal rise in the air temperature and increasing frequency of extreme weather events. In order to evaluate these processes and events correctly – to establish whether they already anticipate a changed climate or whether they are just the result of usual weather and climate variability – and prepare scenarios of the future climate and its (possible) results in natural and social environments, it is necessary to be accurately acquainted with the history of climate, both in pre-instrumental and instrumental periods for which measurement and observation data of meteorological stations are available.

To study the climate variability in Slovenia during the instrumental period of over a hundred years, five meteorological stations can mainly be taken into account. Two of them operate on the Slovenian territory, i.e. Ljubljana and Maribor, and three in the vicinity, i.e. Trieste, Zagreb and Villacher Alps. These stations began with measurements and observations in the mid-19th or the second half of the 19th century and have collected continuous series of data of sufficient quality. Temperature and precipitation data have been collected for Trieste since 1841, for Ljubljana and Villacher Alps since 1851, for Zagreb since 1862, and for Maribor since 1876. Trieste nicely exemplifies climate changes in Slovenian areas with moderate mediterranean climate, Ljubljana in the areas with subalpine variety of moderate continental climate of central Slovenia, Maribor and Zagreb represent the moderate continental climate of eastern Slovenia (subpannonian climate), and Villacher Alps the mountain climate (Ogrin D., 1996; Ogrin D., Plut, 2009).

The basic problem of analysing the series of climatic data over many years and establishing the changeability and climate trends arises from lack of homogeneity of data series. To obtain reliable results, the meteorological stations should have operated at the same places all the time, their surroundings should not have significantly changed nor the technology and methodology of measurements or observations. Wherever these circumstances of measurements have changed, detailed metadata about the history of observations are needed to correct and homogenise the data series. The problem of data series homogeneity is particularly acute with urban meteorological stations. These stations often migrate from the centre to the periphery, cities grow during the instrumental measurements period, the surroundings of these stations is urbanised and all that influence the measurements of air temperature. Although this impact cannot be entirely eliminated in the process of data homogenisation, the long-term trends of warming in the cities are much higher than in non-urban stations. This fact contributes to the problems of the identification of general trends in warming and regional responses to global warming.

The mentioned problem of large impact of urban climate on measurements of air temperature, and consequently the warming trend, is encountered also in Ljubljana. Beside the several relocations of the meteorological station in the first century of the measurements, its migration after the Second World War from the city centre to Bežigrad at the margin of the city, urbanised in the next decades, including densely building-up the surrounding areas of the station, is especially important for evaluating the long-term warming trends (Dolinar et al., 2010). Because of this, the warming trends for Ljubljana, especially in the last 30 years, even when using homogenised data, greatly exceed the world averages (Dolinar, Vertačnik, 2010).

It is not possible to determine precisely how much of the warming trend is due to the urban heat island. In the case of Ljubljana, we have tried to assess the influence of the urban climate on the warming trend in mean annual and seasonal air temperatures by comparing trends with Zagreb. The meteorological station Zagreb-Grič has not moved in more than 150-years history. It is located on a hill Grič, which has not experienced major urban and other changes from the second half of the 19th century. We therefore believe that the impact of the city's enlargement on temperature trends in Zagreb is minimal, and that the increased differences in trends between Ljubljana and Zagreb after 1950 can be attributed to the increased impact of urban heat island of Ljubljana on the measurements of the air temperature.

Temperature and precipitation series for Ljubljana and Zagreb have already been studied individually in the scholarly literature at different times; Ljubljana: Manohin (1952; 1965), Gams and Krevs (1990), Kajfež-Bogataj (1990; 1992), D. Ogrin (2003; 2015), Vysoudil and Jurek (2005), Bertalanič et al. (2010), Dolinar et al. (2010); Zagreb: Goldberg (1953), Šegota (1970; 1981), Juras (1985), Penzar, Juras and Marki (1992), Penzar et al. (1992a), Radić, Pasarić and Šinik (2004), Zaninović (2006), etc. Hence it follows that the problem of climate changing and establishing the trends of changes has not been topical only in the last decades, when the opinion prevails that a human is the main culprit of the current changing, but these questions became a subject of research soon after the sufficiently long series of climate data had been available.

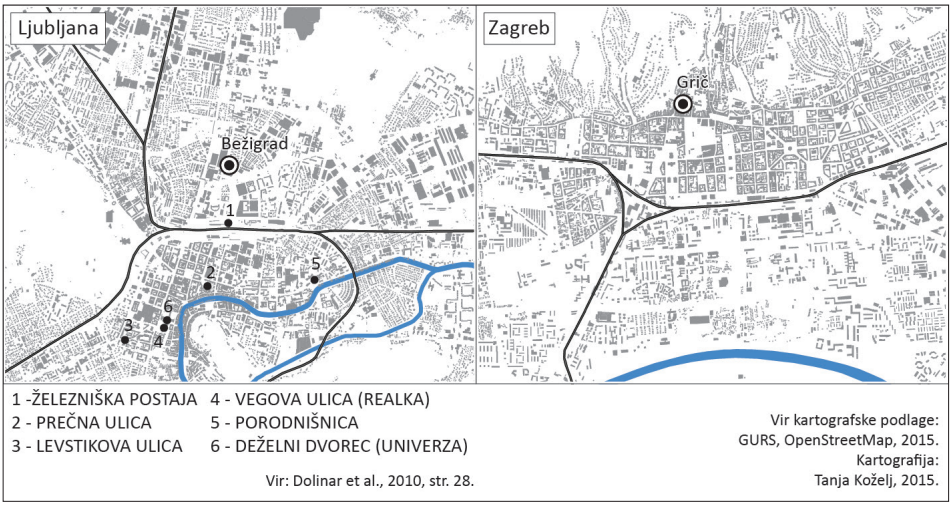
The urban heat island phenomenon has been in focus of several theoretical debates (e.g. in Oke, 1999; Souch, Grimmond, 2006; Gartland, 2008) as well as in case studies carried out in cities in Slovenia (Žiberna, 1991; Jernej, 2000; Konovšek, 2006), Central Europe (Lazar, Buchroithner, Kaufmann, 1995; Bottyán et al., 2005; Bokwa, 2011; Vysoudil et al., 2012) and elsewhere (Wanner, 1991; Montávez, Rodríguez, Jiménez, 2000; Kim, Baik, 2002). However, relevant examples of the analyses of the impacts of urban heat island on long-term temperature trends have not been found in the literature.

2 DATA SERIES AND METHODS

To determine the long-term temperature trends in Ljubljana and Zagreb, and the impact of the Ljubljana urban climate on warming trends, we analysed homogenised and non-homogenised data. The source of homogenised data was the website of the project HISTALP, where the long-term series of climate measurements for the territory of the

Alps are collected (Auer et al., 2007). The non-homogenised database has been composed of published series of data over many years for Ljubljana (Krevs, 1986; Klimatografija Slovenije, 1995) and for Zagreb (Penzar, Juras, Marki, 1992). The base has been upgraded for Ljubljana for the last 20 years with the data from the archives of the National Meteorological Service at the Slovenian Environment Agency (Agencija RS za okolje/ ARSO), and the 1990–2010 data for Zagreb from the archives of the Hydrometeorological Institute of Croatia (Državni hidrometeorološki zavod Republike Hrvatske). The basis of our calculations have been the average annual and seasonal temperatures, for Ljubljana for the period 1851–2010 and for Zagreb-Grič for the period 1862–2010.

Figure 1: Locations of meteorological observations in Ljubljana and Zagreb
Slika 1: Lokacije meteoroloških opazovalnih prostorov v Ljubljani in Zagrebu



The meteorological station of Ljubljana has changed its location and instrumentation several times in its 150-year history, while the Zagreb station has only changed its micro-location and instrumentation. In view of the homogeneity of data series, the Zagreb station is in better position since it has operated throughout at Grič (157 m a.s.l.). It was only in the initial period of measurements that, due to extending the Royal Secondary Modern School, the Stevenson screen was moved from the northern to the southern wing of the building; however, it was all the time located on the northern side, on a window on the first-floor. The fact that the station was not moved may mainly be credited to the world-famous geophysicist Andrija Mohorovičić, who was, on the basis of his own observations, familiar with the characteristics of the city's climate and the impact of moving the station on the homogeneity of the measured data (Mohorovičić, 1897; Herak, Penzar, Herak, 2011). The Zagreb-Grič station has a complete series of temperature (and precipitation) data, since its operation did not stop even during the First and the Second World Wars, despite certain troubles (Katušin, 2011).

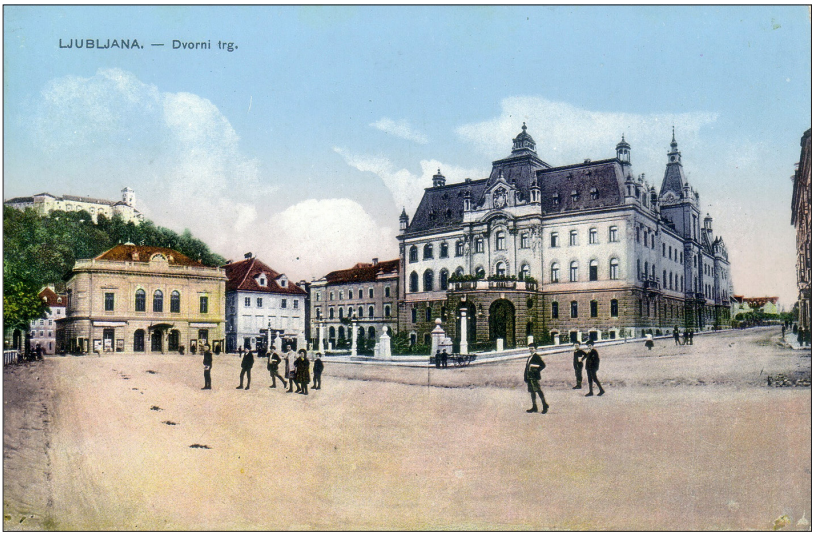
The station in Ljubljana was moved longer distances within the city. Despite the corrections made for Ljubljana, its data are less homogenous, due to a more versatile history and somewhat poorer knowledge of measurement circumstances in individual periods and a greater number of interpolated values, and above all, due to the moving of the station after the Second World War to the northern fringe of the city (Bežigrad, 299 m a.s.l.). According to Trontelj (2000), after the moving of the station in 1947, measurements were done on a 'large meadow' which was gradually built-up in the following decades and thus the measurement circumstances were significantly changed. Therefore, the impact of urban climate is present in temperature series for Ljubljana, also in the homogenised data series, which have been our basis for the assessment of the urban heat island on the warming trends.

Table 1: A short overview of the history of meteorological observations in Ljubljana and Zagreb
Preglednica 1: Kratek pregled zgodovine meteoroloških opazovanj v Ljubljani in Zagrebu

Ljubljana*	**Zagreb-Grič****
1850–1852: Telegraph office of the railway station, 1st floor – east, at the fringe of the city at that time, 298 m a.s.l.	1861–1864: The Great Secondary School, 1st floor – northern wing of the building
1853–1895: Prečna ulica street, 295 m, 298 m, 290 m a.s.l.; data for 1863 and 1864 are missing; city centre	1864: Stevenson screen relocated to the 1st floor of the southern wing
1895–1919: precipitation measurements; Levstikova ulica street, 297 m a.s.l.	1861–1891: meteorological measurements and observations managed by I. Stožir
1895–1924: Secondary school in Vegova ulica street, station relocations within the building 306 m, 304 m, 297 m a.s.l.; city centre 1921–22: parallel air temperature measurements at Šiška and in Šlajmerjeva ulica street	1892: observations taken over by A. Mohorovičić, gradual replacement of instruments
1921–1948: the University building, Institute of Geography, station relocations within the building, 309 m, 305 m, 295 m a.s.l; city centre	1896: Secondary school moves to a new location, meteorological observatory remains on its original location
1948– : Bežigrad, Celjska (Vojkova) ulica street, 299 m a.s.l.; fringe of the city, later densely built-up	Uninterrupted daily recording of climate elements since 1861; 157 m a.s.l.

*Sources/Viri: * Gavazzi, 1925; Povše, 1984; Trontelj, 2000; ** Katušin, 2011; Herak, Penzar, Herak, 2011*

Figure 2: The seat of the University of Ljubljana (former Provincial Mansion), where the Geographical Institute carried out measurements of air temperatures between 1921 and 1948 (postcard from 1913; collection D. Ogrin)
Slika 2: Sedež Univerze v Ljubljani (nekdanji deželni dvorec), kjer so na Geografskem inštitutu potekale meritve temperature zraka med leti 1921 in 1948 (razglednica iz leta 1913; zbirka D. Ogrin)



To study the temperature trends, we used linear regression analysis and Mann-Kendall trend test. With the first method, we assessed rates of temperature change in the studied time series. Linear regression analysis is one of the parametric methods and among the conditions for its use is a normal frequency distribution of the data. The latter was verified using Kolmogorov-Smirnov test with Lilliefors correction and Shapiro-Wilks test. Analyses have shown pronounced deviations from normal frequency distribution for several studied time series. Also the trends observed by linear regression analysis, and tests of their statistical significance, show considerable differences between them. Methodological issues and the results of these analyses deserve a more detailed consideration and will be dealt within a separate article. In this paper some selected calculations were used mainly to illustrate the effects of urban heat island in temperature trends.

Since the non-normality of the frequency distribution of the data and the absence of statistically significant linear trends are common phenomena in the study of climate, the use of nonparametric methods for studying trends is a common practice. These methods are robust, insensitive to the frequency distribution of the data (Mann, 1945; Kendall, 1975; Hirsch, Slack, Smith, 1982) and give much more 'loose' results compared to parametric methods. Among the most widespread is the Mann-Kendall trend test with Lilliefors correction. It is based on a rank correlation (Kendall's tau) and is intended to test only the monotony of the trend, i.e. whether data are monotonously

rising or falling, or confirm the null hypothesis that there is no trend in the time series (or, otherwise, these data are randomly distributed in the time series). The 'loose' results are evident also in our research, as the method shows the existence of statistically significant monotonous trends also in some cases, where the linear regression analysis shows statistically insignificant trends.

Descriptive statistics, linear trends and 20-years moving averages in our study have been calculated using Excel for Windows (Microsoft; 2013) and SPSS (IBM; 2013), and the Mann-Kendall trend test using XLSTAT (Addinsoft; 1995–2014).

3 RESULTS AND DISCUSSION

3.1 100-years trends in mean annual and seasonal air temperatures in Ljubljana and Zagreb

The results of the analyses of the homogenised data show the same variability in the mean annual air temperatures in Ljubljana and Zagreb, and minor differences in variability of seasonal temperatures. The most variable temperatures in both cities are found in the winter, and the least variable in the summer. Also, the most pronounced trends of warming since the mid-19th century are found in the winter. In Ljubljana, the trends of warming are more pronounced, both in homogenised and non-homogenised data (Tables 2 and 3). Although, without taking the impact of the urban climate into account, we would expect more pronounced warming trends in Zagreb, due to more continental character of its temperature regime. Seasonal temperatures in Ljubljana, without exception, have been increasing since the mid-19th century to the present day. The warming trend is the most pronounced in winter, which is demonstrated in the increase of the winter temperatures in Ljubljana by more than 2 °C from the mid-19th century to the present day. Until the early 20th century, the winter temperatures were below-average, in the middle of the first half of that century several exceptionally warm winters have been encountered, and in the next few decades winter temperatures have variated around 150-year average. From the 1980s on, there is a pronounced upward trend in winter temperatures. Winter is followed by spring, and similar trend is evident in mean annual temperatures. Summer temperatures have increased more intensely in the last 25 years, when the mean summer temperature has been by 1.5 °C higher than the 160-year average.

The coldest year in the studied period was 1871, and the warmest was 2000. Very warm years have mainly occurred in a row since 2000. The coldest winters were in the first 100 years of measurements. Very warm winters are most typical for the last two decades (the warmest winter 2006/07) and for the beginning of the 20th century. The latter period was followed by a fast decrease in winter temperatures. The warmest summer was in 2003. Besides hot summers of the past two decades, there were some already at the beginning of measurements and in the mid-20th century. In contrast, cool summers in Ljubljana occurred at the beginning of measurements and in the first half of the 20th century.

Figure 3: Changes in mean air temperatures in Ljubljana (1851–2010)
Slika 3: Spreminjanje povprečnih temperatur zraka v Ljubljani (1851–2010)

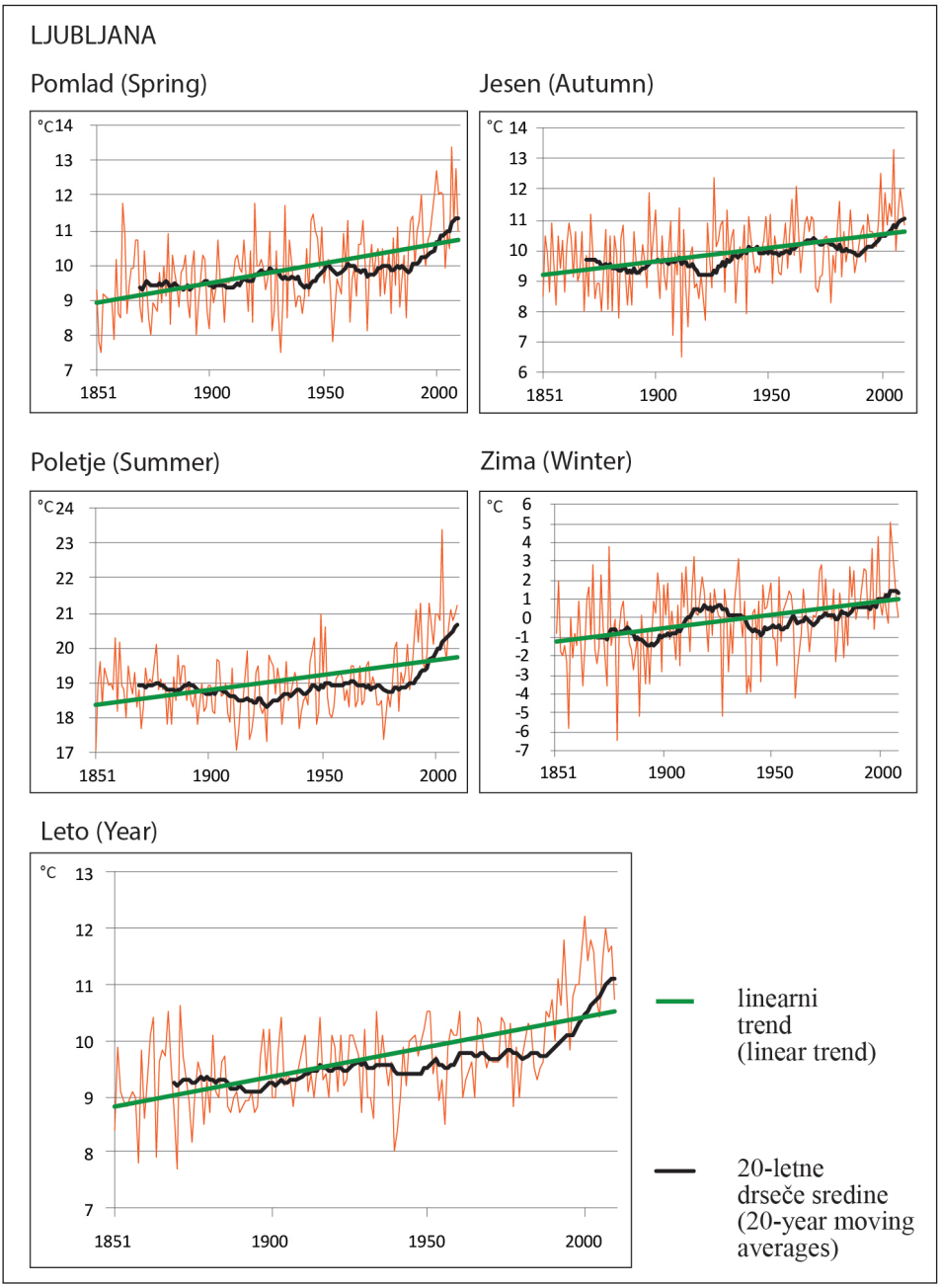


Figure 4: Changes in mean air temperatures in Zagreb (1862–2010)
Slika 4: Spreminjanje povprečnih temperatur zraka v Zagrebu (1862–2010)

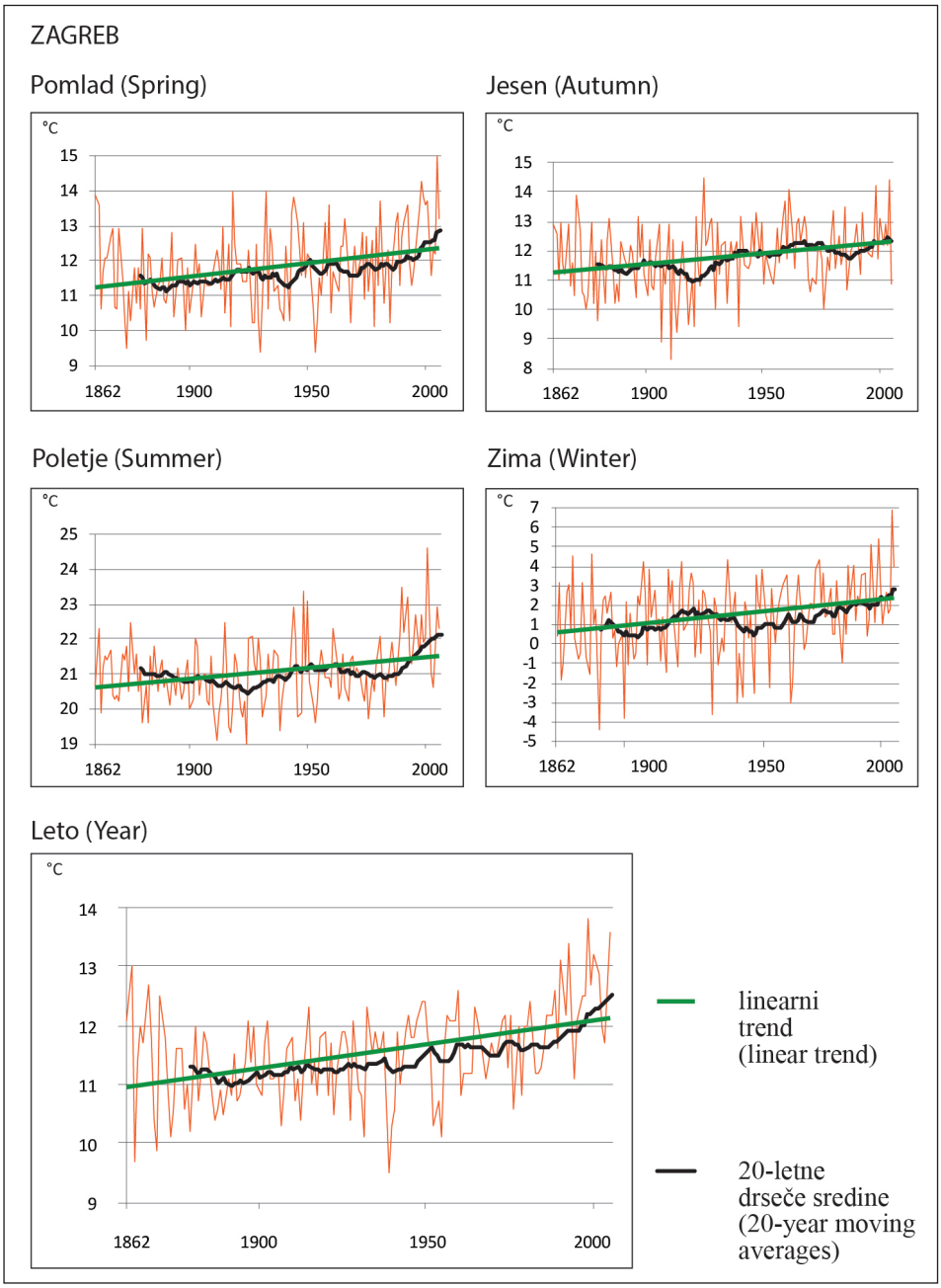


Table 2: Variability of the air temperature in Ljubljana in the period 1851–2010 (in °C)
Preglednica 2: Spremenljivost temperature zraka v Ljubljani v obdobju 1851–2010 (v °C)

	Avrg.	Stand. deviation	Coolest season (year)	Warmest season (year)	Trend* (°C / 100 years)	The warmest seasons (years)	The coolest seasons (years)
Spring	9.9	1.1	7.5 (1932)	13.4 (2007)	+1.1 (+1.3)**	2007, 2009, 2000, 2002	1932, 1853, 1955, 1958
Summer	19.0	1.0	17.1 (1851, 1913)	23.4 (2003)	+0.9 (+1.0)**	2003, 1994, 1998, 2010	1851, 1913, 1926, 1918, 1978
Autumn	9.9	1.1	6.5 (1912)	13.3 (2006)	+0.9 (+0.9)**	2006, 2000, 1926, 1963	1912, 1908, 1915, 1922
Winter	–0.1	1.8	–6.5 (1879/80)	5.1 (2006/07)	+1.4 (+1.7)**	2006/07, 2000/01, 1876/77, 1997/98	1879/80, 1857/58, 1890/91, 1928/29
Year	9.7	0.8	7.7 (1871)	12.2 (2000)	+1.1 (+1.2)**	2000, 2007, 1994, 2002	1871, 1858, 1864, 1940

** According to Mann-Kendall test all the trends during this period are statistically significant (p <= 5%).*
*** Non-homogenised data*

Zagreb shows similar tendencies of air temperature changes to Ljubljana, only the trends are less explicit (Table 3). In Zagreb, too, it was winters that have warmed most in the past 150 years. They have been by 1.8 °C warmer in recent years than in the 1860s. They are followed by springs. Mean annual temperatures in recent years have been by a gross degree higher than at the beginning of the measurements. The trend of increasing of the mean annual temperatures amounts to 0.9 °C /100 years, and is comparable to the warming trend in most of Europe which amounts to about 0.8 °C /100 years (Beniston et al., 1998), and is slightly higher than the global warming trend (0.74 ± 0.18 °C) (Kajfež-Bogataj, 2008). In Zagreb, too, most of the warmest years have occurred in the last 15 years, whereas the coolest years were in the 19th century, with the exception of 1940.

Table 3: Variability of the air temperature in Zagreb in the period 1862–2010 (in °C)
Preglednica 3: Spremenljivost temperature zraka v Zagrebu v obdobju 1862–2010 (v °C)

	Avrg.	Stand. deviation	Coolest season (year)	Warmest season (year)	Trend* (°C / 100 years)	The warmest seasons (years)	The coolest seasons (years)
Spring	11.8	1.1	9.4 (1932, 1955)	15.0 (2007)	+0.8 (+0.9)**	2007, 2009, 2000, 1920, 1934	1932, 1955, 1875, 1883
Summer	21.1	0.9	19.0 (1926)	24.6 (2003)	+0.7 (+0.5)**	2003, 1992, 1950, 1994	1926, 1913, 1919, 1940
Autumn	11.8	1.1	8.3 (1912)	14.5 (1926)	+0.7 (+0.6)**	1926, 2006, 2000, 1963	1912, 1908, 1915, 1921, 1941
Winter	1.5	2.0	–4.4 (1879/80)	6.9 (2006/07)	+1.3 (+1.5)**	2006/07, 2000/01, 1997/98, 2008/09	1879/80, 1890/91, 1928/29, 1939/40
Year	11.5	0.8	9.5 (1940)	13.8 (2000)	+0.9 (+0.9)**	2000, 2007, 1994, 2008, 2009, 2002	1940, 1864, 1871, 1933

** According to Mann-Kendall test all the trends during this period are statistically significant (p <= 5%).*
*** Non-homogenised data*

3.2 Assessment of the impact of urban heat island on warming trends in Ljubljana

The explicit trend of warming in Ljubljana – particularly in the last 30 years – that greatly exceeds the world average (Dolinar, Vertačnik, 2010) is the result of several factors. All the circumstances of measurements in individual periods, especially in the initial decades when air temperature was measured at non-standard times, are not known. However, the spreading of the city in the second half of the 20th century was certainly the main reason, since it was not possible to eliminate the impact of this factor with data homogenisation (Bertalanič et al., 2010). After the relocation of the meteorological station to the margin of the city in 1947, the surrounding areas of the measurement location were densely built-up and thus transformed from suburban to completely urban environment, which resulted in the urban heat island's impact on the measurements of temperatures. According to the researches performed by Jernej (2000), Ljubljana has a single-cell and stable urban heat island, where the city centre is warmer than its surroundings by about 1 °C in the annual average, by 1.2 to 1.5 °C in summer months, and by 0.4 to 0.5 °C in winter. Differences between the highest temperatures in the centre and the lowest ones in the southern, marshy outskirts of Ljubljana are from 5 to 7 °C, while in clear winter nights and the subsequent occurence of fog, when snow cover still lies outside the city, they can even reach 10 °C.

The impact of the urban heat island of Ljubljana on temperature trends can be assessed by comparing trends in Ljubljana and Zagreb before and after 1950, when the building-up of the surroundings of the Ljubljana meteorological station has started (Table 4). Between 1862 and 1950, both Zagreb and Ljubljana recorded a gradual increase in air temperatures, in terms of mean annual, winter, autumn and spring temperatures. Only the summer temperatures show no trend. Temperature rise was slightly more pronounced in Ljubljana, but the difference in trends, except the winter, was not greater than 0.2 °C. According to Mann-Kendall test, none of the trends is statistically significant for Zagreb for this period, while the trends for winter and annual average air temperatures are statistically significant for Ljubljana. The summer temperatures started to increase intensively after 1950, particularly in Ljubljana, with linear trends ranging between +1.0 °C (autumn) to +2.1 °C (summer) / 50 years. In Zagreb, trends are significantly lower, except for the winter. According to the Mann-Kendall test there in no statistically significant autumn temperature trend in Zagreb.

Similar winter air temperature rising trends are found for Zagreb and Ljubljana for the period after 1950. The warming trends for spring, summer and autumn are between 0.4 and 0.7 °C / 50 years, and the mean annual temperature trend for 0.4 °C / 50 years higher in Ljubljana than in Zagreb. When the trends are calculated on non-homogenised data which contain more non-climatic influences, they are higher for an additional one or two tenths of °C (Table 4). The biggest differences are found between the summer trends, which is not surprising. According to the findings of Jernej (2000), Ljubljana heat island's intensity is the highest in summer. The urban heat islands are the most intense in summer also in other cities of similar size and structure as Ljubljana, for example in Brno and Olomouc, Czech Republic (Dobrovolný et al., 2012; Vysoudil et al., 2012) and in other cities of Central Europe (Pongracz, Bartholy, Dezso, 2010). The gap between the warming trends in Ljubljana

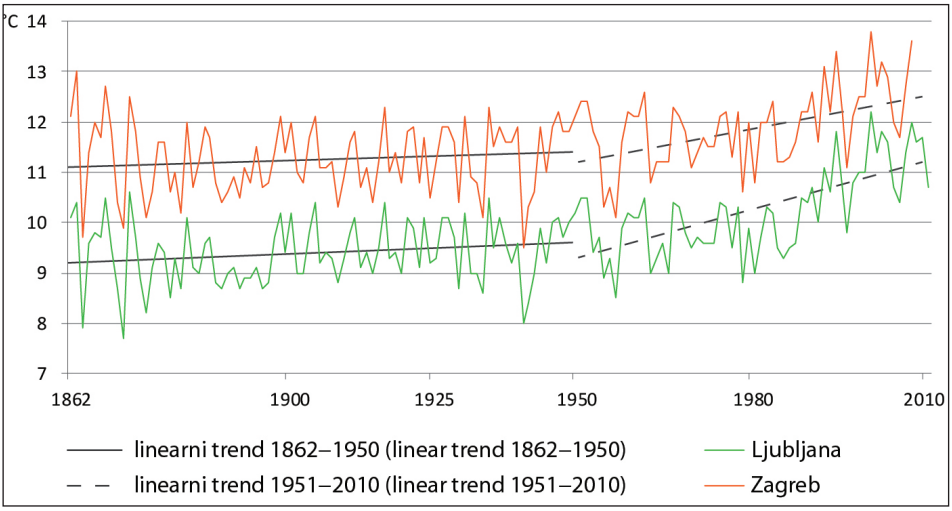
and Zagreb after 1950 may, in our opinion, be mainly explained by the impact of urban heat island, resulting from the urban growth of Ljubljana and the increased concentration of the built-up areas in the surroundings of the meteorological station. If we take these findings into account, we get 100-years warming trends for Ljubljana, which are slightly higher than the warming trends in most of Europe, but more comparable with them.

Table 4: Comparison of linear trends of air temperatures in Ljubljana and Zagreb in the periods 1862–1950 and 1951–2010
Preglednica 4: Primerjava linearnih trendov temperature zraka v Ljubljani in Zagrebu v obdobjih 1862–1950 in 1951–2010

	1862–1950 (°C / 100 years) Homogenised data		**1862–1950 (°C / 100 years) Non-homogenised data**		**1951–2010 (°C / 50 years) Homogenised data**		**1951–2010 (°C / 50 years) Non-homogenised data**	
	Ljubljana	Zagreb	Ljubljana	Zagreb	Ljubljana	Zagreb	Ljubljana	Zagreb
Spring	+0.5*	+0.3	+0.8*	+0.7	+2.0*	+1.7*	+2.1*	+1.7*
Summer	+0.0	+0.0	+0.4	+0.3	+2.1*	+1.4*	+2.2*	+1.5*
Autumn	+0.6	+0.4	+0.6	+0.8	+1.0*	+0.5	+1.2*	+0.5
Winter	+0.9	+0.4	+1.4	+1.3	+2.0*	+2.0*	+1.7*	+1.6*
Year	+0.4*	+0.2	+0.8*	+0.8*	+1.7*	+1.3*	+1.8*	+1.3*

** Statistically significant trends, Mann-Kendall test (p <= 5%)*

Figure 5: Linear trends of mean annual air temperatures in Ljubljana and Zagreb in the periods 1862–1950 and 1951–2010
Slika 5: Linearni trendi povprečnih letnih temperatur zraka v Ljubljani in Zagrebu v obdobjih 1862–1950 in 1951–2010



4 CONCLUSION

Comparison of long-term air temperature trends between Ljubljana and Zagreb demonstrated that the warming trends are more pronounced in Ljubljana. The trend for mean annual temperature in Ljubljana, calculated on the homogenised data, shows an increase by +1.1 °C / 100 years while in Zagreb by +0.9 °C / 100 years. The warming trend in Zagreb is comparable with trends in large parts of Europe, while the trends in Ljubljana exceed them. In both cities the most intensive warming has been found out in winter season, while the lowest trends are characteristic for summer and autumn air temperatures (Table 4).

The differences in the warming trends are even bigger when comparing trends since 1950. The trend of mean annual temperatures in Ljubljana amounts to +1.7 °C / 50 years compared to 1.3 °C / 50 years in Zagreb. Slightly higher (+0.5 °C / 50 years) is the difference between the trends when calculated on non-homogenised data, containing effects of several non-climatic influences on temperature trends. The trend for Ljubljana in the last 30 years exceeds the world average (Dolinar, Vertačnik, 2010). The main reason is the expansion of the city in the second half of the 20th century, and the process of building-up the area surrounding the meteorological station in Ljubljana. This changed its character from suburban to urban, and resulted in a strong influence of urban heat island, whose impacts could not be eliminated with the data homogenisation (Bertalanič et al., 2010). By comparing trends for the two cities before and after 1950, the contribution of the urban heat island in Ljubljana to the warming trends after 1950 is estimated to be 0.3 to 0.4 °C / 50 years (even 0.5 °C / 50 years when calculated on non-homogenised data), and around 0.2 °C / 100 years on the long-term trends.

(Translated by Marko Krevs)

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OCENA VPLIVA MESTNEGA TOPLOTNEGA OTOKA NA DOLGOROČNE TRENDE SEGREVANJA OZRAČJA V LJUBLJANI

Povzetek

V prispevku je ocenjen vpliv mestnega toplotnega otoka Ljubljane na trend segrevanja ozračja. Ocena temelji na primerjavi dolgoročnih trendov temperature zraka v Ljubljani in Zagrebu. Meteorološka postaja Zagreb-Grič deluje od ustanovitve leta 1862 ves čas na griču v središču mesta, medtem ko se je ljubljanska postaja večkrat selila. Z vidika homogenosti podatkov in trenda segrevanja je pomembna selitev po 2. svetovni vojni iz centra Ljubljane na mestno obrobje za Bežigrad, ki je bil v naslednjih desetletjih urbaniziran. S tem so postopoma prišle meritve temperature zraka pod močan vpliv mestnega toplotnega otoka, ki ga pri homogenizaciji podatkov ni mogoče v celoti odpraviti.

Povprečne letne temperature zraka, izračunane na podlagi homogeniziranih podatkov, imajo v Ljubljani in Zagrebu enako spremenljivost, nekaj razlik je v spremenljivosti sezonskih temperatur. V obeh mestih so najbolj spremenljive zimske temperature, najmanj pa poletne. Zime se med vsemi letnimi časi od sredine 19. st. do danes tudi najbolj izrazito segrevajo.

Zaradi bolj celinskega značaja temperaturnega režima bi pričakovali, da so trendi segrevanja ozračja višji v Zagrebu kot v Ljubljani. Vendar izračuni kažejo, da so trendi segrevanja ozračja v Ljubljani, izračunani iz homogeniziranih in nehomogeniziranih podatkov (Preglednici 2 in 3), izrazitejši. Sezonske temperature se v Ljubljani brez izjeme od sredine 19. st. do današnjih dni dvigujejo. Trend ogrevanja je najbolj izrazit pozimi, saj so se zimske temperature v Ljubljani od srede 19. st. do današnjih dni zvišale za nekaj več kot 2 °C. Do začetka 20. st. so bile zime podpovprečno hladne, sredi prve polovice tega stoletja so se vrstile nadpovprečno tople zime, v naslednjih desetletjih so bile zimske temperature okoli 150-letnega povprečja. Od 80. let 20. st. dalje sledi izrazit trend naraščanja zimskih temperatur. Zimskemu trendu sledi trend dvigovanja pomladnih temperatur in trend povprečnih letnih temperatur. Poletne temperature zlasti izrazito naraščajo v zadnjih 25 letih, ko je povprečna poletna temperatura za 1,5 stopinje višja od 160-letnega povprečja.

Najhladnejše leto v obravnavanem obdobju je bilo 1871, najtoplejše pa leto 2000. Zelo topla leta si večinoma sledijo od leta 2000 dalje. Najhladnejše zime so bile v prvih

sto letih meritev. Zelo tople zime so značilne predvsem za obdobje zadnjih 20 let (najtoplejša zima 2006/07), tople so bile zime tudi v začetku 20. st., ki jim je sledilo obdobje hitrega zniževanja zimskih temperatur. Najtoplejše poletje je bilo leta 2003. Razen v zadnjih dveh desetletjih je bilo nekaj nadpovprečno toplih poletij še na začetku meritev in sredi 20. st. Nasprotno so se hladna poletja v Ljubljani vrstila na začetku meritev in v prvi polovici 20. st.

Zagreb ima podobne tendence spreminjanja temperature zraka kot Ljubljana, le da so trendi manj izraziti (Preglednica 3). Tudi v Zagrebu so se v zadnjih 150 letih najbolj segrele zime, ki so v zadnjih letih za 1,8 °C toplejše kot v 60. letih 19. st. Sledijo jim trendi pomladanskih temperatur. Povprečne letne temperature so v zadnjih letih za stopinjo višje kot so bile v začetku meritev. Trend segrevanja povprečnih letnih temperatur znaša v Zagrebu +0,9 °C / 100 let. Trend je na ravni stoletnih trendov v večjem delu Evrope (Beniston in sod., 1998) in je nekoliko višji kot je trend segrevanja našega planeta (+0,74 ± 0,18 °C) (Kajfež-Bogataj, 2008). Tudi v Zagrebu se je večina najtoplejših let zvrstila v zadnjih 15 letih, medtem ko so bila najhladnejša, z izjemo leta 1940, v 19. st.

Izrazit trend segrevanja ozračja v Ljubljani, še posebej v zadnjih 30 letih, ki daleč presega svetovno povprečje (Dolinar, Vertačnik, 2010), je posledica več dejavnikov. Zaradi pestre zgodovine meteorološke postaje kljub izvedeni homogenizaciji ni mogoče povsem izključiti vpliva pogostih selitev merilnega mesta in načina meritev na rezultat. Vsi pogoji meritev v posameznih obdobjih, še posebej v začetnih desetletjih, ko so temperaturo zraka merili ob nestandardnih terminih, niso znani. Glavni razlog nadpovprečnega segrevanja ozračja v Ljubljani je prav gotovo širitev mesta v drugi polovici 20. st., saj pri homogenizaciji podatkov tega dejavnika ni bilo mogoče odpraviti (Bertalanič in sod., 2010). Po preselitvi meteorološke postaje leta 1947 na mestno obrobje so okolico merilnega mesta v naslednjih desetletjih gosto pozidali in jo iz primestne spremenili v povsem mestno, s čimer so meritve prišle pod močan vpliv mestnega toplotnega otoka. Po raziskavah Jerneja (2000) ima Ljubljana enoceličen in stabilen toplotni otok, kjer je mestno središče v letnem povprečju toplejše od okolice za okoli 1 °C, v poletnih mesecih 1,2 do 1,5 °C, pozimi pa 0,4 do 0,5 °C. Razlike med najvišjimi temperaturami v središču in najnižjimi v južni, barjanski okolici Ljubljane, so 5 do 7 °C, ob jasnih zimskih nočeh in nekoliko poznejšem nastanku megle, ko je izven mesta še snežna odeja, pa lahko narastejo do 10 °C.

Kakšen je vpliv mestnega toplotnega otoka Ljubljane na temperaturne trende, lahko ocenimo s primerjavo trendov v Ljubljani in Zagrebu pred in po letu 1950, ko se je začela pozidava okolice ljubljanske meteorološke postaje (Preglednica 4). Med letoma 1862 in 1950 tako v Zagrebu kot Ljubljani beležimo postopno dviganje temperature zraka (le poletne temperature ne kažejo trenda spreminjanja). Segrevanje je bilo nekoliko izrazitejše v Ljubljani, vendar razen pozimi razlika v trendih ni bila večja od 0,2 °C. Mann-Kendallov preizkus kaže, da za Zagreb v tem obdobju noben od trendov ni statistično značilen, za Ljubljano pa sta značilna trenda za zimo in povprečno letno temperaturo zraka. Po letu 1950 so začele temperature zraka skokovito naraščati, še posebej v Ljubljani. Linearni trendi zanjo se gibljejo med +1 °C (jesen) do +2,1 °C (poletje) / 50 let. V Zagrebu so trendi, razen za zimo, občutno nižji. Jesenski meseci po Mann-Kendallovem preizkusu ne kažejo statistično značilnega trenda.

Razen zim, ki so se v Zagrebu in Ljubljani segrevale s podobnim trendom, so trendi segrevanja v Ljubljani po letu 1950 za letne čase višji med 0,4 in 0,7 °C / 50 let, za povprečne letne temperature 0,4 °C / 50 let. Še za desetinko do dveh desetink °C / 50 let so razlike večje, če trende izračunamo iz nehomogeniziranih podatkov (Preglednica 4), ki vsebujejo več neklimatskega signala. Da je razlika med mestoma največja med poletnimi trendi, ni presenetljivo, saj je po ugotovitvah Jerneja (2000) intenziteta ljubljanskega toplotnega otoka tedaj največja. Poleti je mestni toplotni otok najbolj intenziven tudi v drugih mestih podobne velikosti in strukture kot Ljubljana, npr. v Brnu na Češkem (Dobrovolný in sod., 2012). Večino razkoraka v trendu segrevanja med Ljubljano in Zagrebom po letu 1950 lahko, po našem mnenju, pripišemo prav vplivu mestnega toplotnega otoka oziroma širjenju Ljubljane in zgoščanju pozidave okoli meteorološke postaje.

GEOGRAFIJA V VRTCIH IN NA RAZREDNI STOPNJI OSNOVNE ŠOLE V SLOVENIJI

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Izvleček
Prispevek daje odgovore na vprašanja: koliko in s katerimi vsebinami je geografija vključena v učne načrte od predšolskega obdobja do vključno petega razreda osnovne šole, v kolikšnem količinskem razmerju je do drugih predmetnih področij in za katere spremembe učnih načrtov bi si bilo potrebno prizadevati pri naslednjih prenovah. Analizirali smo učne načrte, v katere so vključene geografske vsebine. Uporabili smo kvalitativno in semikvantitativno analizo. Kategorije za kvalitativno analizo so bile pokrajinske sestavine oziroma njihove prvine, pokrajine ter orientacija in kartografija.

Ključne besede: geografske vsebine, učni načrt, vrtec, razredni pouk

GEOGRAPHY IN KINDERGARTENS AND AT THE LOWER LEVEL OF PRIMARY SCHOOL IN SLOVENIA

Abstract
The paper elucidates to what extent and with what contents geography is included in syllabuses from the preschool period to the fifth grade, its quantity relation to other subjects, and syllabus changes to be sought in future reforms. We analysed curriculums that incorporate geographical contents, with the use of qualitative and semi-quantitative analysis. Encoding categories comprised landscape elements, regions, orientation and cartography.

Key words: geographical learning, curriculum, kindergarten, primary-level teaching

I UVOD

Raziskovalna skupina pod vodstvom dr. Jurija Kunaverja je leta 2002 zaključila evalvacijo kurikularne prenove geografije, ki je zajela pouk geografije od šestega do devetega razreda osnovne šole ter geografijo na srednjih šolah. Med drugim so ugotovili, da je »vertikalna razvrstitev geografske snovi v osnovni šoli dovolj smiselna in organska« (Kunaver in sod., 2002, str. 52). V raziskavo niso vključili nižjih razredov osnovne šole, kjer so geografske vsebine del interdisciplinarnih učnih predmetov Spoznavanje okolja, Družba ter Naravoslovje in tehnika. Namen tega prispevka je osvetliti in evalvirati vključenost geografskih vsebin na nižjih stopnjah vzgoje in izobraževanja, od vrtca do konca razredne stopnje, kjer geografskih vsebin ne poučujejo učitelji geografije.

Predšolsko obdobje je posebno obdobje v razvoju otroka, v katerem so po mnenju nekaterih avtorjev, npr. Marie Montessori (Batistič Zorec, Krnel, 2009, str. 50), potenciali za učenje največji. V tem obdobju se približno pri tretjem letu starosti zgodi prehod od spontanega k reaktivnem učenju. Do tretjega leta se otrok pretežno uči po 'osebnem programu', sledi prehod na spontano-reaktivno učenje, kjer otrok že sprejema ponujeni program odraslih, če je zanj privlačen (Sutherland, 1992). V predšolski vzgoji sta se večkrat zamenjala dva pogleda na otroštvo in učenje v tem obdobju: prvi je zagovarjal načrtno in sistematično učenje s strukturiranimi programi kot pripravo na šolo, drugi pa brezskrbno, igrivo otroštvo, s poudarkom na socialno-čustvenem razvoju, kognitivni razvoj in učenje pa sta bila zapostavljena (Batistič Zorec, 2002).

Sedanji slovenski kurikulum za vrtce, potrjen leta 1999, poskuša biti v ravnotežju med obema skrajnostma. Je procesno-razvojno naravnan in poudarja odprtost, pestro, raznoliko in uravnoteženo ponudbo različnih področij ter avtonomijo vrtcev. Opredeljuje pet področij dejavnosti. Te »predstavljajo okvir, znotraj katerega so vsebine in dejavnosti strokovna ponudba vzgojiteljem. Na ravni izvedbenega kurikuluma vzgojitelji predlagane vsebine in dejavnosti na različne načine povezujejo, dograjujejo in dopolnjujejo…« (Kurikulum za vrtce, 2007, str. 25). Iz navedenega sledi, da imajo zapisane dejavnosti, kljub odprtosti kurikuluma, prednost pred drugimi že zato, ker so eksplicitno navedene.

Pri izdelavi Kurikuluma za vrtce (2007) je sodelovalo 29 strokovnjakov, od tega so bili glede na izobrazbo vključeni biolog, kemik, matematik, jezikoslovec, diplomant primerjalne književnosti, filozof, muzikolog, profesor športne vzgoje, diplomanti likovne umetnosti, dramske igre, glasbe in plesa, psiholog, pedagog, specialni rehabilitacijski pedagog in vzgojitelj predšolskih otrok. S področja družboslovnih in humanističnih ved, ki se v obveznem izobraževanju ukvarjajo z vzgojo in izobraževanjem (npr. zgodovinarji, sociologi, geografi), ni bilo v skupini nikogar. V pripravo kurikuluma predmetni strokovnjaki niso bili vključeni. Mnenja tistih, ki se ukvarjajo z vzgojo in izobraževanjem v predšolskem obdobju, o vključevanju strokovnjakov različnih predmetnih področij so različna. Kroflič (2001, str. 14) npr. meni, da bi morali sodelovati predmetni strokovnjaki vseh obveznih osnovnošolskih predmetov, kurikularni teoretiki pa bi morali s temeljnimi usmeritvami poskrbeti, da ne bi prišlo do prevelikega 'pošolanja' vrtca.

V osnovnošolskem predmetniku je geografija kot samostojen predmet umeščena od šestega do devetega razreda, v učnem procesu pa so geografski učni cilji in vsebine že

tradicionalno vključeni od prvega razreda naprej. V prvem vzgojnoizobraževalnem obdobju, od prvega do tretjega razreda, je to v okviru predmeta Spoznavanje okolja, v četrtem in petem razredu pa pri predmetih Družba ter Naravoslovje in tehnika. Način in podrobnost določanja učne vsebine v učnih načrtih (to poimenovanje se je ohranilo za predmetne kurikulume) sta odvisna od okvirjev in zahtev, ki jih določijo kurikularni strokovnjaki na osnovi teoretskih predpostavk nacionalnega kurikuluma. To sta bili v devetdesetih letih prejšnjega stoletja v Sloveniji *Bela knjiga o vzgoji in izobraževanju v Republiki Sloveniji* (1995) in *Izhodišča kurikularne prenove v R Sloveniji* (1996). Slednje so nadgradile *Smernice, načela in cilji posodabljanja učnih načrtov* (2007), na katerih je slonel proces posodobitve, ki se je zaključil s potrditvijo posodobljenih učnih načrtov za osnovno šolo leta 2011.

Glavna načela, na katerih temeljijo prenovljeni slovenski učni načrti iz leta 2011, so:

- avtonomija učitelja in šole;
- jasna vodilna ideja predmeta;
- učnociljni in procesno-razvojni model pouka;
- odprtost in izbirnost (fleksibilnost učnega procesa);
- kompetentnost;
- kakovost znanja;
- razvoj metakognitivnih sposobnosti učencev;
- razvojno spremljanje učenčevih dosežkov;
- povezovanje predmetov in disciplin – globalni pristop, ki spodbuja celostno učenje in poučevanje (Žakelj, 2014a).

Kriteriji pri izbiri vsebine za posamezni osnovnošolski predmet so bili: znanstvena primernost in aktualnost, ustrezen obseg vsebine, primerna dinamika obravnave ter usklajenost po vertikali in horizontali. Pri ciljih naj bi ob prenovi leta 2011 dosegli premik od strogega učnociljnega pristopa k procesno-razvojnemu modelu oziroma od poznavanja vsebin in podatkov k obvladovanju strategij pridobivanja in uporabe novih znanj (Žakelj, 2014b). Z vidika naše analize je pomembna uvedba izbirnosti v učne načrte, čeprav v majhnem obsegu, kar omogoča učitelju in učencu delno avtonomno odločanje pri izbiri podrobnejših ciljev in vsebin.

Med avtorji učnih načrtov za razredno stopnjo osnovne šole, ki vključujejo tudi geografske vsebine, je le en geograf. To je avtorica tega prispevka, ki je sodelovala pri pisanju učnega načrta za predmet Družba in bila recenzentka pri učnem načrtu za predmet Spoznavanje okolja. Pri učnem načrtu za predmet Naravoslovje in tehnika geografi nismo sodelovali.

2 EVALVACIJA

2.1 Namen in metodologija evalvacije

Namen evalvacije je ovrednotiti vključenost geografije v kurikulume na nižjih stopnjah vzgoje in izobraževanja, od vrtca do konca razredne stopnje. Postavili smo naslednja raziskovalna vprašanja:

- S katerimi vsebinami in učnimi cilji je geografija vključena v učne načrte od predšolskega obdobja do konca razredne stopnje?
- V kakšnem razmerju so geografske vsebine do vsebin drugih ved, zlasti do vsebin zgodovine in naravoslovja?
- Kateri geografski vzgojnoizobraževalni cilji in vsebine so vključeni v učne načrte predmetov Spoznavanje okolja, Družba ter Naravoslovje in tehnika in kateri ne?
- Za katere spremembe učnih načrtov bi si bilo potrebno prizadevati pri naslednjih prenovah?

Metodološko gre za racionalno evalvacijo ter kvalitativno analizo in vrednotenje učnih načrtov. Uporabili smo tudi semikvantitativno analizo, podatke pa smo obdelali z opisno statistiko. V učnih načrtih smo iskali učne vsebine, dejavnosti in cilje naslednjih učnih sklopov:

- spoznavanje pokrajinskih elementov oziroma njihovih značilnosti (relief, kamnine in geološka zgradba, podnebje, vodovje, prst, rastlinstvo in živalstvo, prebivalstvo, naselja, gospodarstvo);
- spoznavanje različnih pokrajin (od neposredne okolice, domače pokrajine, slovenskih pokrajin do Evrope in sveta);
- razvijanje spretnosti orientiranja in dela z zemljevidi;
- oblikovanje odnosa, stališč, ustreznega ravnanja v duhu trajnostnega razvoja s poudarkom na okoljski vzgoji.

Analizirali smo vsebinsko strukturo in cilje kurikuluma za vrtce ter učnih načrtov za predmete Spoznavanje okolja, Družba ter Naravoslovje in tehnika. Predpostavili smo, da otroci pri spoznavanju geografskih vsebin razvijajo tudi geografske spretnosti, tako specifične kot splošne, ki jim omogočajo vsebinsko in učnoprocesno nadgradnjo. Izjema sta orientacija in kartografija, ki ju zaradi procesne naravnanosti analiziramo posebej.

2.2 Kurikulum za vrtce

Kurikulum za vrtce (2007) je nacionalni dokument. Sprejet je bil leta 1999 in je strokovna podlaga za izvajanje različnih programov javnega vrtca za otroke od prvega do šestega leta starosti. Tiskana različica Kurikuluma za vrtce obsega 56 strani. Vsebina je podana v štirih glavnih poglavjih: *Cilji Kurikuluma za vrtce, Načela uresničevanja ciljev*, *Otrok v vrtcu* ter *Področja dejavnosti v vrtcu*. V slednjem, najobsežnejšem poglavju, so opredeljeni vzgojnoizobraževalni cilji in dejavnosti po naslednjih področjih: gibanje, jezik, umetnost, družba, narava in matematika.

Za vsako področje je v uvodu izpostavljen osnovni namen dejavnosti, kar je podobno kot poglavje *Opredelitev predmeta* v učnih načrtih za osnovno šolo. Sledijo cilji, od splošnih h konkretnejšim, na treh nivojih (1) globalni cilji, (2) cilji ter (3) dejavnosti. Cilji in dejavnosti imajo vlogo operativnih ciljev. Dejavnosti so zapisane posebej za otroke od prvega do tretjega leta starosti in posebej za otroke od tretjega do šestega leta. Sledi še rubrika *Vloga odraslih*, ki je podobna didaktičnim navodilom v osnovnošolskih učnih načrtih.

Področje Družba. »Človek je del družbenega okolja, v katerem raste, živi in deluje. Da bi lahko otroci sodelovali z okoljem, vplivali nanj in ga pozneje aktivno spreminjali, morajo postopoma spoznati bližnje družbeno okolje … in hkrati dobivati vpogled v širšo družbo. Otroci spoznajo svoj domači kraj in se seznanijo s tem, kako so ljudje tod živeli v prejšnjih časih.« (Kurikulum za vrtce, 2007, str. 48). Razviden je poudarek na spoznavanju bližnjega družbenega okolja, kjer je prostorsko omenjen samo domači kraj. Vsa ostala priporočila so usmerjena v spoznavanje odnosov med ljudmi.

Med globalnimi cilji ni eksplicitno navedenega geografskega ali prostorskega cilja. Implicitno pa je prostor vključen v cilj »spoznavanje ožjega in širšega družbenega in kulturnega okolja ter spoznavanje medkulturnih in drugih razlik« (Kurikulum za vrtce, 2007, str. 50). Med 19 operativnimi cilji zasledimo dva geografska: »otrok razvija interes in zadovoljstvo ob odkrivanju širšega sveta zunaj domačega okolja« ter »otrok spoznava značilnosti okolja, ki so pomembne za lokalno skupnost, npr. reka ali gora v bližini, pokrajinski muzej, arheološke izkopanine, pozneje pa tudi značilnosti širšega okolja« (Kurikulum za vrtce, 2007, str. 51). Med primeri dejavnosti od prvega do šestega leta lahko kot geografske opredelimo naslednje: spoznava domači kraj, spoznava različne ustanove, različne poklice, različna geografska in kulturna okolja, se vživlja v položaj drugih ljudi na osnovi stikov z vrstniki, ki izhajajo iz drugih krajev, dežel, s pomočjo knjig, televizije … Šele pri najbolj operacionaliziranih ciljih avtorji 'negeografi' prepoznavajo prostor kot dejavnik družbenega življenja (Kurikulum za vrtce, 2007, str. 50–54). V rubriki *Vloga odraslih* ni vključevanja geografskega vidika, tudi implicitnega ne.

Področje Narava. Že v prvi povedi uvoda je prostor opredeljen kot fizično in družbeno okolje in kot življenjsko okolje otroka, v okviru katerega se razvijajo otrokove sposobnosti, da bi se lahko v okolje dejavno vključeval. V nadaljevanju je poudarjeno otrokovo spoznavanje živali, rastlin, predmetov, pojavov, sprememb v naravi in življenju ljudi glede na letne čase, povezovanje dogodkov v prostoru in času ter usmerjanje otroka v aktivno delovanje za ohranjanje naravnega okolja (Kurikulum za vrtce, 2007, str. 55–56).

Med šestimi globalnimi cilji lahko prepoznamo dva, ki sta tudi geografska: »doživljanje in spoznavanje žive in nežive narave v njeni raznolikosti, povezanosti, stalnem spreminjanju in estetskih razsežnostih; razvijanje naklonjenega, spoštljivega in odgovornega odnosa do žive in nežive narave«. Od 37 ciljev otroci pri osmih pridobivajo geografsko predznanje z naslednjimi vsebinami: živa in neživa narava v medsebojnem vplivanju, varovanje okolja, vremenski pojavi, planet Zemlja, urejanje prostora, pomen lege ter voda (Kurikulum za vrtce, 2007, str. 56–58). Od 39 dejavnosti jih je deset povezanih s spoznavanjem naravnogeografskega okolja: spoznavanje na terenu, zgodbe različnih narodov o naravi, igre z mivko, zrakom, vodo, snegom, ledom, urejanje prostora, izdelovanje modelov, ločevanje odpadkov (Kurikulum za vrtce, 2007, str. 59–61).

V navodilih odraslim so tudi napotki, naj otrok spoznava naravo neposredno, v različnem času dneva in ob različnih vremenskih pogojih. Dobro je, da vzgojitelj izkoristiti posebne situacijske dogodke, kot so mavrica, oblaki, luna na nebu, polž na igrišču, ter omogoči situacije, v katerih otrok opisuje prostor z različnih zornih kotov in mu omogoči razvijanje občutka ob lastnem gibanju (Kurikulum za vrtce, 2007, str. 62).

Področje Matematika. V uvodu in pri globalnih ciljih ni povezave z geografskimi vsebinami. Med cilji, vseh je 16, se dva navezujeta na orientacijo v prostoru. Ne gre za orientacijo v geografskem prostoru, vendar otrok usvaja zanjo pomembne pojme. Cilja sta: »otrok spoznava prostor, njegove meje, zunanjost, notranjost; otrok uporablja izraze za opisovanje položaja predmetov« in »se nauči orientacije v prostoru« (Kurikulum za vrtce, 2007, str. 65).

Med 58 predlaganimi dejavnostmi štiri vključujejo orientacijo v prostoru: »otrok raziskuje igralnice, vso stavbo, dvorišče vrtca; opazuje okolje s tobogana, z vzpetine; hodi po označeni poti, po labirintu v snegu; opazuje, kaj je zunaj in kaj notri; se uči enostavne orientacije v prostoru; opazuje, kje ležijo druge stavbe glede na vrtec, riše načrte po svoji zamisli, po predlogah in po spominu, izdeluje makete stavb in okolice, se igra z zemljevidi« (Kurikulum za vrtce, 2007, str. 71).

Področja Gibanje, Jezik in Umetnost ne vključujejo ciljev in dejavnosti, ki bi bile povezane s spoznavanjem geografskega okolja.

Preglednica 1: Število ciljev in dejavnosti po področjih kurikuluma za vrtce, v katerih so vključene geografske vsebine
Table 1: The number of objectives and activities by curriculum fields for kindergartens that include geography

Področje kurikuluma	Vsi cilji	Geografski cilji	Vse dejavnosti	Geografske dejavnosti	Področje geografije
Družba	19	2	23	7	družbena in lokalna
Narava	37	8	39	12	fizična
Matematika	16	2	58	4	orientacija in kartografija

Vir/Source: Kurikulum za vrtce, 2007

Iz preglednice 1 je razvidno, da so v kurikulumu za vrtce geografske vsebine slabo zastopane. Pomena tako naravnega kot družbenega okolja v njunem prepletanju in soodvisnosti se zavedajo avtorji ciljev in dejavnosti s področja narave, avtorji s področja družbe pa ne. Slednji vključijo spoznavanje domačega kraja in drugih okolij šele bolj na operativni ravni, pri dejavnostih, in to predvsem prek spoznavanja načina življenja ljudi, različnih kulturnih in drugih navad.

2.3 Učni načrti Spoznavanje okolja, Družba ter Naravoslovje in tehnika

Učni načrt Spoznavanje okolja (2011). Spoznavanje okolja je učni predmet v prvem vzgojnoizobraževalnem obdobju. Vključuje naravoslovne, družboslovne in tehniške učne cilje ter vsebine. Pri opredelitvi predmeta je geografija omenjena kot ena od vključenih disciplin.

Med splošnimi cilji predmeta sta dva, ki ju tudi geografi prištevamo 'k svojim': razumevanje okolja in razvijanje spoznavnega področja. Operativni cilji in vsebine so izraženi v obveznih in izbirnih znanjih po tematskih sklopih. Geografska znanja pridobivajo učenci v sedmih tematskih sklopih od dvanajstih.

Tematski sklop Prostor je najbolj geografski. Vseh dvanajst učnih ciljev je geografskih in pokrivajo naslednje vsebine:

- orientacija v prostoru – glavne strani neba, zemljevid, globus;
- območja – domači kraj, domača pokrajina, Slovenija, Evropa, svet;
- pojmi – naselje (mesto, vas), hrib (hribovje), gora (gorovje), ravnina, dolina, reka, potok, morje, cesta, železnica, obdelovalne površine, gozd, puščava, oceani, celine idr.

Učenci spoznavajo različne regije, od domačega kraja do sveta, naravnogeografske in družbenogeografske pojme ter se orientirajo v pokrajini po znanih objektih, po straneh neba ter spoznavajo zemljevid in globus.

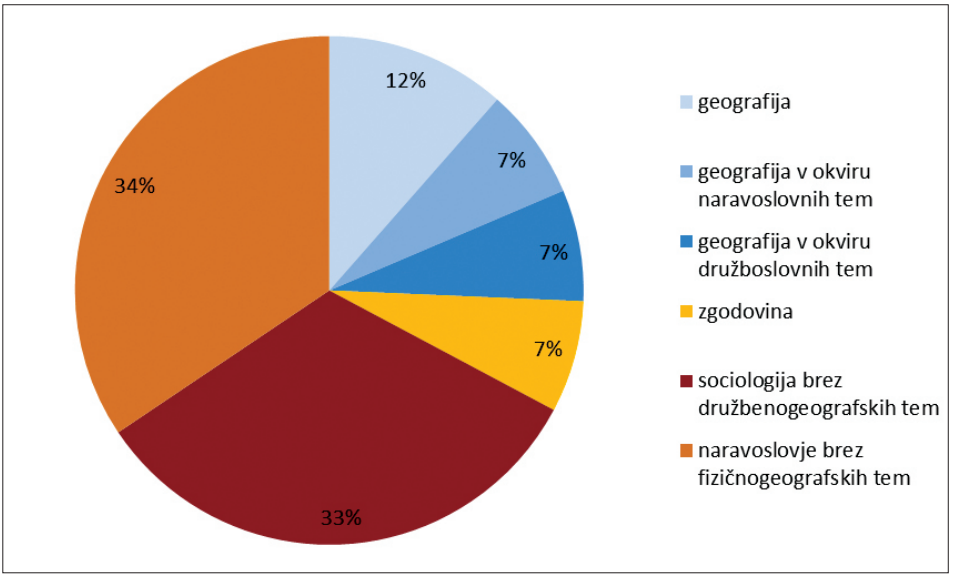
V tematskem sklopu Pojavi je osem od enajstih ciljev povezanih s spoznavanjem vremena. Vsebine so: vremenska stanja, vremenski koledar, vremenski pojavi, merjenje padavin. Sklop Živa bitja obsega 21 učnih ciljev, od tega jih je pet povezanih z geografskimi vsebinami: živa in neživa narava, okolje in živa bitja, življenjska okolja, raznovrstnost živega, rastline in živali, medsebojna odvisnost živih bitij.

Približno tretjino učnih ciljev, šest od 19, lahko v vsebinskem sklopu Skupnosti povežemo z geografijo. Pripadajoče vsebine so: ustanove, država Slovenija, prebivalci in državljani Slovenije, Slovenija v Evropi in posredno tudi prazniki doma in po svetu. Naslednji družboslovni sklop Odnosi ima 25 ciljev, tri lahko povežemo z geografijo (poklic, hobi, povezanost in soodvisnost ljudi, držav, celin).

V petih od 14 učnih ciljev v tematskem sklopu Promet učenci pridobivajo tudi geografsko znanje. Vsebine so: prometna sredstva,vrste prometa (sredstva, vloga), vzroki za potovanja, vpliv prometa na okolje. Tematski sklop Okoljska vzgoja bomo opredelili kot geografski, ker je vseh osem učnih ciljev geografskih. Imajo naslednje vsebine: okolje, naravno in grajeno okolje, onesnaževanje okolja, posledice onesnaževanja za živa bitja, odpadki, ravnanje z odpadki, onesnaževalci vode, tal, zraka, varčevanje z energijo, urejanje okolja.

Učni cilji pri Spoznavanju okolja vsebinsko zajemajo vse osnovne tradicionalne dele geografije. Pri regionalni geografiji je poudarek na lokalni geografiji, posamezni cilji pa širijo prostor na Slovenijo, Evropo in svet kot celoto. Orientacija v prostoru se z orientacije po vidnih objektih širi na spoznavanje glavnih strani neba, učenci spoznavajo zemljevid, globus, skice, modele kot prikaze pokrajine in Zemljinega površja. Družbenogeografske teme obsegajo promet, naselja, prebivalstvo, gospodarske dejavnosti, obdelovalne površine, ustanove, države, naravnogeografske teme pa vremenske pojave (predznanje za kasnejše razumevanje podnebja), živali, rastline, neživo naravo, relief. Precejšen poudarek je na okoljski vzgoji, manj pa na drugih vidikih vzgoje za trajnostni razvoj.

Slika 1: Delež operativnih učnih ciljev pri Spoznavanju okolja po predmetnih področjih
Figure 1: The share of operative learning objectives in the integrated course Environment by subject areas



Vir/Source: Učni načrt Spoznavanje okolja (2011)

Delitev ciljev med področji je nekoliko poenostavljena, a vseeno kaže ustrezno zastopanost učnih ciljev, ki učence od šestega do osmega leta starosti uvajajo v geografsko spoznavanje zlasti bližnjega okolja in širijo njihovo prostorsko orientacijo na Slovenijo, Evropo in svet. Geografija je ustrezno zastopana v primerjavi z naravoslovnimi vedami, kot so biologija, kemija in fizika, če predpostavimo, da vsaka od njih obsega tretjino naravoslovnih ciljev. Zaostaja pa za sociološkimi cilji, ki jih je nekaj manj kot 60, saj so v tej skupini tudi cilji s področja psihologije, etnologije idr. Povezava geografije z drugimi družboslovnimi in naravoslovnimi področji je uravnotežena.

Učni načrt Družba (2011). Predmet Družba je del predmetnika četrtega in petega razreda osnovne šole in je nadaljevanje predmeta Spoznavanje okolja, ki je v drugem vzgojnoizobraževalnem obdobju razdeljen na Družbo ter Naravoslovje in tehniko. V uvodu je namen predmeta opredeljen kot »spoznavanje razmerja med posameznikom, družbo in naravnim okoljem … spoznavanje in vrednotenje okolja (družbenega, kulturnega, naravnega), in sicer v vseh njegovih sestavinah ter interakcijah, soodvisnostih med temi sestavinami« (Učni načrt Družba, 2011, str. 4). Predmet Družba obsega v četrtem razredu dve uri pouka tedensko, v petem razredu pa tri ure tedensko.

Prva med splošnimi cilji predmeta sta tudi splošna cilja geografske vzgoje in izobraževanja. Poudarjata razumevanje družbenega, kulturnega in naravnega okolja v času in

prostoru ter zavedanje interakcij, soodvisnosti kulturnih, družbenih, naravnih procesov in pojavov ter pomembnost trajnostnega razvoja. Sledijo temeljni cilji v treh sklopih (Ljudje v družbi, Ljudje v prostoru in Ljudje v času) ter operativni cilji.

Tema Prostorska orientacija in kartografija ima v četrtem in petem razredu skupaj devet operativnih učnih ciljev, ki obsegajo naslednje vsebine: glavne strani neba, orientacija s kompasom in zemljevidi, sestavine zemljevida, branje različnih zemljevidov, skiciranje zemljevidov, kartiranje, terensko delo. Pri temi Domači kraj učenci spoznavajo naravne osnove za nastanek in razvoj kraja, gospodarske in druge dejavnosti, varnost poti in razumejo vlogo posameznika v skupnosti za urejenost kraja ter varovanje okolja. Od šestih ciljev je pet geografskih.

Tema Domača pokrajina ima štiri geografske cilje in naslednje vsebine: naravne značilnosti domače pokrajine (relief, vode, prst, podnebje, kamnine, rudnine), značilnosti in razlike med naselji v domači pokrajini, gospodarske in druge dejavnosti v domači pokrajini, vplivi človeka na spreminjanje narave.

Cilji pri temi Slovenija – lega in značilnosti so precej splošni in samo pet ciljev ne odraža vsebinskega obsega tega sklopa. Učenci spoznajo naravne enote Slovenije, njene naravne in družbene značilnosti, spoznavajo naravno in kulturno dediščino, razvijajo pozitiven odnos do tradicije, spoznavajo značilnosti trajnostnega razvoja.

Več učnih ciljev ima tema Država Slovenija, čeprav je vsebinsko manj obsežna. Osem od devetih ciljev je pomembnih tudi z vidika geografije in zajemajo naslednje vsebine: država, domovina, politična organiziranost slovenske države, simboli, vloga glavnega mesta, prebivalstvo (manjšine, priseljenci, zdomci, izseljenci), organiziranost Evropske unije, povezanost držav Evropske unije.

Preglednica 2: Število učnih ciljev po področjih v učnem načrtu za predmet Družba
Table 2: The number of learning objectives by fields in the curriculum for Society

Vsebinski sklopi	**Število ciljev**	**Delež ciljev (%)**
Geografske vsebine – Ljudje v prostoru	30	42
Zgodovinske vsebine – Ljudje v času	12	17
Sociološke vsebine – Ljudje v družbi	29	41
Skupaj	71	100

Vir/Source: Učni načrt Družba (2011)

Vseh operativnih učnih ciljev v učnem načrtu za predmet Družba je 71. Geografski in sociološki del sta uravnotežena, premalo pa je učnih ciljev s področja zgodovine. Regionalna geografija obsega pokrajine od domače pokrajine do Evrope in sveta, največji poudarek pa je na spoznavanju slovenskih pokrajin. Čeprav je predmet družbosloven, so v okviru regionalne geografije vključene tudi naravnogeografske vsebine – naravne značilnosti domače in slovenskih pokrajin (relief, vode, prst, podnebje, kamnine, rudnine). Vzgojni vidik je poudarjen v naslednjih vsebinah: vloga posameznika v skupnosti za

urejenost kraja in varovanje okolja, vplivi človeka na spreminjanje narave, značilnosti trajnostnega razvoja.

Učni načrt Naravoslovje in tehnika (2011). Predmet Naravoslovje in tehnika obsega po tri ure tedensko v četrtem in petem razredu. V opredelitvi predmeta in splošnih ciljih ni poudarkov, ki bi eksplicitno vključevali geografijo, sta pa omenjena naravno in umetno okolje. Operativni učni cilji so veliko bolj razčlenjeni kot pri Družbi, kar se kaže v trikrat večjem številu ciljev (215). Ciljev, ki jih lahko štejemo tudi kot geografske, je 54 ali četrtina.

V tematskem sklopu Snovi v naravi so teme Voda, Prst in Zrak. Tema Voda ima šest geografskih ciljev, ki vključujejo naslednje vsebine: kroženje vode, morje, površinske vode, podzemne vode, pitna voda, omejenost vodnih virov, onesnaževanje vode, varovanje vode. Temo Prst opredeljuje šest geografskih ciljev z vsebinami: sestavine prsti, lastnosti prsti, vrste prsti glede na okolje, onesnaževanje prsti. Sedem ciljev pa določa temo Zrak, ki ima naslednje vsebine: atmosfera, zrak – zmes plinov, onesnaževanje zraka, rešitve za čistejši zrak, odnos ljudi do onesnaževanja zraka, alternativni viri energije.

V tematskem sklopu Sile in gibanje je podtema Gibanje Zemlje s šestimi geografskimi cilji in naslednjimi vsebinami: vrtenje Zemlje, dan, noč, mrak, prisojna in osojna stran, Lunine mene, Lunin in Sončev mrk.

Tudi v sklopu Pojavi so geografske vsebine. Tema Veter ima pet geografskih učnih ciljev in vključuje naslednje vsebine: nastanek vetrov, merjenje zračnega tlaka, hitrosti vetrov, smeri vetrov, pomen vetra, izkoriščanje vetra, nevarnosti močnih vetrov. Kar 15 geografskih ciljev ima tema Vpliv Sonca na vreme in obsegajo naslednje vsebine: segrevanje snovi ‘na soncu’, ogrevanje tal, ogrevanje zraka, vpadni kot Sončevih žarkov, ogrevanje prisojnih in osojnih pobočij, segrevanje vode, letni časi in kroženje Zemlje okoli Sonca, spreminjanje temperature zraka z višino, veter in vreme, cikloni in anticikloni ter smer vetra, prenašanje snovi in toplote z vetrovi.

Za geografijo potrebno znanje pridobivajo učenci tudi v sklopu Živa bitja. Kot geografske smo izdvojili devet ciljev z naslednjimi vsebinami: vrste rastlin, živali in glive v neposrednem okolju; najbolj značilne kulturne rastline naših krajev; najbolj značilne domače živali naših krajev; izmenjevanje vode med živimi bitji in okoljem; medsebojna odvisnost živih bitij v naravi; živa bitja, prilagojena na okolje; življenje na Zemlji je bilo nekoč drugačno; posledice človekovega nenehnega posega v naravno okolje; trajnostni razvoj.

Večina geografskih ciljev in vsebin v učnem načrtu Naravoslovje in tehnika (2011) je fizičnogeografskih in zajemajo pokrajinske sestavine voda, zrak, prst, živa narava, ne vključujejo pa kamnin in reliefa.

Prostor je pri 54 geografskih ciljih omenjen samo štirikrat, če ne vključujemo ciljev, povezanih z Zemljo kot planetom. Trikrat je omenjeno neposredno okolje in enkrat planet Zemlja kot prostor spreminjanja življenja.

3 SKLEP

V okviru institucionalne vzgoje in izobraževanja od prvega otrokovega leta starosti do pouka geografije kot samostojnega predmeta v šestem razredu osnovne šole se otrok

redno srečuje tudi z geografskimi vsebinami. Te so opredeljene v štirih kurikulumih: kurikulumu za vrtce ter v treh šolskih predmetnih kurikulumih – učnih načrtih za predmete Spoznavanje okolja, Družba ter Naravoslovje in tehnika.

Preglednica 3: Področja geografije, vključena v kurikulume od vrtca do petega razreda osnovne šole
Table 3: Fields of geography included in the curriculums from the kindergarten to the fifth grade of primary school

		VVU	SPO	DRU	NIT
Področja geografije		1–6 let	6–8 let	9–10 let	9–10 let
Naravni elementi	kamnine			X	
	relief	X	X	X	
	vode	X	X	X	X
	podnebje	X	X	X	X
	prsti			X	X
	rastje	X	X	X	X
	živalstvo	X	X	X	X
Družbeni elementi	prebivalstvo		X	X	
	naselja	X	X	X	
	gospodarstvo	X	X	X	
Pokrajine	lokalna pokrajina	X	X	X	
	Slovenija		X	X	
	Evropa		X	X	
	Zemlja	X	X	X	X
Vzgoja	okoljska vzgoja	X	X	X	X
Geografske spretnosti	kartografija	X	X	X	
	orientacija	X	X	X	

Viri/Sources: Kurikulum za vrtce (1999); učni načrti za predmete Spoznavanje okolja (2011), Družba (2011), Naravoslovje in tehnika (2011)
Razlaga kratic: VVU – vrtec, SPO – Spoznavanje okolja, DRU – Družba, NIT – Naravoslovje in tehnika

Horizontalno, znotraj posameznih učnih načrtov, je geografija najmanj celovito vključena pri predmetu Naravoslovje in tehnika ter v kurikulumu za vrtec. Pri Naravoslovju in tehniki spoznavajo učenci različne pojavne oblike in naravne procese, povezane z vodo, zrakom, prstmi, rastlinstvom in živalstvom, velik poudarek je tudi na varovanju teh okoljskih sestavin, le redko pa je njihovo spoznavanje povezano s prostorom, s pokrajino. Podobno so v vrtcu ustrezno zastopane naravnogeografske vsebine, razen kamnin in prsti, zelo pomanjkljiva pa sta prostorski in družbenogeografski vidik.

Predmeta Spoznavanje okolja in Družba imata geografske vsebine precej uravnotežene. Vključujeta skoraj vse pokrajinske elemente in pokrajine, pri slednjih je največji poudarek na lokalni pokrajini in Sloveniji, ne vključujeta pa dovolj spoznavanja kamnin in osnov geomorfologije.

Vertikalno, po področjih geografije, so slabše zastopane naslednje teme: kamnine, prsti, prebivalstvo, pokrajine. Spoznavanje kamnin je vključeno samo v predmet Družba. Tudi relief je v primerjavi z drugimi naravnogeografskimi elementi obravnavan manj poglobljeno. Učni cilji vključujejo le spoznavanje morfoloških tipov reliefa, brez seznanjanja s procesi nastanka in preoblikovanja, kakor učenci spoznavajo druge naravne elemente. V prihodnje si bo potrebno prizadevati, da se v celotno vertikalo bolj neposredno vključi tudi spoznavanje prsti in kamnin. V učni načrt predmeta Naravoslovje in tehnika je potrebno vključiti spoznavanje geoloških in geomorfnih procesov, vodo, zrak, prst, rastlinstvo in živalstvo pa obravnavati tudi kot dele pokrajin s poudarkom na medsebojnem součinkovanju vseh pokrajinskih elementov v duhu vzgoje in izobraževanja za trajnostni razvoj.

Vse večji pomen medpredmetnih področij in medpredmetnega povezovanja nudi v praksi priložnosti za 'geografske' projekte, saj je geografija kot veda že sama po sebi naravnana na povezovanje različnih družbenogeografskih dejstev, dogodkov, procesov. Učitelji geografije na osnovni šoli lahko v sodelovanju z razrednimi učitelji prispevajo k celovitejši obravnavi različnih tem že na razredni stopnji.

Pri spreminjanju kurikulumov v prihodnje bi bilo dobro, da bi bili geografi dejavnejši in, če bo le mogoče, vključeni v proces spreminjanja. Potrebno si je prizadevati, da bi bili pri nastanku kurikuluma za vrtce prisotni didaktiki vseh predmetnih področij. Dokler pa velja sedanji kurikulum, ki je načeloma odprt, lahko geografi s svojimi predlogi geografskih vsebin in dejavnosti za otroke pomagamo bogatiti program vrtca, bodisi v neposrednem stiku s predšolskimi vzgojitelji ali prek pisnih prispevkov v različnih medijih. To je pomembno tudi zato, ker v dodiplomskem izobraževanju vzgojiteljic in vzgojiteljev sodeluje geografska stroka samo na primorski univerzi, na univerzah v Ljubljani in Mariboru pa ne.

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GEOGRAPHY IN KINDERGARTENS AND AT THE LOWER LEVEL OF PRIMARY SCHOOL IN SLOVENIA

Summary

The aim of this paper is to highlight and partially evaluate geography teaching at lower levels of education. We set forth the following questions: to what extent and with what contents and activities is geography incorporated into the curriculums from preschool period to the fifth grade; what is its quantity relation to other subjects; what curriculum changes are to be sought in future reforms? With the use of semi-quantitative and

qualitative approach, we analysed curriculums that incorporated geographical contents. Encoding categories comprised landscape elements, regions, orientation and cartography.

Kindergarten curriculum is process- and development-oriented. It emphasizes openness, a diversified and balanced offer of various fields, as well as autonomy of kindergartens. It determines five fields of activities. These "constitute a framework within which the contents and activities are a professional offer for educators. The educators implement the curriculum by employing various methods of integrating, upgrading and supplementing the proposed contents and activities." (Kurikulum za vrtce, 2007, p. 25).

Kurikulum za vrtce [Curriculum for Kindergartens] was the result of the cooperation that included twenty-nine experts, but not e.g. primary-level experts, subject didacts. Thus, there is no geographer, historian, sociologist, etc. among the authors, which is also reflected in the curriculum contents. Geographical objectives and activities were found in three fields – society, nature and mathematics. The field of society includes two geographical objectives out of 19 and seven activities out of 23. Most of the proposed themes are not spatially addressed and geographical activities are as follow: children become acquainted with their home environment, various institutions, professions, geographical and cultural environments; they put themselves in the positions of others on the basis of their contacts with peers from other places and lands and with the help of books, TV, etc. The field of nature includes eight geographical objectives out of 37, covering the following contents: living and nonliving nature in mutual co-dependence, environmental protection, weather phenomena, planet Earth, spatial planning, the importance of geographical position, water. Spatial orientation and cartography are part of mathematics, and the only two geographical objectives out of 16 (Table 1).

Regarding the learning about landscape elements, natural-geographical elements are better integrated than human-geographical ones and regional geography is the least represented of all. There should be a greater inclusion of familiarizing with stones, soils, population-related themes, economy is largely ignored, and even more so various types of landscape.

The primary-school curriculums include geography as an independent subject from the sixth to the ninth grade. However, in the learning process, geographical learning objectives and contents are traditionally included from the first grade onwards.

From the first to the third grade of primary school, natural and social science themes are part of school subject called Environment. Geographical learning objectives and contents include all basic geographical fields and are well represented in comparison to other scientific fields. Out of 183 teaching objectives there are 47 geographical ones. Roughly one half is contained in two geographical thematic clusters, one quarter in natural science themes and one quarter in social science themes (Figure 1). This points to a suitable representation of learning objectives, through which pupils of 6–8 years obtain basic geographical knowledge, especially of their immediate environment, and expand their spatial orientation to Slovenia, Europe and the world.

The subject Society is part of the curriculum of the fourth and fifth grade of primary school and is the continuation of the subject Environment, which is in the second educational period divided into Society on the one hand and Natural sciences and technology on

the other. The main share of geographical learning objectives is contained in the subject Society, as much as 42% (Table 2). The contents include human-geographical, physical-geographical and regional-geographical contents and activities, as well as orientation and cartography. Physical-geographical contents are linked to learning about various types of landscape which the pupils now learn integrally for the first time. Emphasis is on familiarizing with the domestic landscape and other types of Slovenian landscapes. The pupils learn also about the EU from the political point of view.

Objectives contained in the syllabus Natural sciences and technology are much more divided, amounting to three times more than in the curriculum Society. A quarter of the learning objectives out of the 54 may also be considered as geographical. They provide a detailed presentation of waters, weather, soils, fauna, flora – also from the perspective of environmental education. However, they do not deal with rocks (save in connection with soil) or relief. As a rule, learning objectives do not associate phenomena with the space (Table 3).

Horizontally, within individual curriculum, geography is the least integrally incorporated into Natural sciences and technology (followed by kindergarten) and is given more comprehensive presentation in the subject Environment. The geographical contents contained in the subjects Environment and Society are quite balanced. The said subjects include nearly all geographical elements and different areas – the latter with the main emphasis on the local area and Slovenia. However, they do not include enough learning of rocks, and sustainable development education is only declaratively included in curriculums. Vertically, by geographical fields, the less represented themes are as follow: rocks, soils, population, landscapes. Familiarization with rocks is included only in the curriculum Society. Similarly, relief is covered in less detail than other natural-geographical contents. Learning objectives include only learning about the morphological types of relief, while ignoring the processes of evolution and transformation. By learning about the waters, weather, soil, flora and fauna, the pupils get acquainted with various natural processes, including in relation to one another.

In the future it is recommendable for geographers to be more active in changing curriculum for kindergarten and, if possible, to be more involved in the changing process. All efforts should be made to include the didactics of all subject areas in developing the curriculum for kindergartens. However, as long as the existing – principally open-ended – curriculum remains valid, geographers as well as parents can still do many things. For instance, they may propose various geographical activities for children to the educators and encourage them to discover the geographical characteristics of the kindergarten's immediate surroundings as well as more distant landscapes. This is important also because only at one Slovenian university a higher geography teacher lectures on the program for the education of preschool teachers.

(Translated by Manca Gašperšič)

TRADITIONAL AGRICULTURAL LANDSCAPE OF LIPTOVSKÁ TEPLIČKA VILLAGE: IDENTIFICATION AND PROTECTION OF DIVERSITY

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Abstract
The paper focuses on traditional agricultural landscape (TAL) of arable land and grasslands in Slovakia. The results are based on field case study research in Liptovská Teplička village. Special emphasis is put on the identification of landscape and species diversity, interlinking them with the nature protection strategy. Contemporary nature protection of Liptovská Teplička village is mostly oriented towards nature habitats. The results of case study research underline that improvement needs to be focused on the preservation of TAL types which are currently subjected only to minimal protection.

Key words: traditional agricultural landscape, cultural landscape, landscape diversity, nature protected areas, Liptovská Teplička, Slovakia

TRADICIONALNA KMETIJSKA POKRAJINA V VASI LIPTOVSKÁ TEPLIČKA NA SLOVAŠKEM: PREPOZNAVANJE IN VAROVANJE RAZNOVRSTNOSTI

Izvleček
Članek se osredotoča na tradicionalno kmetijsko pokrajino (TKP) na obdelovalnih tleh in travnikih. Rezultati temeljijo na terenski raziskavi v katastrski občini Liptovská Teplička. Posebna pozornost je namenjena prepoznavanju pokrajinske raznolikosti in biodiverzitete ter njunemu povezovanju s strategijo varovanja narave. Na preučevanem območju je obstoječe varovanje narave usmerjeno predvsem k varovanju naravnih habitatov. Rezultati študije poudarjajo, da se je v prihodnosti potrebno usmeriti k zaščiti vseh tipov TKP, ki so v sedanjosti zaščiteni v najmanjši možni meri.

Ključne besede: tradicionalna kmetijska pokrajina, kulturna pokrajina, pokrajinska raznolikost, varovana območja narave, Liptovská Teplička, Slovaška

I INTRODUCTION

The landscape of Slovakia is characterized by a rich landscape diversity, together with plant and animal biodiversity as well. The diversity is mostly based on natural conditions and has been constantly transformed by human economic activities. The vast majority of the agricultural landscape in Slovakia has been affected by collectivisation and other developmental activities such as industry, transport and urbanisation (Bezák, Mitchley, 2014). The remnants of traditional agricultural landscapes (TALs) have been preserved mostly as small patches in less accessible rural areas and they document the long-evolving relationships between humans and landscape (Lieskovský et al., 2014). TALs consist of mosaics of small-scale arable fields and permanent agricultural cultivation modes such as grasslands, vineyards and high trunk orchards. TALs are also important from the landscape diversity and protection of plant and animal biodiversity point of view. Based on the results of TALs inventory, four main types were distinguished in Slovakia (Špulerová et al., 2011):

- TAL with dispersed settlements, characterized by the presence of mosaics of arable land, grassland, orchards and buildings of dispersed settlements;
- TAL of vineyards, characterized by presence of vineyards, arable land, grassland or orchards;
- TAL of arable land, grasslands and orchards, characterized by dominance of orchards and presence of grassland or arable land;
- TAL of arable land and grasslands consisting only from mosaics of arable lands and/or grassland.

The presence of specific land use elements such as dispersed settlements, vineyards, orchards and the ratio between arable land and grasslands, significantly influence the structure and character of individual TAL sites (Mojses, Petrovič, 2013; Munteanu et al., 2014). The most important sources of biodiversity are related to field bounds, stone walls, terraces, also grasslands and roads adjacent to fields (Dobrovodská, 2006) as well as grasslands in undisturbed and unfertilized sites with a long history of management (Imrichová, 2006).

TALs with valuable habitats are not protected by special legislative protection in Slovakia, i.e. a fact which might cause the loss of biodiversity connected to these specific habitats as a consequence of succession and overgrowth of TALs by shrubs and trees (Špulerová et al., 2013). To stop this negative trend, a project was set-up aimed at developing a strategy for protection of traditional agricultural landscapes (see acknowledgment). In this paper attention is given to extensively cultivated farmland and TAL of arable land and grasslands, which is characterized by a higher diversity of landscape pattern and by the presence of semi-natural habitats that significantly contribute to the provision of ecological functions in the landscape and provide multifunctional ecosystem services to society. Liptovská Teplička cadastral community represents a rural area of high landscape-ecological and biodiversity value (Dobrovodská, 2014). Special focus is given to the identification of nature protection measures which may contribute to protection and preservation of TAL.

2 METHOD AND CASE STUDY AREA

For the purposes of our paper a TAL of arable land and grassland was surveyed. TAL is defined as a structure of extensively cultivated fields, meadows, pastures, orchards and vineyards, or recently abandoned plots in the early stages of succession which have been unaffected by agricultural collectivisation. TAL is characterized by small-scale structure of plot division, and by ways of using the land which remained unchanged by socialistic collectivisation, or by preserved forms of anthropogenic relief, or by preserved features of traditional agricultural technologies. The TAL sites in this paper were mapped according to the handbook produced for countryside inventory of TALs throughout the entire territory of Slovakia (Dobrovodská, Špulerová, Štefunková, 2010).

The cadastral community of the Liptovská Teplička village covers an area of 9,869 ha and is located below the ridge of the Low Tatras at altitudes of 846 to 1429 m a.s.l. Administratively the territory is a part of Prešov region, Poprad district. The village was established in 1634. In the past the population was mostly engaged in agriculture, especially in cattle and sheep breeding, but also in forestry, rafting and tanning (Encyklopédia miest ..., 2005). The village itself has maintained its agricultural character up to the present day. The Liptovská Teplička village had a population of 2,373 in 2014 (Dobrovodská, 2014) and statistics confirm a population increase in the wider rural settlement area. With regard to age structure, 60% of the population is of productive, 25% of pre-productive and only 15% is of post-productive age. Among the economically active inhabitants, the most common areas of occupation are manufacturing (195), forestry, logging and related services (185), agriculture and tourism (70).

The population of Liptovská Teplička village has two notable strengths. The first is the historical diligence of the local people, with their common sense and ability to utilize rational approaches in developing their domestic region. The second is reflected in favourable demographics, with a predominantly working-age population: several middle and younger generations have migrated to work or have studied outside the region and have returned later in life, creating a pool of potential workers for the agricultural sector able to replace the older farmers when they retire.

Liptovská Teplička village belongs to the type of rural settlements which retains agricultural production carried by individual farmers, with a prevalence of livestock farming (Repka et al., 1994). The existence of narrow strip parcels in this area was conditioned by the less favourable natural conditions for agriculture, particularly the steep relief of the area. The dominant form of the present landscape structures is grassland, varying in type of land use as intensively or extensively utilized meadows or pastures, some of them tessellated. The village was also affected by the collectivisation of agriculture, many barns and shepherd huts were removed and part of the terraced and mosaic landscape was transformed into large-block fields or grassland.

Traces of preserved traditional agriculture in this TAL remain in five different types of mosaic under different management intensity and with the presence of various balks: extensively utilized meadows, abandoned meadows and pastures, extensively utilized pastures, abandoned pastures and mosaics of meadows and arable fields. The dominant TAL structure

in Liptovská Teplička village is extensively utilized meadows with either muddy-rocky terraces or rocky mounds. Extensive agriculture and organic farming have affected the species richness of grass-covered former arable fields (Špulerová et al., 2013).

Regarding nature protection measures, this paper is focused on two perspectives. Firstly, on the landscape segments covered by legislative measures for the protection of nature and landscape at the national and international level under the Act no. 543/2002 Coll. on nature and landscape protection. These are measures concerning the network of national protected areas, Natura 2000 locations (European network of protected areas), species protection, significant habitats and elements of territorial systems of ecological stability (bio-centres and corridors). Evaluation of legislative measures that protect natural and historical resources is focussed on legislative measures on protected water, soil and protected forest resources, and on legislative measures to protect cultural and historical monuments. Secondly, emphasis is on the ecologically important landscape segments without legislative protection, in this case wetlands and cultural-historical landscape elements.

3 RESULTS: IDENTIFICATION AND PROTECTION OF DIVERSITY

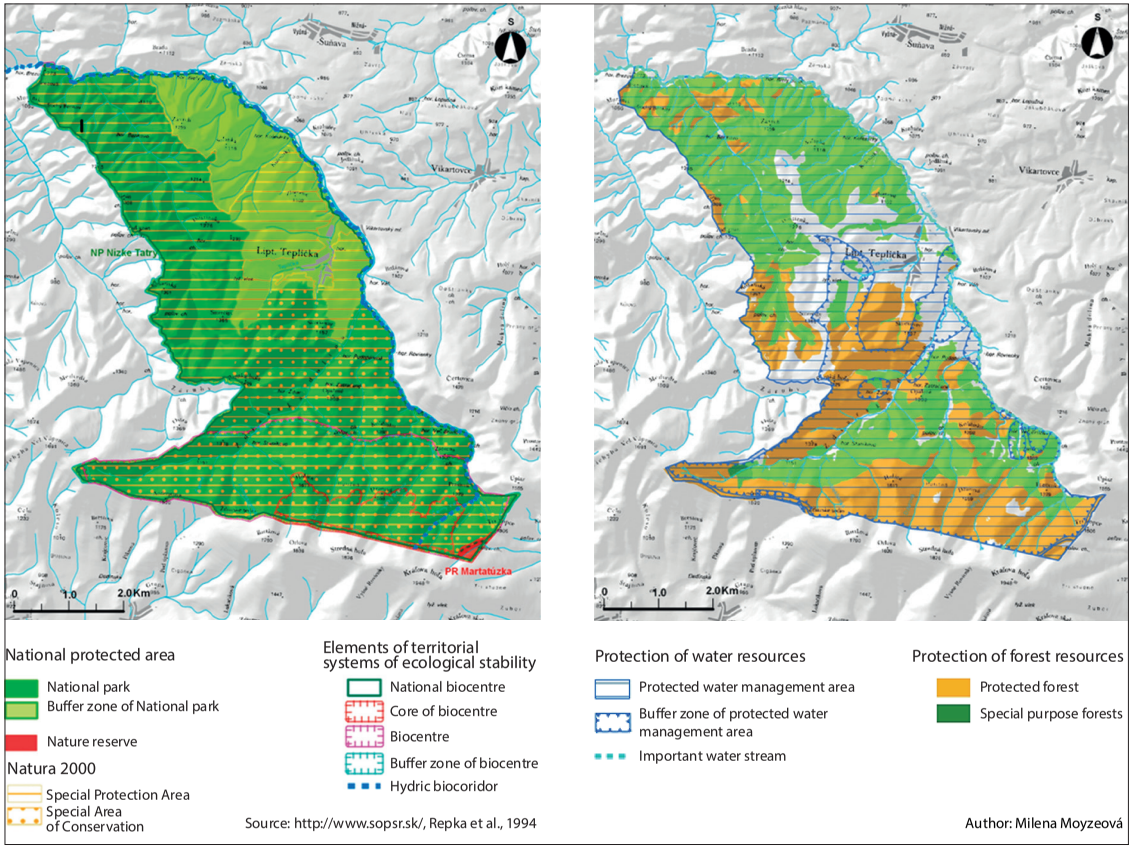
3.1 Identification of landscape diversity and localization of nature protection areas

In Liptovská Teplička cadastral community, the vegetation of grassland and bounds, generated as a result of agricultural activities, is characterized by high species diversity and semi-natural character (Ružičková, Dobrovodská, Valachovič, 1999). In terms of territorial nature protection, the case study area is located in the Low Tatras National Park (3rd degree of protection) and its protection zone (2nd degree of protection). The nature reserve Martalúzka (5th degree of protection) is situated in the southern part of the cadastral community. It consists of habitats ranging from transition forest to alpine meadows, rich in plant and animal species (Figure 1).

The landscape-ecological value of the case study area has been increased by the presence of Natura 2000 sites. These are the Special Area of Conservation (SAC) Kráľovohoľské Nízke Tatry and the Special Protection Area (SPA) Nízke Tatry, designated under the Habitats directive and the Birds directive, respectively, as containing some of Europe's most valuable and threatened species and habitats. These protected areas constitute elements of a territorial system of ecological stability. The Kráľovohoľská part of the Low Tatras National Park is a biocentre of national significance and the watercourse of Čierny Váh is a hydrological bio-corridor of regional importance.

These ecologically significant elements together with historical and cultural features of the landscape have not yet been protected by legislation, but in terms of the landscape value they need to be maintained in this area. Ecologically significant elements include two wetland sites of local importance. These are the wetlands near the Čierny Váh (area 2,300 m^2) and the Ždiarsky Potok creek (area 450 m^2). Both sites are hatching place for

Figure 1: Cadastral community of Liptovská Teplička with designated nature protection areas
Slika 1: (Za)varovana območja katastrske občine Liptovská Teplička



amphibians and are of local hydrological and eco-stabilizing value. Significant cultural and historical landscape elements are present in the form of terraced grasslands with tree and shrub vegetation and a mosaic of small-scale arable fields and grassland located around the built-up part of the village. Part of the historical landscape structure are the wooden barns and about 500 earth cellars located on the slope behind the built-up areas of the municipality. Two-meters-deep cellars are still used to store the harvest of potatoes, vegetables and flowers, as they keep a stable temperature throughout the year.

Field surveys conducted in the case study area confirmed the significance of the existence of a TAL area in terms of biodiversity. Vegetation of grassland and mounds is present, with three habitat types of European importance found: species-rich *Nardus* grasslands on siliceous substrates in mountain areas and submountain areas in continental Europe, lowland hay meadows, and mountain hay meadows. One habitat of national importance was also identified, i.e. mesophile pastures. The best management for such habitats, and which is in fact applied in this area, is regular cutting or grazing. These ecosystems represent a refuge for many rare and endangered species, as shown by statistics from field records (Špulerová et al., 2011):

- 19 vascular plants which are endangered according to the Slovak Red List (Feráková, Maglocký, Marhold, 2001), seven of them protected according to national law under the Regulation of Ministry of the Environment (No. 579/2008 of Col.);
- three bird species of European importance according to the Birds Directive (Directive 2009/147/EC) and one mollusc species of European importance according to the Habitat Directive;
- a list of other animal species included in the National Red List: seven bird species (Aves), six species of beetles (Coleoptera), three species of grasshoppers (Orthoptera), three species of millipedes (Diplopoda) and ten species of spiders (Araneae).

The presence of protected areas in the case study area implies the presence of natural or semi-natural ecosystems. To determine whether and how much the protected areas have a positive impact on environmental quality requires determining how much they discourage human activities that threaten their status. The area of traditional agricultural landscape under discussion is located in the protection zone of the Low Tatras National Park, which represents the lowest degree of protection.

3.2 Contemporary protection of natural, cultural and historical resources

The quality of the environment in the Liptovská Teplička case study area is determined by the occurrence of natural resources (Figure 2). We analysed the occurrence of water, soil and forest resources. From the hydrological point of view, the territory belongs to the basin of the main stem of the Váh river and the sub-basins of the tributary Čierny Váh. The whole surveyed area is located in a protected water management area (PWMA), that of the eastern part of the Low Tatras, with an area of 805 km^2, with a usable quantity of surface and ground water resources of 4.76 m^3/s. A small part of the southeastern

corner of the Liptovská Teplička territory extends to the PWMA upper catchment area of the Hnilec river. Several water sources are situated in the case study area that are used to supply the population with drinking water from springs – a major spring Bruno with a protected zone of 7,259 ha, a spring above the village (area of protected zone 31.7 ha), the spring Macová (area of protected zone 59 ha), the spring Small Brunov-Bočný Brunov (area of protected zone 90 ha), as well as several boreholes: Rovienky – four boreholes (area of protected zone 71.4 ha), Borehole LT 19 (area of protected zone 20 ha), two boreholes – LT20 and LT21 (area of protected zone 45 ha). These groundwater resources provide high-quality water that complies with drinking water standards. 90 to 95% of the population in Liptovská Teplička village is supplied from public water supply system. The village has built a local water supply, managed by the Podtatranská Water Company, which supplies other towns in the Tatry region as Spišská Nová Ves, Kežmarok and Poprad. Despite this main water supply, however, some of the locals – particularly in the upper parts of the village named Kobyliarky, Na Hálkoch, and Štefanov – dig their own wells even today.

Forests cover 5,086.66 ha, which is 83.6% of the study area. In addition to production forests, two other categories of forests are present: protective forests (2,824.8 ha or 57% of the forest area) and special purpose forests (47.5 ha or nearly 1% of the forest area). We identified four categories of protective forests: forests on extreme sites (constituting an area of 657.29 ha; 13% of the total forested area), the mountain forests of the upper treeline (1,557.32 ha or 32% of the forest area), the forests of the dwarf pine zone (552.31 ha; 11% of the forest area), and other forests with significant soil protection function (57.89 ha; 1% of the forest area). Special purpose forests are designed to establish gene reserve for forest tree species.

The best quality soils, of the first to the fourth quality grade, which are protected under the law, are not found in the Liptovská Teplička cadastral community. There are only soils with low and average site quality, with low humus content (Bielek, 2002). They are as follows: cambisol podzol (northern part of cadastral community), redzic cambisol (central part), cambisol modal acid (western part), cambisol redzic (on the south) and modal podzols and humus-iron (southern and southeastern part of cadastral community; Šály and Šurina, 2002). The soil texture is sandy loam (northern and southern part) and loam (central part of the cadastral community; Čurlík and Šály, 2002).

Despite the low soil quality, agriculture has a rich tradition in the area. The land is managed by small farmers and the Agricultural Cooperative of Liptovská Teplička, who practise organic farming on about 60 ha of land. They cultivate mainly cereal oats, wheat and feed grain. In recent years farmers have produced organic spelt and buckwheat. The alluvial soil around Čierny Váh is not used, because there is a high level of water, and the soils are waterlogged. The agricultural cooperative maintains conservation of grassland habitats on the traditional grassland mosaics, thus increasing the landscape-ecological value of the area. The current state of grassland habitats is quite favourable, so for ongoing TAL preservation we recommend maintaining the current and proposed management measures and principles of the Agricultural Cooperative of Liptovská Teplička's organic farming, which are ably supported by agri-environmental schemes. The schemes include

support measures concerning species-rich grassland, less favoured areas, and organic farming, all of which apply to Liptovská Teplička.

In terms of the presence of cultural and historical resources, the locomotive depot and surrounding area (declared as a national cultural monument in 1989) is situated on the outskirts of the village. This area contains four historical objects: the caretaker's house (an area of 26 m^2), the railway station (60 m^2), a rustic house (58 m^2), and a locomotive depot (146 m^2). They were built in 1919 and represent local folk architecture with a rectangular floor plan. Terraces, mounds and combined terraces with collected rocks with different heights and compositions have been erected here since 1634. The part of Liptovská Teplička cadastral community which contains these features forms a landscape with characteristic mosaics of small strip fields and balks, which has not lost its historical cultural and agricultural form (Dobrovodská, 2014).

4 CONCLUSION

The Liptovská Teplička cadastral community has preserved the traditional agricultural landscape and original objects of folk architecture such as barns and potato cellars. These traditional and valuable parts of agrarian culture have gradually ceased their productive functions in society, but they should be considered as a cultural heritage, as the physical, social, and spiritual values of the creative work of previous generations (Slavkovský, 2002). Their presence in Liptovska Teplička contributes to increasing landscape diversity and overall environmental quality of this mountain village.

The indicated measures of nature protection and protection of the natural resources, cultural and historical monuments in Liptovská Teplička village have increased the significance, stability and biodiversity of the landscape, the quality of the environment and the quality of human life. The protection of natural and historical resources is oriented towards protection of natural habitats, protected water and forest resources and historical monuments. These contribute to the preservation of the local TAL environment in this instance, but not to the preservation of TAL generally. The importance of TAL lies in both biological and cultural diversity, but this is not well recognized in Slovak legislation, as this falls under two separate legislative sectors – nature conservation and culture. Therefore, this study seeks to contribute to building up our knowledge base regarding the links between biological and cultural diversity and the implications of this for policy and decision making in the area of sustainable development.

The cultural landscapes can be seen as the result of hundreds of years of creation and sensitive cultivation of landscape structures respecting natural conditions (Krnáčová et al., 2013). Biodiversity studies have documented high biodiversity and occurrences of many rare and threatened species within the remnants of the semi-natural habitats in mosaics of TAL, but nature conservation is mostly oriented towards nature habitats. Herewith, we support a basic principle of modern nature protection: to preserve the greatest possible diversity of living systems, in order to preserve the maximum possible diversity of the conditions in which they live (Lieskovský et al., 2010). Considered in view of this principle and of the results of our research, improvement needs to be focused on the

preservation of these TAL types which are currently subjected only to minimal protection. The results of this TAL research form a valuable data source for further TAL assessment, specifically concerning their natural and cultural-historical value, and their future trends and threats. Evaluation of protective elements has created the basis for the elaboration of a strategy for preservation of this traditional agricultural landscape.

(Translated by James Asher)

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TRADICIONALNA KMETIJSKA POKRAJINA V VASI LIPTOVSKÁ TEPLIČKA NA SLOVAŠKEM: PREPOZNAVANJE IN VAROVANJE RAZNOVRSTNOSTI

Povzetek

Katastrska občina Liptovská Teplička na Slovaškem se razteza na 9869 ha južno od Nizkih Tater, na nadmorski višini od 846 do 1429 m. V upravnem smislu je del Prešovske regije in okrožja Poprad. Vas se prvič omenja leta 1634; prebivalstvo se je v preteklosti večinoma ukvarjalo s kmetijstvom, pretežno z govedorejo in gojenjem drobnice, gozdarstvom, splavarjenjem in strojenjem kož. V letu 2014 je v naselju živelo 2373 prebivalcev: demografska (pozitivna demografska dinamika, priselitve povratnikov) in zaposlitvena (60 % je aktivnega prebivalstva) struktura sta ugodni. Na tem območju je tudi zelo zanimiva zemljiško-posestna struktura. Odločilni posegi kolektivizacije so ta del Slovaške predvsem zaradi manj ugodnih pogojev za intenzivno kmetijstvo večinoma zaobšli, zato je zanimiva za preučevanje kot tradicionalna kmetijska pokrajina (TKP), tj. kot kulturna pokrajina, v kateri so se ohranili zanimivi elementi soodvisnosti med naravo in človekom. Na preučevanem območju so tako prepoznali številne poteze TKP z mozaično kombinacijo obdelovalnih površin in travnikov; gozd pokriva 84 % celotnega ozemlja preučevane katastrske občine.

Tradicionalna kmetijska pokrajina izkazuje veliko pokrajinsko raznolikost, ki jo lahko prepoznamo v reliefnih oblikah, bogatih vodnih virih, vrstah prsti, vegetacijskih tipih ipd. (sliki 1 in 2), kar predpostavlja odlično podlago za oblikovanje strategije varovanja narave. Ker je preučevano območje izjemno bogato tudi z vidika rastlinske in živalske biodiverzitete, na to območje z zaščitnimi ukrepi posegajo tudi mednarodne in državne regulative in direktive (npr. Kategorizacija zavarovanih območij, evropski direktivi o habitatih in pticah, Natura 2000 ipd.).

Rezultati študije, ki se osredotoča na prepoznavanje izjemno bogatih elementov raznolikosti tradicionalne kmetijske pokrajine ter rastlinske in živalske biodiverzitete, nakazujejo, da je obstoječa strategija varovanja narave ter zaščite naravnih, kulturnih in zgodovinskih virov usmerjena predvsem v varovanje naravnih habitatov. Avtorici poudarjata, da se je v prihodnosti potrebno usmeriti k zaščiti vseh tipov tradicionalne kmetijske pokrajine, ki so v katastrski občini Liptovská Teplička zaenkrat zaščiteni le v najmanjši možni meri.

(Iz angleščine prevedla I. Potočnik Slavič)

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POSKUS VEČKRITERIJSKEGA ISKANJA ALTERNATIVNIH KRMNIH RASTLIN NA OBMOČJU SPODNJE SAVINJSKE DOLINE

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Izvleček
Od 19. st. dalje se z intenzifikacijo živinoreje in vse večjih potreb po mesnih izdelkih za krmo živine uporabljajo predvsem rastline z velikim hektarskim donosom in hranljivostjo. Med njimi prevladuje silažna koruza, ki je zelo ranljiva za pomanjkanje vode ter vročinske valove, če se ti pojavijo v ključnih fenofazah. V članku z vidika kriterija rastlinske odpornosti na sušo in ekonomike pridelovanja iščemo možnosti uporabe drugih krmnih rastlin, predvsem krmnih žit in metuljnic, kot alternativo silažni koruzi.

Ključne besede: silažna koruza, krmne rastline, NDVI, kmetijska suša, geografija naravnih nesreč, Spodnja Savinjska dolina

MULTI-CRITERIA EVALUATION OF THE ALTERNATIVE FODDER CROPS USE IN THE LOWER SAVINJA VALLEY

Abstract
From the 19th century onwards, with the intensification of livestock production the demand for meat products is increasing. For animal feed are primarily used plants that allow maximum yield per hectare. Among them, the dominant crop is silage maize but, it is very vulnerable crop due to water shortages and heat waves during the peak growing season. In this article, we are looking for opportunities to use other fodder crops as alternative to silage maize, especially cereals and fodder legumes.

Key words: silage maize, fodder crops, NDVI, agricultural drought, natural hazards, Lower Savinja Valley

1 UVOD

V zadnjem času se bolj zavedamo, da je človek povsem nemočen pred naravnimi pojavi, kot so poplave, suše in druge vremenske ujme ter plazovi. Teh pojavov sicer ni nič več, kot jih je bilo v preteklosti, a so časovno drugače razporejeni prek leta. Obenem je človek zaradi netrajnostnega in nesonaravnega načina bivanja, delovanja in pridelovanja vse bolj ranljiv. Poleg tega smo zaradi boljše medijske pokritosti tudi bolje informirani o dogodkih. Pogosti načini soočanja z naravnimi pojavi so predvsem osredotočeni na odpravljanje posledic pojavov. Še vedno se posveča premalo pozornosti preventivnim, trajnostnim ukrepom, ki bi lahko z interdisciplinarnimi pristopi dodobra omilili posledice ali jih celo preprečili. Državne ustanove bi morale pripraviti ustrezno strategijo za preprečevanje in zmanjševanje posledic naravnih nesreč (Krepitev pripravljenosti Evrope …, 2013; Adaptation strategies, 2014).

V prispevku se bomo osredotočili na sušo in ukrepe za zmanjšanje oziroma preprečevanje njenih posledic. Med takšne ukrepe sodi nadomeščanje rastlin, ki so na sušo zelo slabo prilagojene s tistimi, ki so bolje prilagojene in kljub temu še vedno dajejo ekonomsko upravičen hektarski donos. Ukrep je po ocenah nekaterih agrometeorologov razmeroma uspešen način spopadanja s sušo (Grah, 2012), čeprav se v kmetijski praksi pogosteje odločajo za katerega izmed drugih ukrepov za zmanjšanje škode zaradi suše. Mednje sodijo namakanje, gnojenje, pridelovanje hibridnih sort koruze, uporaba fitofarmacevtskih sredstev, zgodnejše pobiranje pridelkov itd. Ne glede na to je ukrep nadomestnih rastlin mogoče zaslediti v literaturi, celo v tehnoloških priporočilih za zmanjšanje občutljivosti kmetijske pridelave na sušo (Tehnološka priporočila za …, 2008). Kot nadomestne rastline se najpogosteje priporoča različne zrnate krmne rastline (pšenica, oves, proso, ječmen, soja, krmni bob, krmni grah itd.) ter metuljnice (lucerna, inkarnatka, različne vrste detelj in že zgoraj omenjene stročnice – soja, bob, grah itd.). Nekatere od teh, predvsem zrnate krmne rastline, so bile v preteklosti zelo cenjene in tudi bolj uveljavljene za krmo živine, saj vsebujejo precej visoke koncentracije škroba. Njihovo pridelovanje se je kasneje zmanjšalo, saj je koruza zagotavljala količinsko večje pridelke z mnogo višjo škrobno vrednostjo (Korošec, 1989). Predvideva se tudi, da je na uveljavitev koruze v živinoreji močno vplival prihod železnice v drugi polovici 19. st., ki je prinesel večjo liberalizacijo trga ter znižanje cen mleka (Bernik, 1998). Kmetijstvo je bilo primorano stremeti k vse bolj intenzivni pridelavi, saj so bile v živinoreji potrebne večje količine krme.

Pri iskanju nadomestnih rastlin je potrebno upoštevati več različnih dejavnikov. Prvi pogoj so rastne zahteve rastline, kot so prst, potrebe po vodi, podnebje, relief itd. Poleg teh na izbiro vplivajo tudi pridelovalni stroški ter hektarski donos. To kaže na potrebo po natančnem prikazu primernih vrst nadomestnih rastlin, z vsemi potrebnimi parametri, kar bi pridelovalcem omogočilo lažjo odločitev (Korošec, 1989).

V raziskavi smo se ukvarjali s silažno koruzo in nekaterimi drugimi krmnimi rastlinami. Ugotavljali smo njihovo prilagodljivost na sušo z metodo daljinskega zaznavanja – vegetacijskega indeksa NDVI (ang. *Normalized Difference Vegetation Index*) in ekonomiko pridelovanja krmnih rastlin ter izpostavili najprimernejše rastline, ki bi lahko nadomestile silažno koruzo. Obravnavane krmne rastline smo izbrali na podlagi literature

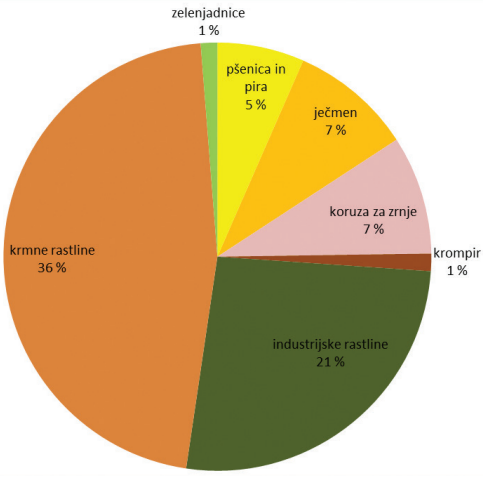
in bi lahko bile po priporočilih agronomov dovolj dobro nadomestilo silažni koruzi (npr. nekatere metuljnice in krmna žita). Kot dodatni razlog lahko navedemo, da so jih v različnih rastnih pogojih več let testirali na poskusnih poljih. V okviru te raziskave nismo izvajali dodatnih testiranj, s katerimi bi preučevali možnosti zamenjave silažne koruze z drugimi kulturnimi rastlinami.

1.1 Obravnavano območje

V prvem delu analize smo se osredotočili na območje šestih občin Spodnje Savinjske doline (Braslovče, Polzela, Prebold, Tabor, Vransko in Žalec). Območje je zaradi ugodnih naravnih pogojev (večje sklenjeno ravninsko območje, za kmetijstvo zelo primerne prsti, zadostne povprečne letne količine padavin itd.) še vedno pretežno kmetijsko. Zato je tudi delež delovno aktivnih prebivalcev v primarni dejavnosti visok (18,9 %) v primerjavi s slovenskim povprečjem (4,9 %; 2010). Še posebej izstopa občina Tabor s 30,9 % zaposlenih v primarni dejavnosti (Družinski člani na …, 2015).

Po podatkih popisa kmetijstva leta 2010 po namenu kmetijske pridelave prevladujejo kmetijska gospodarstva s pridelavo za (izključno ali pretežno) lastno porabo (787 kmetijskih gospodarstev; 53 %). Delež tržno usmerjene pridelave je v Spodnji Savinjski dolini (47 %) nad slovenskim povprečjem (40,5 % kmetijskih gospodarstev; 2010), kljub obdobno neugodnim gospodarskim razmeram v hmeljarstvu. Prevladuje specializirana pašna živinoreja, pogoste oblike so še mešane kmetijske dejavnosti poljedelstva in živinoreje ter mešane živinoreje in poljedelstva (Kmetijska gospodarstva po rabi …, 2013).

Slika 1: Poljščine po deležih površin v občinah Spodnje Savinjske doline v letu 2010
Figure1: Main crops by shares of agricultural land in the municipalities of the Lower Savinja Valley (percentage of area)



Vir/Source: Kmetijska gospodarstva po rabi …, 2013

Med vrstami poljščin prevladujejo krmne rastline (silažna koruza, metuljnice) s 36 %, sledijo industrijske rastline z 21 % in žita z 19 % vseh kmetijskih površin v Spodnji Savinjski dolini (slika 1). Med poljščinami prevladuje silažna koruza (1305 ha; 60,6 %), kar celo presega pridelavo hmelja (1218 ha). Med žiti prevladujeta ječmen (428 ha) in koruza za zrnje (416 ha), ki se prav tako uporabljata za krmo živali (Kmetijska gospodarstva po rabi …, 2013).

V drugem delu analize smo zaradi narave raziskave obravnavali celotno Slovenijo. Upoštevali smo hektarski donos ter odkupno ceno silažne koruze in krmnih rastlin v sušnem letu 2012.

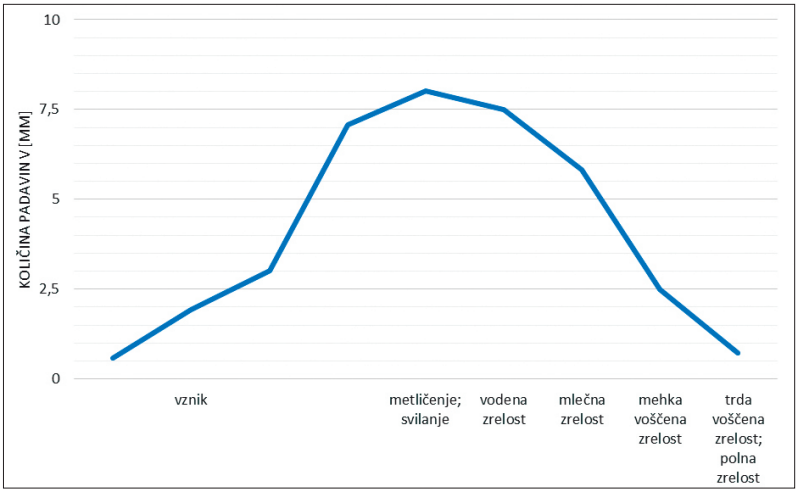
1.2 Rastne značilnosti koruze

Koruza (*Zea mays* L.) je kritosemenka in enokaličnica. Po prilagodljivosti na svetlobo jo uvrščamo med C4 rastline, to je rastline, ki so se prilagodile na vroče in sušno okolje z veliko količino svetlobe. V procesu fotosinteze lahko vgrajujejo CO_2 pri zelo močni svetlobi ali ob višji temperaturi. Koruza najbolje uspeva na prsteh s srednje težko teksturo, ki imajo ugoden delež humusa. To so prsti peščeno-glinaste in peščeno-ilovnate teksture z deležem humusa od 2 do 4 %. Koruza razvije plitev šopast koreninski sistem, ki sega do maksimalne globine 30 cm. Njeno absorbcijsko območje je majhno, primerljivo krogu s premerom 45 cm. Za pridelovanje koruze je potrebna povprečna mesečna temperatura v rastni dobi od maja do konca septembra vsaj 13,5 °C. Setev poteka v globino med 3 in 6 cm, ko se temperatura tal na globini 5 cm zviša na 8 °C, oziroma pri semenu z nižjo biološko vrednostjo med 10 in 12 °C. Setev se običajno prične že konec aprila, vendar je to zelo različno, odvisno od vrste dejavnikov, predvsem od vremenskih razmer, a tudi od vrste in sorte koruze (Čergan, 2008).

V celotni rastni dobi koruza na vsakem kvadratnem metru površine za rast in razvoj neposredno porabi približno 700 l vode. Obenem so v vročem in sušnem okolju še velike izgube vode zaradi evapotranspiracije. Poraba vode narašča s temperaturo in z nižanjem zračne vlažnosti. Razlike v porabi vode so opazne tudi v različnih razvojnih fazah. Najvišja poraba je v času cvetenja (metličenje in svilanje) in oploditve (slika 2), ki potekata med 10. julijem in 10. avgustom, lahko tudi več kot 20 dni. Koruza je prav v tem času najbolj občutljiva za pomanjkanje vode. Posledice se kažejo v zmanjšanju pridelka (slika 3) in v različnih poškodbah, npr. zmanjšanju višine rastline, zakrnelosti storžev, slabši oploditvi , sušenju listov, zmanjšani odpornosti proti škodljivcem in boleznim (Čergan, 2008).

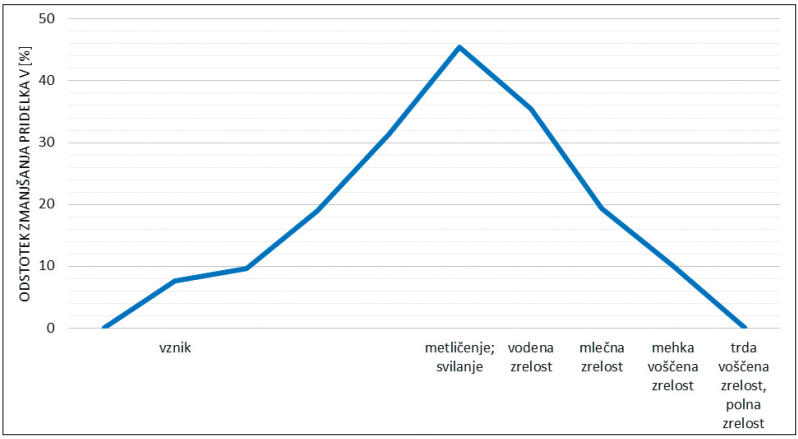
Koruza se na sušo odziva mnogo slabše kot nekatere druge rastline. Pri njej namreč čas cvetenja in oploditve v zmernem pasu pogosto sovpada z najvišjimi temperaturami in primanjkljajem padavin. Kljub temu nekateri ugotavljajo, da je koruza, poškodovana zaradi suše, še bolj hranljiva kot v običajnih razmerah. Zaradi pomanjkanja vode v prsti se škrob namesto v zrnju kopiči v steblu (Prepadnik, 2012). Kljub temu je pridelek količinsko manjši, pogosto ga uničijo še različni škodljivci in tako ni uporaben za krmo živali (Čergan, 2008).

Slika 2: Dnevne količine padavin, potrebne za rast koruze v posamezni fenološki fazi
Figure 2: The daily rainfall requirements of maize by phenophases



Vir/Source: Čergan, 2008

Slika 3: Zmanjšanje pridelka koruze zaradi pomanjkanja vode v posameznih fenofazah
Figure 3: Maize yield reduction due to the lack of water by phenophases



Vir/Source: Čergan, 2008

Slika 4: Polje silažne koruze v Braslovčah v juliju 2013 (foto: A. Jelen)
Figure 4: The field of silage maize in Braslovče in July 2013 (photo: A. Jelen)

Slika 5: Močno poškodovano polje koruze v Pondorju v začetku avgusta 2013 (foto: A. Jelen)
Figure 5: Heavily damaged maize field in Pondor in the early August 2013 (photo: A. Jelen)

2 METODOLOGIJA

Primernost pridelave nadomestnih krmnih rastlin namesto silažne koruze smo določali z dvema kriterijema: rastno odpornostjo pred sušo ter ekonomiko pridelovanja silažne koruze in nadomestnih rastlin. S tem smo želeli določiti najprimernejšo nadomestno krmno rastlino in zadostiti različnim dejavnikom, ki vplivajo na odločitev kmetovalcev o pridelovanju krmnih rastlin.

2.1 Rastna odpornost rastlin pred kmetijsko sušo

Rastna odpornost rastlin pred kmetijsko sušo je stopnja poškodovanosti posamezne rastlinske vrste v času višjih temperatur in primanjkljaja v vodni bilanci. Rastno odpornost smo določili z deležem poškodovanosti morfološke strukture rastlin. Pridobili smo ga z vegetacijskim indeksom NDVI ter ga dodatno preverili s podatki o ocenjeni škodi na kmetijskih kulturah zaradi kmetijske suše. NDVI izračunamo kot razmerje med razliko vrednosti bližnje infrardečega (*IR*) in rdečega (*R*) kanala ter njuno vsoto.

$$NDVI = \frac{(IR - R)}{(IR + R)}$$

Osnovno interpretacijo lahko opravimo vizualno, saj intenzivne zelene barve pomenijo zdravo rastje, manj intenzivne zelene do rjave in sive nezdravo rastje, pozidane površine brez rastja ali vodne površine. V analizi smo izločili vodne in pozidane površine, saj imajo te podobne vrednosti kot poškodovano rastlinstvo. Vrednosti indeksa NDVI se nahajajo v intervalu med –1 in +1. Višja vrednost indeksa kaže na intenzivnejše rastje in s tem tudi bolj zdravo in manj poškodovano zaradi suše (Oštir, 2006). Vrednosti indeksa NDVI so se na preučevanem območju občin Spodnje Savinjske doline v juliju 2012 gibale med –1 in +0,62.

Pri analizi rastne odpornosti smo najprej določili prostorsko razširjenost izbranih kulturnih rastlin. Poleg silažne koruze smo vključili izbrane krmne rastline, ki so jih v letu 2012 kmetovalci prav tako pridelovali na preučevanem območju: deteljo, lucerno, deteljno-travne mešanice ter travno-deteljne mešanice. Podatke o vrstah poljščine na vsakem GERK-u (grafična enota rabe kmetijskih gospodarstev) za kategoriji rabe tal *njiva* in *hmeljišče* (šifri rabe tal 1100 in 1160) smo pridobili na Agenciji za kmetijske trge in razvoj podeželja (Podatki o vrsti …, 2013). Ključna dejavnika za izbor teh krmnih rastlin sta bila dejanska pridelava na tem območju v preučevanem obdobju ter najmanjša pridelovalna površina (1 ha). Ker se po metodologiji vpisa v GERK upošteva le glavne vrste rastlin, podrobnejši izbor in analiza nista bila mogoča. Tako so vrste metuljnic, kot so inkarnatka, aleksandrijska detelja itd. uvrščene v kategorijo detelj. Podobno je tudi pri mešanicah, saj ne vemo natančno, katere rastline jih sestavljajo (Podatki o vrsti …, 2013).

Sledil je izračun vegetacijskega indeksa NDVI na nivoju posamezne njive z določeno krmno rastlino. Za izračun vegetacijskega indeksa NDVI je potrebno izbrati satelitski

posnetek iz ustreznega časovnega obdobja, ko je večina krmnih rastlin v najobčutljivejših fazah vegetacijskega obdobja. V tem obdobju so lahko poškodbe zaradi suše za nekatere vrste usodne in vplivajo na končni pridelek same rastline. Izbrali smo satelitski posnetek satelita Landsat 7 ETM+, posnet 9. julija 2012, z visoko kvaliteto posnetka (stopnja 9 od 10) in neznatno oblačnostjo (6 %) (NASA Landsat Program …, 2013). Omenjeni satelit je od 31. 6. 2003 v okvari, saj se je pokvaril korektor snemalnih vrstic. Na posnetku se tako pojavljajo diagonalne vrstice, ki zajemajo približno 22 % podatkov celotnega posnetka. Napake smo odpravili s programom *Landsat Gapfill*, ki zapolnjuje vrzeli z metodo triangulacije z upoštevanjem mejnih vrednosti (Stevenson, 2012). Sicer je bolje, da posnetkov s takšnimi ali podobnimi napakami za potrebe znanstvenih analiz ne uporabljamo. V našem primeru zaradi objektivnih razlogov (preučevano obdobje poletje 2012, nedelovanje drugih satelitov v tem obdobju) tega ni bilo mogoče zaobiti. Izračun NDVI smo izvedli z orodjem *VegIndex* v programu *IDRISI Taiga*.

Poleg indeksa NDVI smo rastno odpornost določili še s stopnjo poškodovanosti rastlin zaradi kmetijske suše ter rezultate obeh primerjali med seboj. Uporabili smo podatke o ocenjeni stopnji škode za leto 2012 na kmetijskih zemljiščih, pridobljenih na Upravi RS za zaščito in reševanje. Kazalnik prikazuje delež površin poškodovanih poljščin zaradi suše glede na celotno površino zemljišča. Površina poškodovanega posevka je morala biti vsaj 31 % (Ocena škode na …, 2013), da se je poljščina lahko uvrstila med poškodovane zaradi suše. Podatke o stopnji poškodovanosti smo prikazali in analizirali tudi prostorsko tako, da smo jih združili s prostorskim prikazom GERK za leto 2012.

2.2 Ekonomika pridelovanja krmnih rastlin

Kmetovalci, ki se poleg živinoreje ukvarjajo tudi s pridelavo krme, se pogosto srečujejo z ekonomiko pridelovanja rastlin. Pri tem je bistvenih več dejavnikov, mdr. zadostna količina potrebnih hranil, hektarski donos in nizki stroški pridelave. V naši raziskavi smo te kriterije uporabili pri iskanju ustrezne nadomestne rastline. Ekonomiko pridelovanja krmnih rastlin smo določili z več kazalniki: potrebe krave molznice po škrobu in beljakovinah, odkupna cena pridelka, pridelanega na hektarju površine, ter stroški pridelave krmne rastline.

S prvim kazalnikom podajamo dnevno in letno potrebo krave molznice po škrobu in beljakovinah za vzdrževanje telesne mase (vzdrževalna funkcija) in proizvodnjo mleka (proizvodna funkcija). Izračunali smo ga ob naslednjih predpostavkah: upoštevali smo povprečno telesno maso (600 kg) krave molznice črnobele pasme, ki ni breja in ne potrebuje dodatnih hranil za vzrejo prirasta ter daje povprečno dnevno 20 litrov mleka (Korošec, 1989) s povprečno laktacijo 305 dni (Podgoršek, Perpar, 2012). Upoštevali smo povprečno vsebnost maščob v mleku (4 %). Višja kot je vsebnost maščob v mleku, večje so potrebe po škrobu in beljakovinah (Korošec, 1989).

Potrebe živali po hranilnih snoveh smo podali s škrobnimi enotami (ŠE) in prebavljivimi beljakovinami (PB). Škrobna enota (ŠE) je vrednost, učinkovitost posameznega hranila v primerjavi s čistim škrobom (škrobna moka) in predstavlja delež škroba v krmi. En kg koruze predstavlja 800 ŠE, ima torej enak učinek kot 800 g škrobne moke.

Prebavljive beljakovine (PB) se določajo na podlagi beljakovinskega razmerja, tj. razmerja med prebavljivimi beljakovinami (PB) in škrobnimi enotami (ŠE). Pri proizvodnji mleka je to razmerje 1 : 4,6, pri vzdrževalni funkciji pa 1 : 10. Krave molznice črnobele pasme tako za proizvodnjo mleka potrebujejo 275 g ŠE ter 60 g PB na liter mleka dnevno. Za vzdrževanje telesne mase dnevno potrebujejo 3200 g ŠE ter 320 g PB (Cizej, 1991). Po izračunu dnevnih in letnih potreb po škrobu in beljakovinah za vzdrževanje telesne mase in proizvodnjo mleka smo izračunali še količino povprečne dnevne količine različnih vrst krme, s katero bi pokrili potrebe krave molznice po hranilih. Upoštevali smo obstoječe podatke ŠE in PB na 1 kg krme v povprečnem enkratnem (ena košnja oz. ena žetev) hektarskem donosu krmne rastline (Korošec, 1989).

Naslednja kazalnika ekonomike pridelovanja krmnih rastlin sta odkupna cena pridelka, pridelanega na hektarju površine, ter stroški pridelave. Hektarski donos je kazalnik, ki nam podaja donosnost, količino določenega pridelka na enem hektarju kmetijske površine. Za pridelovalce je to pomemben podatek, saj se tudi na podlagi tega odločijo za pridelovanje določene kulturne rastline (Korošec, 1989). Uporabili smo podatke o količinah rastlinske pridelave v letu 2012 (Krznar, 2013) ter indekse cen kmetijskih pridelkov pri pridelovalcih za leto 2012 Statističnega urada Republike Slovenije (Indeksi cen in cene …, 2013). Ker se za nekatere krmne rastline ne zbirajo podatki o cenah, smo pregledali oglase kmetovalcev na različnih spletnih straneh (kmetijskioglasnik.si; bolha.com itd.) za preučevano časovno obdobje in se posvetovali s kmetovalci in agronomi ter upoštevali srednje vrednosti cen. Izračunane odkupne cene pridelka na hektarju površine smo nato primerjali še z izračuni stroškov pridelave poljščin. Takšna primerjava namreč omogoča, da preverimo, ali imajo kmetovalci ob pridelovanju krme dobiček ali le pokrivajo večino stroškov. Izračune stroškov pridelave poljščin smo povzeli po modelnem izračunu Kmetijskega inštituta Slovenije za leto 2012. Izračun obsega stroške materiala, najetih storitev, stroške dela in drugih obveznih dajatev. Od izračunanih stroškov so že odštete pridobljene subvencije (Kalkulacije v rastlinski ..., 2013).

3 RAZPRAVA

3.1 Rastlinska odpornost

Preglednica 1 prikazuje rezultate izračunov NDVI. Območje preučevanja smo razdelili na dve različni reliefni območji. V ravninskem delu do 300 m n. v. je bila poškodovanost vseh rastlin višja kot v gričevnatem in hribovitem območju nad 300 m n. v. Razlogi za razlike so verjetno v rastnih pogojih, tipih prsti, reliefu in vegetaciji. V gričevnatem in hribovitem pasu prevladujejo gozdne površine, ki delujejo kot naravni zadrževalnik presežkov padavin. Poleg tega gozdne površine s prestrezanjem padavin skladiščijo vodo, kar bližnjim poljščinam nudi dodaten vir vode ob sušah, in tudi zmanjšujejo evapotranspiracijo (Brilly, Šraj, 2005).

Slika 6 prikazuje izračunan NDVI za celotno območje preučevanja, tudi za površine, ki jih v okviru raziskave nismo analizirali (gozd, pozidane in vodne površine). Različne

vrste površin smo razdelili v kategorije poškodovanosti. Pozidane in vodne površine smo izločili s prekrivanjem več slojev (kataster stavb, ceste, kategorizirani vodotoki, vodne in druge pozidane površine) in ugotovili, da zavzemajo območja z NDVI pod –0,55. Ostale površine so predstavljale različno poškodovano rastlinstvo, ki smo jih uvrstili v posamezne stopnje poškodovanosti z naravnim intervalom po Jenksu. V času snemanja satelitskega posnetka, v začetku julija 2012, so bile nekatere poljščine v ključnih fenofazah in zato bolj ranljive za vremenske razmere. To se kaže tudi v vrednostih NDVI, ki so zato nizke ali celo negativne. Bolj ranljivo je ravninsko območje, kjer je človek s poselitvijo krčil gozdne in vodne površine ter ustvaril umetne kmetijske ekosisteme, potrebne nenehnega vzdrževanja.

Na ravnini sta bili najmanj poškodovani lucerna in detelja, podobne vrednosti dosegata tudi obe travni mešanici (preglednica 1). Najbolj je bila poškodovana silažna koruza. V podobnem razmerju, a z nižjo stopnjo poškodovanosti, so bile vrednosti tudi v gričevnatem in hribovitem območju.

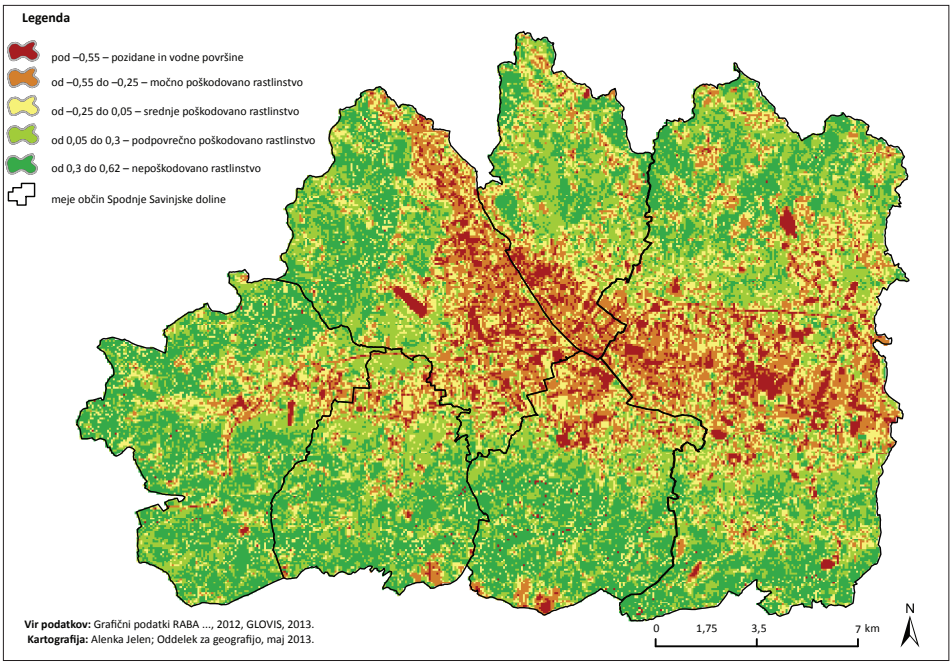
Preglednica 1: Povprečne vrednosti NDVI za izbrane krmne rastline
Table 1: The average NDVI values for the selected fodder crops

Krmna rastlina	NDVI celotnega območja	NDVI na ravninskem območju (do 300 m n. v.)	NDVI v gričevnatem in hribovitem območju (nad 300 m n. v.)
Silažna koruza	0,17	0,13	0,18
Detelja	0,21	0,20	0,23
Lucerna	0,22	0,21	0,25
Deteljno-travne mešanice*	0,18	0,18	0,22
Travno-deteljne mešanice**	0,20	0,18	0,19

** Deteljno-travne mešanice so mešanice trav, kjer prevladujejo detelje. Primerne so le za kratkotrajno pridelovanje na njivah.*
*** Travno-deteljne mešanice so mešanice, kjer je delež trav v mešanici višji od deleža detelj. Namenjene so setvi večletnih in trajnih travnikov (Korošec, 1989).*

Na preučevanem območju je bila s popisom določena škoda zaradi suše na 32,8 % vseh kmetijskih zemljišč, večinoma v ravninskem območju (približno do n. v. 300 m). Po podatkih Uprave RS za zaščito in reševanje je celotna škoda v letu 2012 na območju preučevanih občin znašala 10.371.388 € (Ocena škode na …, 2013). Naši izračuni kažejo, da je bilo največ škode v hmeljarstvu in pridelavi silažne koruze. Po površini je bilo največ poškodovanih trajnih travnikov (2493 ha), čeprav je bila stopnja poškodovanosti teh razmeroma nizka (35 %).

Slika 6: Poškodovanost kmetijskih in drugih površin glede na vrednosti NDVI
Figure 6: The damage of agricultural and other areas according to the NDVI values



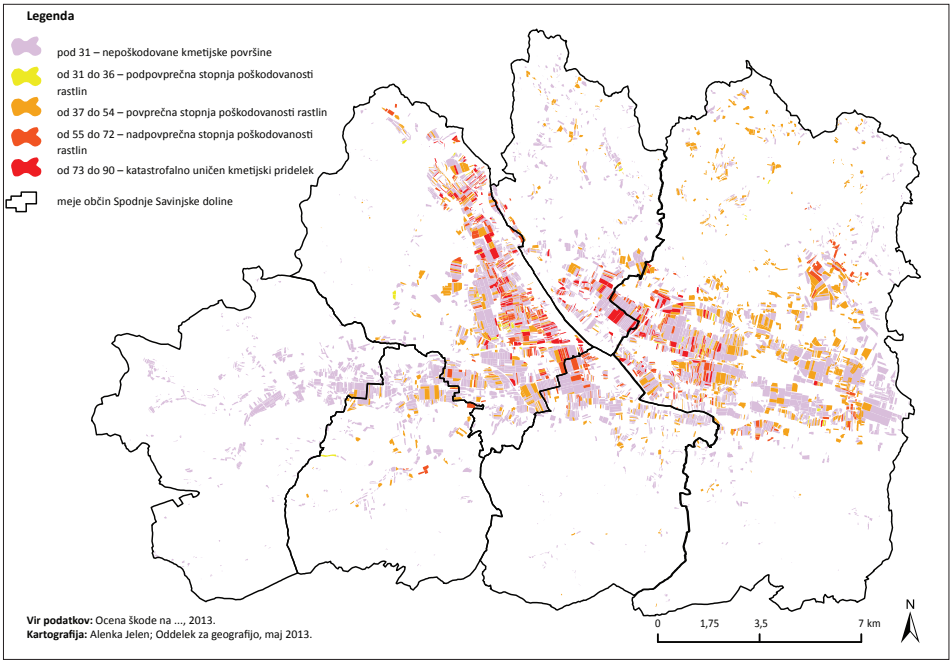
Na sliki 7 so prikazani vsi GERK-i kmetijskih površin. Razvrščeni so v več kategorij glede na povprečno stopnjo poškodovanosti. V zahodnem delu območja prevladujejo nepoškodovane površine, saj so na Vranskem ocenili, da ni bilo škode zaradi suše. V vzhodnem delu prevladujejo povprečno poškodovane površine, medtem ko na prodnatem vršaju Savinje v osrednjem delu območja prevladujejo nadpovprečno in katastrofalno poškodovane kmetijske površine, ki večinoma predstavljajo njivske površine.

Na celotnem območju je bilo zaradi suše poškodovanih 64 % vseh površin (1015,6 ha), ki so bile posajene s koruzo (za zrnje in silažo). V ravninskem območju je bila povprečna poškodovanost koruze višja (57,7 %) kot v pasu gričevij in hribovij (54,7 %) (preglednica 2). Ostale obravnavane poljščine niso presegle 50 %-ne maksimalne stopnje poškodovanosti zaradi suše. Najnižja povprečna stopnja poškodovanosti celotnega območja je bila pri lucerni, sledita ji mešanici in detelja. Nekoliko nenavadni so bili rezultati za obe reliefni območji, saj je bila poškodovanost pri vseh metuljnicah in mešanicah višja na območju gričevij in hribovij. Tu je bila tudi večina površin metuljnic in mešanic, v ravninskem delu tovrstne pridelovalne površine niso zadostovale kriteriju 1 ha, zato jih je tam manj. Posledično je bilo manj poškodovanih površin v ravninskem delu kot na območju gričevij in hribovij. V nadaljnjih raziskavah bi bilo očitno potrebno dopolniti metodologijo in razširiti preučevano območje.

Preglednica 2: Stopnja poškodovanosti krmnih rastlin zaradi suše po deležih površine
Table 2: The stage of damage to fodder crops due to the drought (percentage of area)

Krmna rastlina	Povpr. stopnja poškodovanosti na celotnem območju	Povpr. stopnja poškodovanosti na ravninskem območju (do 300 m n. v.)	Povpr. stopnja poškodovanosti v gričevnatem in hribovitem območju (nad 300 m n. v.)
Silažna koruza	57,0	57,7	54,7
Detelja	47,8	39,2	48,0
Lucerna	40,0	39,8	41,0
Deteljno-travne mešanice	46,6	46,4	48,5
Travno-deteljne mešanice	45,0	44,5	47,5

Slika 7: Stopnja poškodovanosti rastlin glede na popis škode
Figure 7: The degree of plant damage according to the census



Iz izračunov NDVI in stopnje poškodovanosti rastlin po suši sledi, da je lucerna najprimernejša krmna rastlina kot nadomestek silažni koruzi. Tako pri analizi podatkov popisa škode zaradi suše kot pri NDVI je dosegla nižje vrednosti in bila manj poškodovana kot silažna koruza. Tudi ostale krmne rastline dosegajo vrednosti, ki kažejo, da so bile

ob suši manj poškodovane in so torej odpornejše od silažne koruze. Pri analizi vrednosti NDVI in ocen popisa škode zaradi suše na obravnavanem območju ugotavljamo, da bi bilo pri nadaljnjih analizah potrebno obravnavati večje območje. Na tak način bi dobili različen nabor krmnih rastlin, kar bi dalo tudi natančnejše rezultate o njihovi odpornosti na ekstremne sušne in vročinske razmere.

3.2 Ekonomika pridelovanja krmnih rastlin

V preglednici 3 je prikazan primer izračuna potreb po škrobu in beljakovinah krave molznice črnobele pasme s 600 kg telesne mase, ki daje povprečno 20 litrov mleka dnevno s povprečno letno laktacijo 305 dni (Korošec, 1989; Podgoršek, Perpar, 2012). Ločeno so izračunane dnevne in letne potrebe po škrobu in beljakovinah za pridelavo mleka in vzdrževanje telesne mase ter njihova skupna količina.

Preglednica 3: Dnevne in letne potrebe krave molznice po škrobu in beljakovinah v krmi
Table 3: Dairy cows daily and annual needs for starch and proteins

Krava molznica s 600 kg telesne mase	**Povprečna dnevna/ letna količina mleka (l)**	**Škrob za proizvajanje mleka (kg)***	**Prebavljive beljakovine za proizvajanje mleka (kg)****	**Škrob za vzdrževanje telesne mase (kg)**	**Prebavljive beljakovine za vzdrževanje telesne mase (kg)**	**Skupaj škrobne enote (kg)**	**Skupaj prebavljive beljakovine (kg)**
Dnevne potrebe po škrobu in beljakovinah	20	5,5	1,2	3,2	0,32	8,7	1,52
Letne potrebe po škrobu in beljakovinah	6100	1677,5	366	976	97,6	2654	463,6

Vira/Sources: Korošec, 1989; Podgoršek, Perpar, 2012
** Ob 4 %-ni vsebnosti maščob ter z osnovo 275 g škrobnih enot na liter mleka, dnevno*
*** Ob 4 %-ni vsebnosti maščob ter z osnovo 60 g prebavljivih beljakovin za liter mleka, dnevno*

Dnevne potrebe krave molznice po hranilih so torej 8,7 kg čistega škroba (ŠE) ter 1,52 kg prebavljivih beljakovin (PB). Letne potrebe krave molznice za obdobje laktacije znašajo 2654 kg čistega škroba in 463,6 kg prebavljivih beljakovin. Največ škroba in beljakovin potrebujejo krave molznice za proizvodnjo mleka. Čistega škroba za proizvodnjo mleka je potrebno kar 42 % več kot za vzdrževanje telesne mase. Pri prebavljivih beljakovinah so te vrednosti še višje, kar 73 % beljakovin se porabi za proizvodnjo mleka. Kmetovalec mora ob tem upoštevati tudi, da izbrana krma ne vsebuje le čistega škroba in beljakovin, ampak še druga hranila ter ostale snovi (Korošec, 1989). Zato so lahko končne količine krme manjše.

Preglednica 4: Odkupna cena pridelka na hektarju površine nekaterih krmnih rastlin v letu 2012
Table 4: Price of yields per hectare for some fodder crops in 2012

Tip krme	Škrobne enote (kg)	Prebavljive beljakovine (kg)	Potrebna dnevna količina krme za pridelavo 20 l mleka (kg)	Hektarski donos v letu 2012 (t/ha)	Povprečna cena 1 kg krme v letu 2012 (€)	Odkupna cena pridelka na hektarju površine (€)
Srednje kakovostno seno (različne travne mešanice; dvakratna letna košnja)	0,30	0,09	27,33	4,60	0,15*	690,00
Zelo kakovostno seno (različne travne mešanice; trikratna letna košnja)	0,40	0,10	20,50	5,50	0,10	572,72
Silažna koruzna krma	0,19	0,04	44,32	39,40	0,065**	2561,00
Travna silaža (trava in travne mešanice; trajni travniki)	0,17	0,04	49,70	12,80	0,06***	768,00
Lucerna (pašna trava, zelena krma)	0,10	0,03	82,00	6,40	0,08****	512,00
Črna detelja (pašna trava, zelena krma)	0,11	0,03	78,10	5,60	0,08****	448,00
Inkarnatka (pašna trava, zelena krma, le poleti; pridelek v okviru DTM)	0,11	0,02	75,93	5,60	0,08****	448,00
Krmna žita – koruzno zrnje	0,82	0,07	10,00	7,10	0,20	1420,00
Krmna žita – ječmen	0,70	0,08	11,71	4,70	0,18	846,00
Krmna žita – pšenica	0,75	0,10	10,93	5,50	0,20	1100,00
Krmna žita – proso	0,67	0,08	12,24	1,60	0,42	667,68
Sirek (suha krma)	0,09	0,07	91,11	4,30	NP	NP

Viri/Sources: Korošec, 1989; Krznar, 2013; Indeksi cen in …, 2013
** Cena je ocena na osnovi različnih virov (mdr. oglasov kmetovalcev)*
*** Cena je bila preračunana iz cene 65 € za 1000 kg težko silažno balo*
**** Cena je bila preračunana iz cene 30 € za 500 kg težko silažno balo*
***** Cena je bila preračunana iz cene 40 € za 500 kg težko silažno balo (krma s 66 % suhe snovi)*
NP ni podatkov o ceni

V prvem delu preglednice 4 podajamo izračune količin čistega škroba in prebavljivih beljakovin v posamezni krmni rastlini ter predvidene dnevne količine krme za zadostitev potreb krave molznice po hranilih. Največje količine čistega škroba pridelamo s krmnimi žiti, med 0,67 in 0,82 kg na 1 kg celotne mase pridelka, saj se v zrnu akumulira največja količina škroba glede na celotno rastlino. V travnati in koruzni silaži je ta količina nižja, saj ta vsebuje več sveže snovi. Vrednosti čistega škroba so podobne tistim, ki jih pridobimo z zeleno krmo metuljnic (lucerna, črna detelja, inkarnatka) (Korošec, 1989). Precej višje vrednosti čistega škroba od pričakovanih so pri različno kakovostnem senu travnih mešanic. Razlog je v večji akumulaciji škroba v bolj posušenem senu (Prepadnik,

2012). Največ prebavljivih beljakovin vsebujejo posušeno seno ter krmna žita, med 0,07 in 0,10 kg na 1 kg krme. Metuljnice in travnata ter koruzna silaža vsebujejo nekoliko manj beljakovin, okoli 0,04 kg na 1 kg krme.

Krma iz samo ene krmne rastline se v živinski krmi ne pojavlja pogosto, saj kmetovalci sestavljajo krmo glede na količine hranilnih snovi (Korošec, 1989; Podgoršek, Perpar, 2012). Drugi razlog za uporabo pestre krme je v sami količini. Krava molznica je dnevno zmožna s krmo zaužiti med 15 in 20 kg suhe snovi, odvisno od pasme in možnosti laktacije (Orešnik, Lavrenčič, 2013). Iz preglednice 4 je razvidno, da bi bilo realno mogoče krmiti živino z eno vrsto krme le v primeru sena in krmnih žit. V ostalih primerih so količine krme zelo velike, zato je v takšnih primerih potrebno kombinirati z drugimi krmnimi rastlinami. Pri travni in koruzni silaži so vrednosti količine krme med 44 in 50 kg suhe snovi dnevno, pri metuljnicah med 75 in 82 kg suhe snovi. Še posebej visoke so vrednosti pri sirku, kar 91 kg suhe snovi.

V zadnjem delu preglednice 4 so prikazani hektarski donosi krmnih rastlin, povprečne odkupne cene 1 kg pridelka ter odkupna cena pridelka, pridelanega na hektarju površine. Največji hektarski donosi so tako pri silažni koruzi, za približno pol manjši ali več pri travni silaži, krmnih žitih (koruza v zrnju, pšenica) in lucerni. Ostale krmne rastline dosegajo nižje hektarske donose, še posebej proso (1,6 t/ha). Odkupne cene 1 kg krme so najvišje pri krmnem žitu, npr. za proso kar 0,42 € za kg; najnižje so za metuljnice ter silažo, npr. za koruzno silažo 0,065 € za kg. Če upoštevamo še hektarski donos, da dobimo odkupno ceno pridelka, vidimo opazne razlike med krmnimi rastlinami. Najvišje odkupne cene dosegajo koruzna silaža in krmna žita, najnižje pa krmne metuljnice in različno kakovostno seno.

Če želimo izbrati najprimernejšo krmno rastlino, je potrebno od prihodkov pridelka, pridelanega na hektarju površine, odšteti vse stroške pridelave. Pri izračunih stroškov so upoštevani vsi izdatki, oddaljenost parcele od kmetije, do odkupnega mesta, stroški setve, spravila, materiala, dela in drugih obveznih dajatev. V preglednici 5 so prikazani rezultati takšnih izračunov, ki smo jih povzeli po Kmetijskem inštitutu Slovenije (Kalkulacije v rastlinski …, 2013). Najvišji stroški pridelave so pri koruzi za zrnje in silažo, najnižji pa pri krmnih žitih. Podatkov za izbrane metuljnice ni bilo mogoče pridobiti.

Preglednica 5: Stroški pridelave izbranih krmnih rastlin glede na povprečni hektarski donos v letu 2012
Table 5: The production costs of selected fodder crops according to the average yield per hectare in 2012

Krmna rastlina	Stroški pridelave v letu 2012 glede na povprečen hektarski donos (€/ha)
Pšenica	983,42
Ječmen za prodajo	890,08
Koruza za zrnje	1598,04
Silažna koruza	1776,24
Ječmen za domačo krmo	878,78
Travna silaža	1278,96
Seno (trikosni travnik s 7,9 t/ha)	1398,63

Vir/Source: Kalkulacije v rastlinski …, 2013

Rezultati analize ekonomike pridelovanja rastlin kažejo, da se z vidika kmetovalca finančno bolj splača pridelovanje sena, krmnih žit in silažne koruze kot pridelovanje metuljnic. Te so sicer odpornejše na kmetijsko sušo, kot smo že ugotovili v prvem delu analize. Kmetovalec lahko z njimi zagotovi zadostne količine krme za dnevne potrebe krave molznice ali lahko ob prodaji krme zasluži. Po drugi strani so stroški pridelovanja silažne koruze, travne silaže in sena precej visoki v primerjavi s pridelovanjem krmnih žit. S prodajo sena trikosnega travnika ima kmetovalec vsaj enkratno izgubo, saj so stroški pridelave precej visoki.

4 SKLEP

V prvem delu analize smo dokazali, da je glede odpornosti na sušo lucerna najprimernejša krmna rastlina kot nadomestek silažni koruzi. Lucerna je tako pri analizi podatkov popisa škode zaradi suše kot pri NDVI dosegla nižje vrednosti in bila manj prizadeta zaradi suše kot koruza za silažo. Tudi ostale preučevane krmne rastline dosegajo vrednosti NDVI in stopnje poškodovanosti po popisu škode, ki dokazujejo, da so ob suši manj prizadete in odpornejše nanjo kot silažna koruza. Z vidika ekonomike pridelovanja ugotavljamo, da metuljnice kot samostojna krma niso primerne, zato bi jih bilo potrebno kombinirati z drugimi rastlinami.

Na podlagi več kriterijev so z ekonomskega vidika najprimernejše nadomestilo za silažno koruzo različna sena travnih mešanic ter krmna žita. Pridelovanje travnih mešanic je tudi stroškovno zahtevno, kmetovalec bi bil z njihovo prodajo celo v izgubi. Veliko bolj ekonomsko donosna so nekatera krmna žita (pšenica, ječmen). Vendar so to le teoretični predlogi nadomeščanja rastlin v strukturi krme, ki se lahko močno razlikujejo od dejanskega načina krmljenja živali. Zato bi bile potrebne še dodatne analize, ki bi tudi v praksi potrjevale ustreznost izbranih krmnih rastlin kot nadomestilo za silažno koruzo. S kompleksno analizo smo pokazali, da pri kmetovalcih, ki sami pridelujejo krmo, izbira krme samo z ekonomskega vidika ni najbolj ustrezna. V prihodnosti bo tako zaradi vse ekstremnejših vremenskih razmer potrebno upoštevati odpornost rastlin v različnih situacijah ter tudi druge rastne značilnosti, kar je bilo do sedaj bolj drugotnega pomena.

V prihodnjih analizah bi bilo potrebno ugotavljanje primernosti določenih krmnih rastlin kot nadomestilo silažni koruzi razširiti na daljše časovno obdobje. Žal zgolj eno vegetacijsko obdobje ne omogoča splošno veljavnih ugotovitev, saj se sušni dogodki med seboj zelo razlikujejo. Vsaka suša je posebna in zato tudi različno vpliva na fenološki razvoj rastlin. Podobno velja tudi za preučevanje ekonomike pridelovanja. Z enim vegetacijskim obdobjem ne zajamemo razlik v spremembah cen, količin letnega pridelka in povpraševanja. Tudi ti vidiki so zelo pomembni, saj prav tako vplivajo na izbiro krmne rastline.

Dodatno bi bilo potrebno izbrati tudi večje preučevano območje, ker bi tako prišli do ključnih ukrepov za posamezno območje. Ključni dejavnik pri tovrstnih raziskavah so tudi podatki o poljščinah. Na primeru šifranta kulturnih rastlin posamezne enote GERK vidimo, da zaradi metodologije vpisa ne moremo opravljati analize za točno določeno poljščino. Na večjem preučevanem območju bi tako pridobili širši nabor

potencialnih nadomestnih krmnih rastlin, kar bi verjetno dalo konkretnejše rezultate in možnost primerjave.

Potrebno bi bilo pridobiti tudi novejše podatke o količini škrobnih enot in prebavljivih beljakovin v krmi ter dnevnih potreb hranil pri živalih, ali uporabiti podatke o energijski vrednosti krme. Poleg tega bi bilo potrebno uporabiti kakovostnejše satelitske posnetke, saj smo pri tej analizi uporabili posnetek z 22 % manjkajočih podatkov, kar zelo zmanjšuje natančnost rezultatov in tudi splošnih ugotovitev.

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MULTICRITERIA EVALUATION EXPERIMENT OF THE ALTERNATIVE FODDER CROPS USE IN THE RESEARCH OF THE LOWER SAVINJA VALLEY

Summary

In the first part of the analysis (plant resistance), we have proven that alfalfa is the best fodder crop as a substitute for silage maize. Comparing the results of the census data loss due to the drought in 2012 and NDVI values, the alfalfa scored much better (higher NDVI) than the silage maize. The other analysed fodder crops have similar values, demonstrating that they are less prone to damages by drought and more resistant than silage maize. Regarding the economics of the production, the fodder legumes are considerably less suitable, so they had to be combined with other plants. According to the several economic criteria, the most appropriate compensation to silage maize is a

various mixture of grass hay and feed grains. However, growing grass mixtures is very costly and does not compensate all the investments. Much more economically viable are some feed grains (wheat, barley). Additional analysis is suggested which would confirm the suitability of the selected alternative plants as a replacement for silage maize in practice. In the somewhat complex analysis, we have proven that choice of the fodder crop cannot be made only from the economic point of view. Since more extreme weather conditions are expected in the future, farmers will need to consider also plant resistance to various weather situations and other growth characteristics, which had been until now of secondary importance.

Further analyses of the suitability of certain fodder crops as substitute to silage maize would have to be extended over a longer period. Drought events considerably differ from each other and have therefore quite different effects on phenological development of the plants. One growing season simply does not take into account the differences in price changes, annual production volumes and market demands. These aspects are very important, since the periodic fluctuations influence the farmer's choice of fodder crops.

At the same time, it would also be necessary to extend the studied area, as this would bring the differences between the inner parts of study area and therefore specific key actions in each area could be proposed. The specific data proved to be a key factor in the study, since in the case of the graphic parcel crop code of agricultural land (in Slovenian GERK), an analysis entry cannot be made for each specific crop plant. With broader study area we would also gain a wider range of different potential alternative fodder crops.

It would also be necessary to obtain the most recent data on the starch unit quantities, available digestible proteins in feed and animal's daily nutrient requirements or use the data of the energy value of feed. Finally, the use of satellite imagery of the highest quality would greatly improve the accuracy of the results and general observations. The results of the analysis based on the images with 22% of missing data proved to be very problematic.

(Translated by the authors)

GEOTOURISM AS A FACTOR OF DEVELOPMENT OF MID-BOSNIAN SCHIST MOUNTAINS AREA (EXAMPLE OF FOJNICA MUNICIPALITY)

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Abstract
Mid-Bosnian Schist Mountains is an area of significant geological and geomorphological diversity and aim of this study is to analyse the possibility of the development of geotourism on the example of Fojnica municipality. Evaluation of natural and anthropogenic characteristics was conducted for selected old mines of the region since Fojnica has a long mining history. Results show that Bakovići mine has the greatest geotouristic potential. Further research should be directed towards the creation of a complete geotouristic product for both Fojnica municipality and the entire Mid-Bosnian Schist Mountains area.

Key words: Geotourism, old mines, Mid-Bosnian Schist Mountains, Fojnica

GEOTURIZEM KOT DEJAVNIK RAZVOJA SREDNJEBOSANSKEGA SKRILAVEGA HRIBOVJA (PRIMER OBČINE FOJNICA)

Izvleček
Srednjebosansko skrilavo hribovje je geološko in geomorfološko zelo raznoliko. V raziskavi smo analizirali možnosti razvoja geoturizma na primeru občine Fojnica. Izvedli smo vrednotenje naravnih in antropogenih značilnosti izbranih starih rudnikov na območju Fojnice, ki ima dolgo rudarsko tradicijo. Rezultati kažejo, da ima rudnik Bakovići največji geoturistični potencial. Nadaljnje preučevanje bo usmerjeno v pripravo celovitega geoturističnega produkta za občino Fojnica in za celotno Srednjebosansko skrilavo hribovje.

Ključne besede: geoturizem, stari rudniki, Srednjebosansko skrilavo hribovje, Fojnica

I INTRODUCTION

Geotourism, as a new form of tourism, emerged in the tourism literature during the last twenty years. The first attempt to define the concept of geotourism dates back to the early 1990s when T. Hose gave a definition that was based on geology and geomorphology. Newsome and Dowling (2010) define geotourism as follows: 'A form of natural area tourism that specifically focuses on landscape and geology. It promotes tourism to geosites and the conservation of geo-diversity and an understanding of Earth sciences through appreciation and learning. This is achieved through independent visits to geological features, use of geo-trails and view points, guided tours, geo-activities and patronage of geosite visitor centers.' The best definition, in regards to this present work, is the one from Rybár (2010): 'Geotourism is tourism connected to a wide range of values of geosites (geological, geomorphological, petrological, mineralogical, palaeontological, etc.) plus the tourism related processes attached to them. Geotourism has also an explorative connotation. It frequently includes archaeology, art, architecture as well as mining related industrial activities.'

Within the researches related to the promotion and tourist valorization of geosites there is a great number of those dealing with the mining heritage, and that is how the concept of mining tourism emerged. Tourism related to the preservation and promotion of the mining heritage in abandoned mining areas and/or areas related to or dependent on mining can be called mining tourism.

Mining heritage includes natural (especially geological and geomorphological), historical, architectural, technological, technical, artistic and other aspects (Rybár et al., 2012). There are multiple possibilities of using abandoned mines for tourism purposes and Schejbal (2011) identifies the following ones. What will be applied depends on the individual site and its preservation:

- recreational use as a natural rest and relaxation area;
- use of artificial water bodies for sporting purposes;
- use of quarries for organizing motorsports, cycling and running events;
- climbing;
- natural science excursions;
- tours aimed at studying the technology of mining (surface and underground);
- use of underground space for therapeutic purposes.

Practice of using old mines for tourism purposes has long been recognized, and the most famous is Wieliczka mine in Poland. This mine is on the UNESCO list of natural and cultural heritage since 1978 and in 1994 it was declared as Poland's historical monument. Today, there is an ever growing interest in mining tourism from, at least, two aspects: on the one hand mining tourism is considered an action sport, an adventure, while on the other hand it gives the opportunity for tourists to get familiarized with the tools, technologies, ores and the way of life and work of miners (Rybár, Hvizdák, 2010). In most of the areas where mining activities were once concentrated, local communities now have to rely on tourist valorization of old mines to ensure further development. Therefore,

the development of tourist traffic is very important for those local communities. There is a great potential for cultural and historical monuments, educational routes and other tourist attractions, but they must be properly popularized and purchased (Teplická, Čuliková, Sőkeová, 2011). There are numerous instances of successful mining tourism, serving as examples how this kind of tourism can be a significant branch of tourism on both local and national level.

Due to its geological and geomorphological features, Bosnia and Herzegovina also has the potential for development of this type of tourism. The area of research (Fojnica municipality, located within the Mid-Bosnian Schist Mountains) was chosen because this is an area of significant geological diversity with many vestiges of old mining and smelting activities. Mining tunnels, groves, tailings and other vestiges serve as an evidence of long-lasting and vibrant mining and smelting activities in this area.

Considering all the above mentioned, the aim of this paper is to identify and introduce the most important ancient mines of Fojnica area whose evaluation could contribute to the enrichment of tourism in the municipality, but also ensure the preservation of traces of long-term mineral exploitation in this area. Assessment of old mines of Fojnica area was conducted on the basis of natural and anthropogenic characteristics of the selected sites.

2 RESEARCH AREA

Fojnica municipality is located in the central part of Bosnia and Herzegovina (Figure 1) and includes ranges of Vranica mountain in the west, Zec mountain in the southwest, Pogorelica mountain in the south and Zahor and Kruščica mountains in the north. The area is crisscrossed by numerous streams, with the major rivers Fojnica, Željeznica and Kozica.

In geological terms this area belongs to the Mid-Bosnian Schist Mountains which have a high degree of particularities if compared to other parts of the Dinarides in Bosnia and Herzegovina. Deposits of Paleozoic to Cenozoic age are present in the area (Figure 2), built of genetically diverse rocks: igneous, sedimentary and metamorphic. Metamorphic rocks are represented by dark green schists, followed by quartz-sericite schist, graphite-chlorite schists and phyllites, and quartzites, as well as marbles and metasandstones that appear in contact with rhyolites. Sedimentary rocks are represented by limestones and dolomites. Igneous rocks are also considerably widespread, mainly in the highest parts of the Vranica mountain. They are represented by the rhyolites or quartz porphyry.

Geology of the area is the main factor in the shaping of the relief of a wide area, including both lithological (mostly volcanic rocks) and tectonical characteristics (Mid-Bosnian Schist Mountains are bordered by large faults, but also dissected by a series of small ones). This area has a significant vertical relief diversity and according to their hypsometric characteristics, it is a mountainous area (share of the area above 1000 m is more than 55%). Several endogenous and exogenous factors (low temperature, ice, snow, denudation, and fluvial erosion) led to the creation of today's relief.

Figure 1: Geographical location of Fojnica and location of selected mines
Slika 1: Geografska lega Fojnice in lokacije izbranih rudnikov

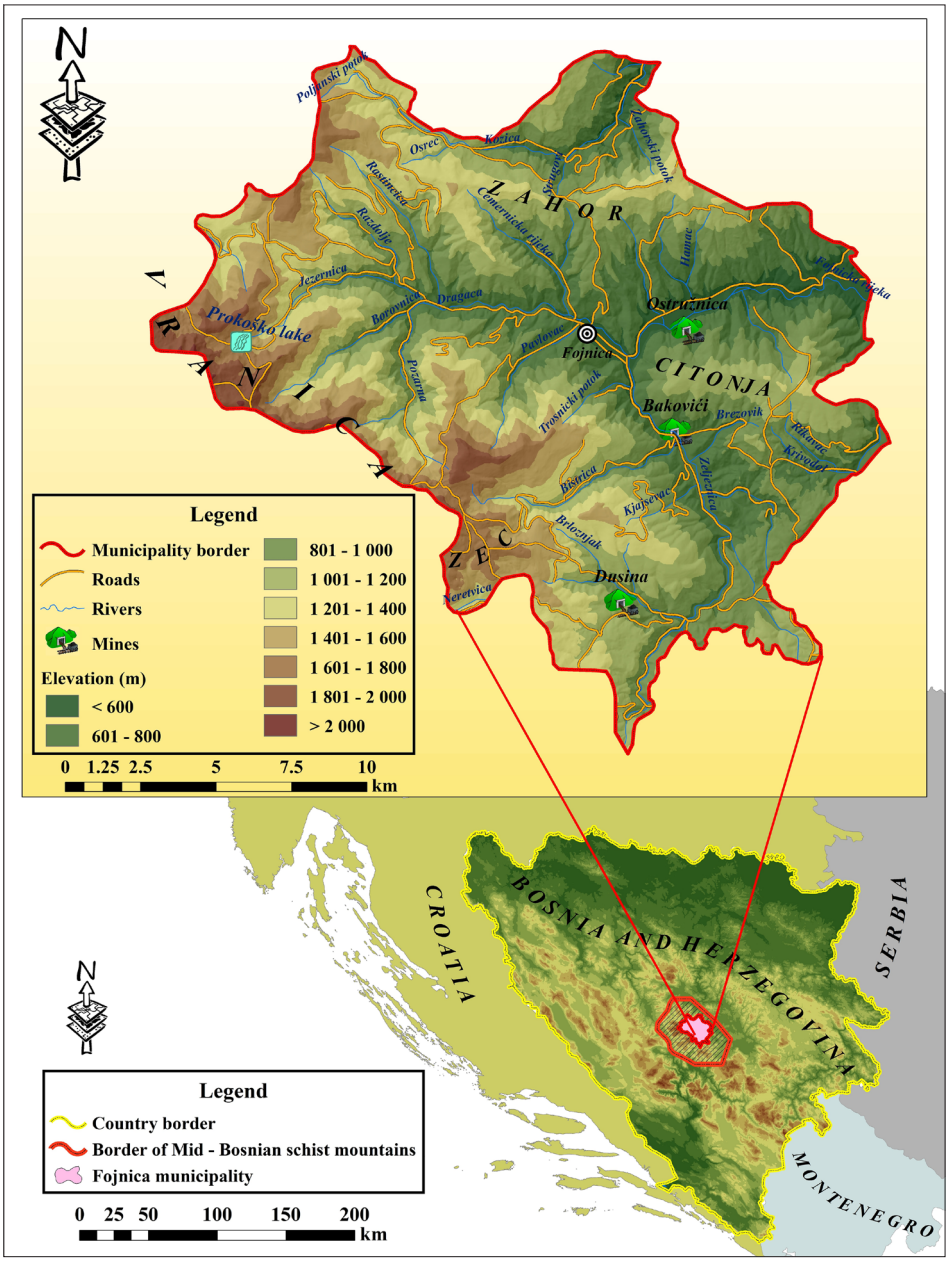
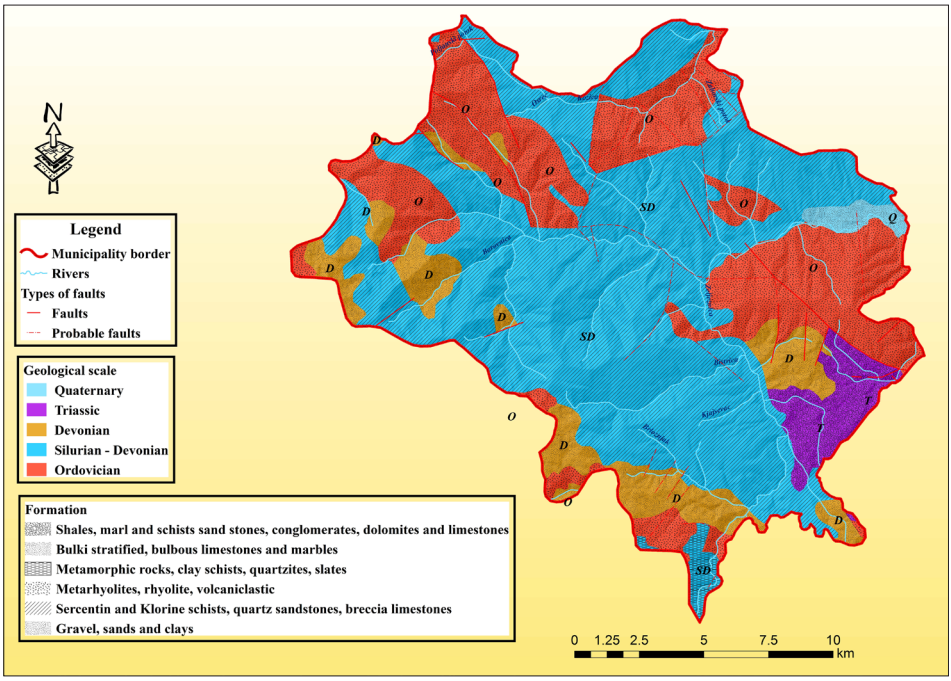


Figure 2: Geological map of the research area
Slika 2: Geološka karta preučevanega ozemlja



3 METHODS

Based on the analysis of the literature related to mines and mining of Mid-Bosnian Schist Mountains, those sites considered of having geotouristic potential were selected. Afterwards, in selected localities of former mining activities in the area of Fojnica, field research has been conducted. Preliminary field studies were published in the early spring of 2013 within which the following mining sites were identified (selected) for further processing: iron mine Dusina, gold mine Bakovići and silver mine Ostružnica. During further field surveys photographic documentation for the selected sites was collected. The maps used in the field work included topographic maps at the scale of 1 : 25 000 and geological maps at the scale of 1 : 50,000 and 1 : 100,000. The evaluation of collected field data was performed using a modified methodology of Rybár (2010) who developed a model for evaluation of value/attractiveness of geotouristic objects through two basic principles – natural and anthropogenic (Table 1). Each parameter was assessed with grades 0 to 8.

Table 1: The parameters of evaluation of value/attractiveness of geotouristic sites (Rybár, 2010)
Preglednica 1: Parametri vrednotenja vrednosti/privlačnosti geoturističnih lokacij (Rybár, 2010)

Natural features	Anthropogenic features
• Primary geological properties	• Age of the object
• Uniqueness	• Historical value
• The accessibility of the object	• Aesthetic value
• Existing scientific and technical literature	• Authenticity
• Conditions of observation (research)	• Connection with the mining tradition of the place and its surroundings
• Safety	• Exceptionality/excellence
• Availability of existing data	• Emotional value
• Visual value of the object	• Utility value of the object
• Value of provided services	• Provided services – options
• Site and tourist environment	• Safety

Final evaluation of geotouristic potentials of selected mines was made as follows:

- score 0–3 (inconvenient / impossible): not suitable for tourist presentation and use (rank 3);
- score 3–6 (difficult / bad): partially suitable for tourist presentation and use (rank 2);
- score 6–8 (suitable / possible): suitable for tourist presentation and use (rank 1).

4 SELECTED MINES OF FOJNICA AREA

For this study, iron mine Dusina, silver mine Ostružnica and gold mine Bakovići were selected. They were selected because of geological characteristics of international significance, historical value, uniqueness, accessibility and their interconnections.

Ostružnica mine has been mentioned in documents from the 14th century (Drmač, 2012) and remained known as the oldest silver mine in Bosnia. Later, due to the frequent Ottoman invasions, mining activities have been relocated in the mountainous part (Deževice, Dusina) and thus significance of Ostružnica declined. Iron, copper and gold were excavated too, besides silver. Ore was found in parallel layers of slate rocks, and pits were right next to the river, or not too far from it, which made the exploitation much easier. More than 150 pits is mentioned in the literature while the toponyms in the Ostružnica area such as: 'Majdan' (= Mine), 'Jame' (= Pits), 'Zlatni dol' (= Golden Valley) all indicate a significant mining activity in the past. The most important caves are in the valley of Brloški creek (right tributary of the Fojnica river) at the foot of the mountain Citonja, 0.5 km southeast of the village Polje Ostružnica (Figure 1). Field research on the site showed that there are no significant remains of the former mining operations. Traces of mining have been largely destroyed by the exploitation of wood in this area. Construction of the trail for harvesting and extracting wood is the most prejudicial to the preservation of traces. The exploitation of forests also increased soil erosion, which caused the backfill of former shafts, although erosion had been present before.

Figure 3: Dusina mine (pits)
Slika 3: Kopi v rudniku Dusina

Dusina mine is referred in the literature as the iron mine (descriptions of an old furnace, large hammers driven by water) while somewhat further from Dusina lead and silver were excavated in the so called Saxony pits. Jurković (1996) states how numerous ore occurrences were explored in the area of Dusina. Saxons used to dig caves in very solid rocks that were crisscrossed with mineral veins. One such cave was singled out for this study. The pit is located west of the Dusina village (Figure 1) and can be reached by the gravel road Dusina–Pogorelica or by challenging hiking trail. Traces of former mining activities are preserved on the site – entrance (window) to the former mine (Figure 3). The site has certain geotouristic potential such as rock outcrops, more pits nearby, and two caves (one is about 300 m east of Saxon pit and the other is about 400 m southwest of the village Dusina).

Bakovići mine is located on the southern slopes of the mountain Citonja, 4.5 km southeast of Fojnica (Figure 1). This mine was the largest gold producer in Bosnia and Herzegovina. Among other mineral resources, gold and silver are particularly well-known in this area, with the largest concentration of gold in oxides and pyrite quartz veins (Filipović, Nikolić, 2009). Production started in 1885 and ceased in 1939, with an interruption from 1918 to 1934. Filipović and Nikolić (2009) indicate that the surrounding tailings of processed ore still contain a certain amount of gold, which leaves the possibility of washing it. Mine includes several tailings and old undermines. Near the Bakovići tailings the entrance to the cave Juris has been established, which dates back to Roman times, and today it stands paved. There is another entrance near the Juris into the mine pit

from where the sulfuric water flows with a yellow precipitate which gets deposited and goes to the Željeznica River. Two more entrances to the pit were established on the other tailings. The first entry is sealed with stones, while the second one is preserved (Figure 4). An oak construction and several meters of underground corridors are visible at the second entrance. Sulfuric water comes out of this cave. The access to the mine is easy and it can be reached through the footpath from the village Bakovići.

Figure 4: Bakovići mine (sulfuric water and entrance)
Slika 4: Rudnik Bakovići (žveplova voda in vhod)

5 RESULTS AND DISCUSSION

It is necessary to perform an evaluation of the attractiveness of selected geotourist sites if we want to develop geotourism. The methodology used in this paper (Rybár, 2010a) provides an opportunity to determine whether the selected site is a potential tourist object with dominant either natural or anthropogenic characteristics. The results obtained in this way represent the basis for the development of projects in geotourism.

Ten parameters were evaluated, and the results are shown in Table 2. The highest average score was met in the safety parameter (score 6.0), which means that no protective equipment for visiting the site is required. Dusina and Ostružnica sites got a lower score than Bakovići because of somewhat poorer accessibility that requires a slightly more physical effort to get to it. Three parameters got the average score of 5.6 (primary geological properties, the accessibility of the site, and the visual value of the site). The area of research, a part of the Mid-Bosnian Schist Mountains, has some significant geological particularities, while among the selected sites Bakovići gold mine stands out. This mine has the highest score when it comes to accessibility. The third parameter is used to assess the visual value of the site and its surroundings. With its beautiful views and mountain scenery Dusina mine stands out (Figure 5), while Ostružnica mine was rated with the lowest score. Three parameters have the score of ≥4: existing scientific and vocational literature, uniqueness, and the conditions of observation (research). For all three parameters Bakovići mine has been assessed with the maximum score. Parameters used to assess the value of services that might be provided to tourists and the availability of information were rated with the lowest score.

After all ten parameters were evaluated, the average score for all three mines was 4.5. Bakovići mine has an average score of 6.5 which makes it suitable for touristic presentation. Dusina mine is partially suitable (score of 4.9), while Ostružnica mine is unsuitable for touristic presentation (score of 2.2) according to its natural characteristics.

Figure 5: Landscape of Dusina mine
Slika 5: Pokrajina v okolici rudnika Dusina

Figure 6: Tailings of Bakovići mine
Slika 6: Jalovina iz rudnika Bakovići

Table 2: Evaluation of the natural characteristics of the old mines
Preglednica 2: Vrednotenje naravnih značilnosti opuščenih rudnikov

Mine	Ostružnica	Dusina	Bakovići	Average
Primary geological properties	3	6	8	5.6
Uniqueness	2	4	8	4.6
Accessibility of the object	5	5	7	5.6
Existing scientific and vocational literature	0	8	8	5.3
Conditions of observation (research)	0	4	8	4.0
Safety	5	5	8	6.0
Availability of existing data	2	2	5	3.0
Visual value of the object	3	8	6	5.6
Value of provided services	2	2	2	2.0
Site and tourist environment	0	5	5	3.3
Average	2.2	4.9	6.5	4.5
RANK	3	2	1	2

Just like in natural characteristics, ten anthropogenic parameters were also evaluated and the results are shown in Table 3. Connection to the mining tradition was rated with the highest score (score of 7.0). A correlation with other old mining areas in Bosnia and Herzegovina (Kreševo, Srebrenica, Olovo) is noticeable as well as the interconnection between these three mines. Two parameters were evaluated with the average score of 6.6: the age of the site and historic value. Bakovići mine has been evaluated with the highest score since some remains from the ancient times were found here, while the other two mines belong to the medieval period. Safety of all three sites for sightseers is good and this parameter is rated 6.0. Four parameters (aesthetic value, exceptionality, emotional value, utility value of the object) were evaluated with an average score of 4.0. In these four parameters, the Bakovići mine has an average rating of 7.0, which indicates a great potential for the development of geotourism on this site. Gold panning might be established on the tailings of Bakovići mine (Figure 6). The lowest-rated parameters are those of authenticity and service capabilities because there are few well-preserved archaeological traces. Collapsed windows are visible, but it is not possible to visit the interior of the mine.

The average value of all three mines for all ten parameters is 4.9. Bakovići mine has the highest average rating, followed by Dusina and Ostružnica mines. The assessments of anthropogenic characteristics suggest that the only mine fully suitable for touristic presentation is Bakovići mine.

Table 3. Evaluation of anthropogenic characteristics of old mines
Preglednica 3: Vrednotenje antropogenih značilnosti opuščenih rudnikov

Mine	Ostružnica	Dusina	Bakovići	Average
Age of the object	6	6	8	6.6
Historical value	6	7	7	6.6
Aesthetic value	0	6	6	4.0
Authenticity	0	5	5	3.3
Connection with the mining tradition of the place and surroundings	8	5	8	7.0
Exceptionality	3	3	6	4.0
Emotional value	0	4	8	4.0
Utility value of the object	0	4	8	4.0
Provided services – options	0	4	6	3.3
Security	5	5	8	6.0
Average	2.8	4.9	7.0	4.9
RANK	**3**	**2**	**1**	**2**

The overall touristic value of the old mines of Fojnica in terms of natural and anthropogenic characteristics is 4.7 (Table 4). It is evident from the ratings that Bakovići gold mine has the greatest geotouristic potential (the average score of 6.8) and that it is suitable for touristic presentation and utilization. Dusina mine is partly suitable (score of 4.9), and Ostružnica mine is considered as unsuitable for touristic presentation and utilization (the average score of 2.5).

Table 4: Values of assessment of natural and anthropogenic characteristics of old mines
Preglednica 4: Rezultati vrednotenja naravnih in antropogenih značilnosti opuščenih rudnikov

Mines	Natural characteristics	Antropogenic characteristics	Overall mark
Ostružnica	2.2	2.8	2.5
Dusina	4.9	4.9	4.9
Bakovići	6.5	7.0	6.8
Average	**4.5**	**4.9**	**4.7**

6. CONCLUSION

The history of mining activities in the area of Fojnica can be traced back to the prehistoric times up to the 20th century. The exploitation of gold, silver, mercury, copper, iron, limestone, and dolomite was being performed which shows the diversity of lithological composition, and generally a high level of geological diversity of the area. After the termination of the exploitation the mines were (and still are) deserted.

Due to the increasing popularity of nature-based tourism and the emergence of geotourism as a new tourist segment the question arises: whether the current state of the mines could be used for tourism purposes and for additional tourist affirmation of Fojnica? The results of the evaluation of natural and anthropogenic characteristics of the three selected mines (Ostružnica, Dusina and Bakovići) show that the overall score of assessment of the touristic value of old mines is 4.7 and that selected mines are partially suitable for touristic presentation and utilization. According to the individual assessments, the results show that Bakovići gold mine possesses the largest geotouristic potential and that it is the most suitable for touristic presentation and utilization (the average score was 6.8). Dusina mine is partially suitable with a score of 4.9, but Ostružnica mine is considered unsuitable for touristic presentation and utilization with an average score of 2.5.

Our results suggest that Fojnica municipality has the potential for development of geotourism based on mining and geological heritage and that further research and activities should be focused on creating integrated geotouristic products which may include geological tours (geotrails of various lengths), recreational gold panning, an educational center with geological and mining facilities, and similar activities. Great potential also lies within connection with other mining areas within the Mid-Bosnian Schist Mountains (e.g. Kreševo municipality).

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GEOTURIZEM KOT DEJAVNIK RAZVOJA SREDNJEBOSANSKEGA SKRILAVEGA HRIBOVJA (PRIMER OBČINE FOJNICA)

Povzetek

Številne raziskave na področju geoturizma se ukvarjajo z rudarsko dediščino. Za vključevanje opuščenih rudnikov v turistične namene obstaja več možnosti (rekreacija, priprava tekmovanj, poučevanje, terapevtski nameni idr.), katere od njih pa bodo izkoriščene, je odvisno od posamezne lokalitete in njene ohranjenosti.

Zaradi geoloških in geomorfoloških značilnosti ima Bosna in Hercegovina velike potenciale za razvoj te vrste turizma. Območje te raziskave (občina Fojnica znotraj Srednjebosanskega skrilavega hribovja) smo izbrali ravno zaradi dejstva, ker ima pomembno geološko diverziteto s številnimi ostanki stare rudarske in talilniške dejavnosti (pridobivali so zlato, srebro, živo srebro, baker, železo ter apnenec in dolomit). Po koncu rudarjenja je sledilo obdobje, ko so rudnike opustili in takšni so ostali do danes. V članku so predstavljeni najpomembnejši stari rudniki v občini Fojnica, ki bi s ponovno valorizacijo lahko prispevali k obogatitvi turistične ponudbe občine, z njo pa bi tudi zavarovali sledove dolgoletnega pridobivanja rud na tem območju.

Na osnovi zgodovinskih virov in terenskih raziskav smo za nadaljnje preučevanje izbrali rudnik železa Dusina, rudnik zlata Bakovići in rudnik srebra Ostružnica. Zaradi geoloških značilnosti so te lokalitete mednarodno pomembne, prav tako zaradi zgodovinske vrednosti, edinstvenosti, dostopnosti in njihove medsebojne povezanosti. Vrednotenje starih rudnikov smo izvedli na osnovi njihovih naravnih in antropogenih značilnosti s pomočjo desetih parametrov. Vsak parameter smo ovrednotili z oceno od 0 do 8, nato pa smo na osnovi dobljenih rezultatov rudnike razvrstili v tri kategorije: neprimeren, deloma primeren in primeren za turistično predstavitev. Uporabljena metoda omogoča določiti, ali je izbrana lokaliteta potencialni turistični objekt s prevladujočimi naravnimi in antropogenimi značilnostmi.

Rezultati vrednotenja naravnih in antropogenih značilnosti treh izbranih rudnikov kažejo, da je skupna ocena turistične vrednosti starih rudnikov v Fojnici 4,7 in da so izbrani rudniki deloma primerni za turistično predstavitev in koriščenje. Posamične ocene kažejo, da ima rudnik zlata Bakovići največji geoturistični potencial in da je najustreznejši za

turistično predstavitev in koriščenje (povprečna ocena 6,8). Rudnik Dusina je z oceno 4,9 delno primeren, rudnik Ostružnica pa je s povprečno oceno 2,5 neprimeren za to.

Rezultati preučevanja kažejo, da ima občina Fojnica možnosti za razvoj geoturizma na podlagi rudarske in geološke dediščine. Nadaljnja preučevanja in aktivnosti bi bilo treba usmeriti v oblikovanje celovitega geoturističnega izdelka, ki bi lahko vključeval različno dolge geološke poti, rekreativno izpiranje zlata, izobraževalno središče z geološkimi in rudarskimi vsebinami in podobne aktivnosti. Velike možnosti so tudi v povezovanju z drugimi rudarskimi območji znotraj Srednjebosanskega skrilavega hribovja (npr. z občino Kreševo).

(Prevedel K. Natek)

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DEPOPULATION AND POPULATION AGEING OF RURAL AREAS IN BJELOVAR-BILOGORA COUNTY (1961–2011)

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Abstract
Bjelovar-Bilogora County is located in the central part of the Croatian Pannonian-Peripannonian space. In spite of good location within Croatia and favourable physiogeographical characteristics, this county was marked by very negative demographic characteristics in last fifty years. In relation to the county as a whole, the demographic situation in the rural parts is more unfavourable than in urban settlements. Between 1961 and 2011, the rural population of the county was reduced for 46.7%.

Key words: Bjelovar-Bilogora County, total depopulation, natural depopulation, emigration, population ageing

DEPOPULACIJA IN STARANJE PREBIVALSTVA NA PODEŽELSKIH OBMOČJIH BJELOVARSKO-BILOGORSKE ŽUPANIJE (1961–2011)

Izvleček
Bjelovarsko-bilogorska županija leži v osrednjem delu hrvaškega panonsko-subpanonskega prostora. Kljub ugodni lokaciji znotraj Hrvaške in ugodnim fizičnogeografskim značilnostim ima v zadnjih 50 letih zelo negativne demografske značilnosti. Z vidika celotne županije so demografske razmere v podeželskih delih še veliko bolj neugodne kot v mestnih naseljih. Med letoma 1961 in 2011 se je delež podeželskega prebivalstva v županiji zmanjšal za 46,7 %.

Ključne besede: Bjelovarsko-bilogorska županija, Hrvaška, depopulacija, naravna depopulacija, izseljevanje, staranje prebivalstva

1 INTRODUCTION

Bjelovar-Bilogora County was formed in 1992 in the central part of Croatian Pannonian and Peripannonian region. With its 2,640 km² (4.7% of the total Croatian land area) it is a medium-sized Croatian county (Statistical yearbook ..., 2014). There is an equal number of Croatian counties that are smaller and larger than Bjelovar-Bilogora County. According to the last census in 2011, the county had 119,764 residents, which composed 2.8% of the total Croatian population (Statistical yearbook ..., 2014). The population density was 45.4 inhabitants per km², which is below the average Croatian population density (75.7 inhabitants per km²). That indicates a more complex demographic situation and series of processes in Bjelovar-Bilogora County which have been predisposed by several factors.

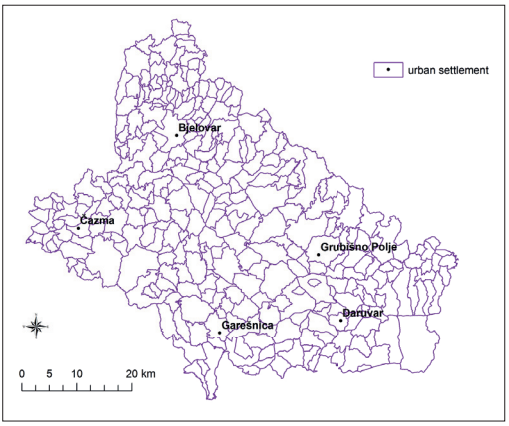
Figure 1: Location of Bjelovar-Bilogora County within Croatia
Slika 1: Položaj bjelovarsko-bilogorske županije v okviru Hrvaške

Source/Vir: https://commons.wikimedia.org/wiki/File:CroatiaBjelovar-Bilogora.png

The county is divided into 23 local administrative units: five administrative towns and 18 municipalities with a total of 323 settlements (according to the 2011 census), of these, five settlements are considered urban: Bjelovar (the county seat), Čazma, Daruvar, Garešnica and Grubišno Polje (The model for the diferentiation ..., 2011). According to the same source, all other settlements are considered rural and transitional. That includes villages and other urbanised settlements in rural areas. For this work all 318 such settlements will be considered rural[1].

1 In Croatia, there are problems regarding the definition of urban settlements. There is only an administrative definition that determines administrative towns and their areas. In that way 128 towns are determined. However, a lot of non-urban settlements are often listed into an area of the administrative town which results in a rapid and fictive growth of the urban population. Therefore in this paper we used the *Model of differentiation between urban, rural and transitional settlements in the Republic of Croatia*, which was published in 2011 by the Croatian Bureau of Statistics. The mentioned publication lists only urban settlements and therefore all non-urban settlements are considered as rural in this paper.

Figure 2: Urban settlements in Bjelovar-Bilogora County
Slika 2: Urbana naselja v bjelovarsko-bilogorski županiji



2 GEOGRAPHICAL LOCATION AND TRAFFIC ISOLATION OF BJELOVAR-BILOGORA COUNTY

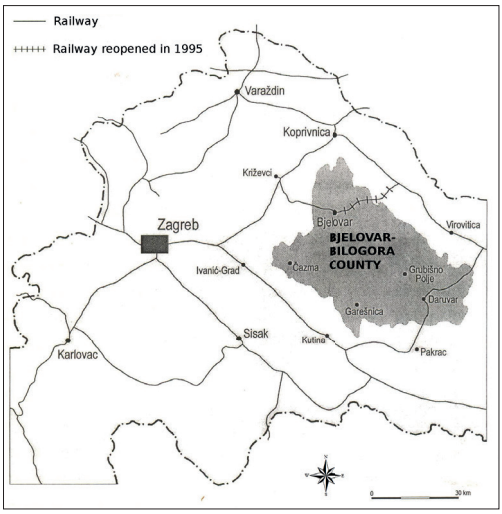
The researched area is part of Central Croatia and is separated from the rest of Central Croatia by the hills of Bilogora to the north, the western slopes of Papuk Mountain (more precisely by its ridges Lisina, Ljutoče and Ravna gora) in the east and the hills of Moslavačka gora on the southern border of the county. Towards the west the county faces the slopes of Kalnik Mountain, and the southernmost area faces the Sava River valley, which connects the county hydrologically. The area of the county as a whole is part of a wider geographical unit called the Lonja-Ilova Basin, which includes the areas of Križevci and Pakrac. The basin has the altitude between 120 m and 150 m above sea level and is intersected by numerous watercourses; the longest are the rivers Česma and Ilova. In this lowland area, the southeastern border has a higher elevation due to tectonics. According to the relief, Bjelovar-Bilogora County is spatially divided in a mountainous and hilly border area and much bigger lowland area in the centre of the county. That division has had a significant impact on socio-economic processes – the natural conditions in this relatively humid basin were extremely favourable for the development of agriculture, hence the long agricultural tradition of the county. According to the 2001 census, the agricultural population in Bjelovar-Bilogora County totalled 20.7%, which represented the largest percentage among the Croatian counties.[2] The valuable agricultural area has encouraged intensive agricultural exploitation and the immigration of an agrarian population that until the mid-20th century settled, spontaneously or planned (colonisation), mostly from agriculturally overpopulated regions (Vresk, 1988). The dominant role of

2 The data from the 2001 census were used because at the time of writing data from the 2011 census had not been published yet.

agriculture in the economy lasted into the early 1990s what greatly influenced the physiognomy of geographical landscapes that had typical agricultural characteristics.

Despite the relatively favourable physio-geographical location, several factors have hindered the development of the central and nodal functions of Bjelovar. Such situation has caused the relative economic backwardness of the county compared with its potential opportunities, as well as demographic regression, intense deruralisation, deagrarisation, polarisation, etc. One of the main factors is the poor transportation links. Roads of international and interregional significance bypass the county, and it is widely accepted that a good location in terms of transportation networks, among other factors, causes an increase in the number of inhabitants that, in turn, leads to the concentration of different functions such as job creation, influx of a workforce, etc. (Ilić, 1995). An example of Bjelovar-Bilogora County's poor transportation links is the fact that apart from the Križevci–Bjelovar–Kloštar railway in the northwest, the only other existing railway is Suhopolje–Daruvar–Banova Jaruga, located in the eastern (peripheral) part of the county (Figure 3). Furthermore, the very important road, which links the Croatian capital Zagreb and Osijek, the main centre of Eastern Croatia, also just touches the northwest of the county and further attaches to the Podravina corridor. Therefore, the vast area in the central part of the county remains outside the main traffic routes and is inadequately connected by local road networks. It is acknowledged that traffic routes directly affect the formation of urban systems (Vresk, 1993). Rail traffic triggers a concentration of population in towns, while road traffic causes population dispersion and contributes to the spread of urban functions. Considering those facts, it is understandable why Bjelovar-Bilogora County is the least urbanised region in Central Croatia.

Figure 3: The rail network in Central Croatia
Slika 3: Železniško omrežje na srednjem Hrvaškem



Source/Vir: Pokos, N. (2000a)

The lack of transportation networks in this area is the result of both Hungarian and Yugoslav economic policies. In 1870, the Hungarians built the Gyékényes–Koprivnica–Zagreb railway that completely bypasses Bjelovar-Bilogora County. Hungarian interests also influenced how the first railway (built in 1885) is passing the county in transverse direction (Barcs–Virovitica–Daruvar). It was not until 1894 that Bjelovar was connected with the Koprivnica–Zagreb[3] railway via Križevci. In 1900, Bjelovar was connected to the Podravina traffic corridor via Kloštar, in 1912 Garešnica and with Grubišno Polje a year later. After World War Two, the Grubišno Polje–Bastaji railway was completed. With the completion of this railway Bjelovar and Daruvar were connected and only the Čazma area remained unconnected.[4] During the 1960s, at the time of building the Garešnica–Banova Jaruga railway which should have connected the whole railway system around Bjelovar with the Sava Valley railway, the development of road transport took place which led to the suspension of railway building in some parts of the Croatian rail network. Rail traffic was suspended across the entire area between Bjelovar, Garešnica, Grubišno Polje, Bastaji and Kloštar. In the former Yugoslavia, most railways terminated in the Bjelovar region (Dugački, 1974). In 1995, the Bjelovar–Kloštar railway was reopened, however, due to its non-rentability the railway management thinks of closing it down again. The described railway transportation system left Bjelovar with only one 'dead-end track', which is one of the most important factors of its slower development and its failing to develop into a proper regional centre. In a period of intense industrialisation in the 1960s and the ever increasing commuting to work centres primarily by rail (Feletar, 1977[5]; Vresk, 1979), the interior of the county remained unconnected by railways which is why numerous people were forced to resettle in the larger cities or their suburbs. The construction of the Sava road (today called European corridor X) after World War Two, which together with the completed railway (in the same direction) became the primary Yugoslav traffic corridor, increased Bjelovar-Bilogora County's isolation. For example, in South Moslavina which is located along the Sava route, the gravitational influence of Zagreb has increased and the region has become an area of demographic and economic concentration. Construction of the Kutina petrochemical complex also contributed to these processes. Conversely, the Northern Moslavina area, which is the part of Bjelovar-Bilogora County, was marked by intensive depopulation, deruralisation and other unfavourable demographic processes.

3 DYNAMICS AND CHANGE IN THE TOTAL RURAL POPULATION, 1961–2011

Table 1 shows the dynamics of the rural population in Bjelovar-Bilogora County between 1961 and 2011. For the total population, according to each census, a number for the

3 The influence of the Hungarian traffic policy is visible in the fact that the Bjelovar–Zagreb railway does not go the shortest way. At Sveti Ivan Žabno it turns towards Križevci and goes northward which increases the distance by 10 km.

4 The Bjelovar–Čazma railway was never built because it was impossible to build a junction at Ivanić Grad due to the swampy area along the Sava River (Hečimović, 1979).

5 The author states that in 1970 an equal number of commuters was coming to Koprivnica by railway as by car and bus. In 1977, that ratio was four times greater in favour of cars and buses.

settlements given by the Croatian Bureau of Statistics is considered (Naselja i stanovništvo Republike Hrvatske 1857.–2011.; Popis stanovništva 2011) although to obtain the total population in 2001 and 2011 censuses a different methodology was used than in earlier censuses.[6] The population was highest in 1961, after that, from one census to the next the population fell what resulted in a total population reduction of 47.2% in a 50-year period. In all intercensal periods, the annual rate of population decline was at least 1%. This rate was the highest in the period 1961–1971 (–1.5%), which was, besides the already mentioned isolation from transportation networks, mostly caused by the intense industrialisation process and development of the service sector which both had polycentric characteristics. This process of expansion did not surpass the level of municipal centres, and those centres therefore attracted people from the surrounding rural areas (Vresk, 1989; Feletar, 1994).[7] Municipal centres have become the focal points for common social and economic development in the municipalities. During 30 years period (1961–1991), the monocentrism of the municipal centre was dominant in territorial and administrative development (on a municipal level) (Malić, Stiperski, 1993). During this period the massive migration of its citizens towards Zagreb and abroad began due to the opening of the former Yugoslav borders. This process of urban concentration of secondary and tertiary economic sectors and resettlement in cities with their subsequent negative effects on the demographic dynamics of the county's rural settlements is best illustrated by the fact that between 1961 and 2011 the proportion of the rural population decreased from 82.7% to 61.1%. In 2011, 38.9% of the total population of the county lived in the five urban settlements. Regarding Table 1 it is important to say that the lowest population decline (–9.3%) in the period 1981–1991 was most likely a result of the increased number of people listed as abroad in 1991 what caused fictively slightly reduced depopulation than in other periods.

Table 1. Dynamics of rural population change in Bjelovar-Bilogora County
Preglednica 1: Dinamika spreminjanja podeželskega prebivalstva v bjelovarsko-bilogorski županiji

Census year	Total population	Index 1961=100	Chain index	Share in county population (%)	Rate of average annual change (%)
1961	138,577	100	–	82.7	–
1971	119,495	86.2	86.2	75.7	–1.5
1981	103,858	74.9	86.9	69.4	–1.4
1991	94,148	67.9	90.7	65.4	–1.0
2001	83,843	60.5	89.1	63.0	–1.2
2011	73,226	52.8	87.3	61.1	–1.4

Sources/Vira: Naselja i stanovništvo Republike Hrvatske 1857.–2001.; Popis stanovništva 2011. 1. Stanovništvo prema starosti i spolu po naseljima. Zagreb, Državni zavod za statistiku

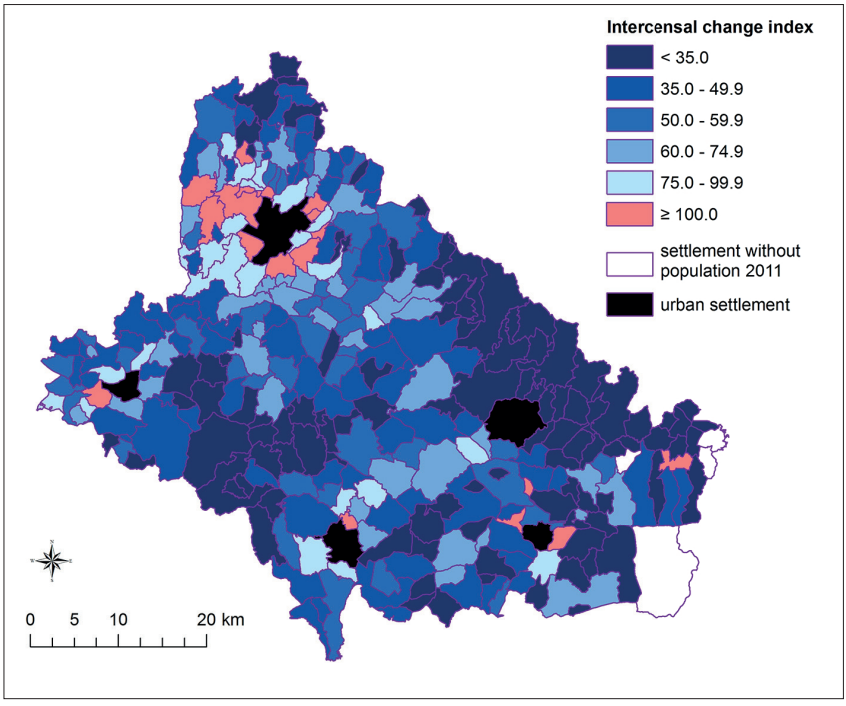
6 More about census methodologies can be found in Pokos (2003), Gelo, Akrap, Čipin (2005) and in methodological explanations of the 2011 census (Popis stanovništva, kućanstava i stanova 2011. godine. Metodološka objašnjenja).

7 According to the previous administrative division (1971–1992), there were five settlements with the status of municipal centres (Bjelovar, Čazma, Daruvar, Garešnica and Grubišno Polje). They are considered as urban in this paper.

4 CHANGES IN THE NUMBER OF RURAL SETTLEMENTS 1961–2011

Of the 318 rural settlements, Figure 4 only shows changes in population for 316 settlements between 1961 and 2011. Because of unspecified changes in the settlement borders, the data for the Trojstveni Markovac and Zvijerci settlements could not be considered as relevant. In fact, both settlements are neighbouring settlements of the county centre of Bjelovar, and, until 1991, had continuous population increases (Trojstveni Markovac from 1948, and Zvijerci from 1931). Between 1991 and 2001 the population of Trojstveni Markovac decreased from 2101 to 1280 and the Zvijerci population from 525 to 62 inhabitants. Since it is unlikely that a larger-scale emigration took place between those two years, it is possible that some parts of those settlements were attached to the Bjelovar settlement between 1991 and 2001, without any public notification of the mentioned changes.[8]

Figure 4: Population change in rural settlements in Bjelovar-Bilogora County (1961–2011)
Slika 4: Spreminjanje prebivalstva v podeželskih naseljih bjelovarsko-bilogorske županije (1961–2011)



8 Unlike some settlements in the county which experienced a large-scale emigration between 1991 and 2001 due to emigration of Serbs, this is not the case with the above-mentioned two settlements. In 1991 only 8% of the total population of Trojstveni Markovac was Serbs and only 4.4% of the population of Zvijerci.

Between 1961 and 2011 four settlements (Bastajski Brđani, Donji Borki, Stara Krivaja and Velika Klisa) lost their entire populations. The settlements are located in the extreme eastern part of the county where the majority of the population in 1991 was Serbs who left those settlements in the autumn of 1991.[9] One-hundred and five settlements experienced a reduction in population of more than 65%. In this group, besides several settlements in the east of the county and around 30 settlements on the southeastern slopes of Bilogora from where many Serbs emigrated in 1991, there were several other settlements on the slopes of Moslavačka gora and on the northwestern slopes of Bilogora where there were no military actions. In these areas the depopulation had been present for a long time. The population was more than halved in 193 settlements (61.1% of rural settlements). Among the other settlements experiencing population decrease only the settlements near urban areas and along the Garešnica–Grubišno Polje road had slightly more favourable circumstances. Of particular concern was the vast central part, between the suburbs of Bjelovar and the other urban centres of Čazma, Garešnica, Daruvar and Grubišno Polje with practically no settlements with increasing populations.[10]

Population growth in that period was recorded in only 18 settlements, i.e. 5.7% of all settlements. These settlements are mostly located near Bjelovar (12 settlements), two settlements are near Čazma and Garešnica while three are located close to Daruvar. The only settlement with a population growth that is not close to any town was Đulovac. This settlement is located on the slopes of Papuk Mountain and is the seat of Đulovac municipality. The population growth of this settlement was a result of the immigration of Croats from Kosovo in 1992, what significantly changed the settlement's ethnic structure.[11] According to these data, it can be concluded that the settlements experiencing the greatest and fastest depopulation were in remote areas and poorly connected to urban centres. The young and mobile population found it impossible to survive in the isolation. This population is hence forced to emigrate to towns or cities (Njegač, 1993). Conversely, the settlements closer to and well connected with cities, especially Bjelovar, the largest city in the county, experienced better demographic indicators such as population growth, stagnation or a smaller population decline.

5 NATURAL DYNAMICS OF THE RURAL POPULATION 1964–2012

To understand the intense process of depopulation and population ageing, which is the main subject of the research, it is necessary to discuss briefly the natural population

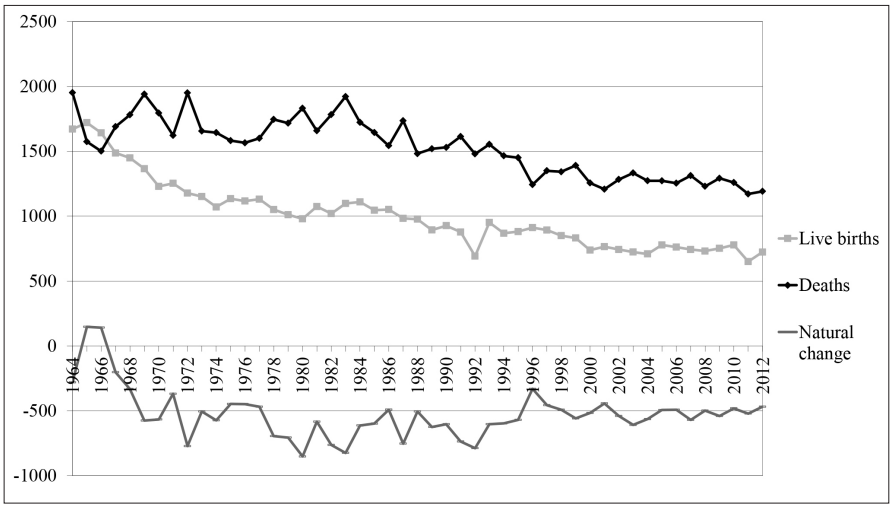
9 In the autumn of 1991, the eastern part of Bjelovar-Bilogora County, more precisely, the western slopes of Papuk Mountain and the southeastern slopes of Bilogora Mountain were occupied by the rebel Serbs and Yugoslav People's Army. The Croatian Army liberated those areas in the autumn and winter of 1991 in military actions *Otkos-10* (Swath-10) and *Orkan '91* (Hurricane-91). Following these operations, many Serbs left this area.

10 In this 'pentangle' a population increase was only noted in two suburbs of Bjelovar, two suburbs of Daruvar and one suburb of Čazma.

11 In 1991, the majority population of Đulovac was Croat (44.1%), while 40.2% was Serb. In 2001 that ratio changed significantly. Croats had an absolute majority of 91.3%, while the proportion of Serbs was 5.6%.

dynamics as one of the main factors accelerating this process. Study of natural population dynamics emerged in 1964. That year marked the beginning of tracking the number of births and deaths at settlement level in Croatia. This work only takes into account the births of mothers with permanent residence in Croatia and the deaths of those who were resident in Croatia.[12] Such methodology has been officially recognised since 1998. Croatia experienced total population decline after both world wars, but natural decline was first recorded in 1991, after which it has been constant until today. The rural population of Bjelovar-Bilogora County has been in continuous natural depopulation since 1967 (Figure 5).

Figure 5: Natural population change in the rural settlements of Bjelovar-Bilogora County (1964–2012) (absolute numbers)
Slika 5: Naravno spreminjanje prebivalstva v podeželskih naseljih bjelovarsko-bilogorske županije (1964–2012) (absolutne številke)



Sources/Vira: Prirodno kretanje stanovništva Republike Hrvatske: tablogrami po naseljima. RZS Zagreb i interna baza DZS

During the entire period 1964–2011, the rural population of Bjelovar-Bilogora County had a very negative natural population change. In that period the number of deaths exceeded the number of births by 24,747 (Table 2). Between 1964 and 1970, the natural population decrease was by far the smallest in absolute terms what is understandable because this period was three years shorter than the other ones. However, the natural decline was the smallest in the relative amount because the natural decline of the population was at its beginning, and in 1965 and 1966 a natural population growth was noted.

12 Until 1998, the children born abroad were also counted into live births in Croatia if their mothers had a residence in Croatia. Persons who died abroad and had a residence in Croatia were also included in the count for persons who died in Croatia until 1998.

If we compare these data with data from Table 1, it is evident that the total population number was most reduced between 1961 and 1971, when the natural population dynamic was relatively favourable. Hence the conclusion that the main cause of the depopulation in the 1960s was a negative net migration and intense emigration from rural areas of the county. The 1960s stand out as the beginning of polarised development. That period was marked by strong development of urban-based activities, such as industry and the service sector which were increasingly attractive to rural populations. The active population of reproductive age was mostly responsible for the deruralisation, as well as the rural-urban migration, which negatively influenced demographic trends in rural settlements even more. The fact that during the 1980s absolute natural decline was significantly worse than in the first decade of the 21st century can be misleading because the relative numbers (rates) show that in the last intercensal period natural decline was more significant than in previous decades due to constant decline of the total rural population. Since the beginning of the 1970s until today, rural areas of the county have an annual natural population decline of more than 500 inhabitants.

The main cause of the natural population decline is a secular decrease in the regional birth rate that even before the 1970s tended to have a low birth rate system or one-child policy, otherwise known as the 'white plague'. Data from the early 20th century show that parts of the county already had a relatively low-level birth rate in Croatian terms.[13] The reason for lower birth rates (fertility) is not a greater proportion of unmarried females, but the intended limiting of the number of children to maintain possession of land through one successor (Gelo, 1987). In the example of Moslavina (at that time including the districts of Čazma, Garešnica and Kutina), Salač (1940) listed the causes of the decline in births noted in this area from the mid-19th century.[14] He stated that birth rates, which in the district of Garešnica fell from 36.2 to 17.9‰ in the period 1904–1940, and migration of the younger population towards smaller and bigger towns, were the most important factors underlying the low natural population growth.

13 In the period 1901–1910, the only districts in Croatia with the natality rate below 30‰ were Bjelovar, Dugo Selo and Sisak, while districts Čazma and Garešnica had a natality rate of 30 to 35‰. A slightly higher natality rate was noted in the Grubišno Polje district (40 to 45‰), while the Daruvar district had a rate over 45‰ (Vuletić, 1964).

14 The author noted five causes of birth drop (planned birth control): 1. The unfavourable religious and moral situation of the population; 2. An understanding and mentality that is against families with numerous children; 3. The early marriage of females; 4. The decline of households and division of land; 5. The constant and systematic propaganda for limiting the number of children (Salač, 1940, p. 63). It is in a way, contradictory statement that the early marriage of female children was prompted by parental wish to join land owned by their children (single children), while on the other hand, he stated that the number of marriages dropped because of marriage in older age. Early marriage is certainly not an underlying reason for limiting the number of children.

Table 2: Natural population change in rural settlements in Bjelovar-Bilogora County
Preglednica 2: Naravno spreminjanje prebivalstva v podeželskih naseljih bjelovarsko-bilogorske županije

Period	Live births	Deaths	Natural change	Rate of average annual change (‰)
1964–1970	10,565	12,234	–1,669	–1.7
1971–1980	11,078	16,914	–5,836	–5.2
1981–1990	10,181	16,541	–6,360	–6.4
1991–2000	8,496	14,146	–5,650	–6.3
2001–2010	7,485	12,717	–5,232	–6.7
Total	47,805	72,552	–24,747	–5.3

Sources/Vira: Prirodno kretanje stanovništva Republike Hrvatske: tablogrami po naseljima. RZS Zagreb i interna baza DZS.

If we compare these data with Table 1 it is clear that the total population had its biggest drop between 1961 and 1971 when the natural population dynamic was relatively favourable. From this, it can be concluded that the main cause of the depopulation in the 1960s was a negative net migration and intense emigration from rural areas of the county. The 1960s stand out as the beginning of growing polarised development due to stronger locating industries and other activities in the cities, which were thus increasingly attractive to the rural population. In the process of deruralisation and rural-urban migration, the active population of reproductive age had the biggest role, increasing the negative demographic trends of the rural settlements. Specific factors behind this accelerated decrease in natality since the 1950s for the entire Croatian territory, which can also be applied to this area, are listed by Wertheimer-Baletić (1996, p. 130):

- Long-term emigration of younger people, which with minor oscillations takes the entire 20th century, and its direct and indirect demographic effects;
- Direct and indirect loss of manpower in the two world wars, especially World War Two, and their effects on the structure of the population by age and sex;
- Model of industrialisation with emphasis on heavy industry and industrial concentration in large urban agglomerations which enhanced the exodus from the countryside and from agriculture;
- Agricultural policy, which did not exist in any of the possible variants (there were no systematic measures to encourage birth nor economic measures that would discourage hiring or going abroad).

6 AGE STRUCTURE OF THE RURAL POPULATION 1961–2011

Among the numerous population structures, structure by age is considered the most important in demographic literature and theory. This structure is very significant for past, current and especially future demographic trends because it describes the future trends for fertility and economic activity (Wertheimer-Baletić, 1999). Any disturbances in the

interrelationship between large and functional age groups may in the long term cause significant difficulties in the natural, and in the overall population trends. Such disturbances also affect economic development, which, among other things, depends on the supply and composition of the workforce. Labour shortages, caused by a reduction in the young and working population contingents, will slow down economic growth and cause new immigration. Together with migration and 'external' or irregular population development conditions (such as wars), the development of the age structure of the population is most affected by natality (birth rate) and mortality. The level of natality/fertility directly determines the influx of the population into childhood and youth and later into fertile, and working-age populations. Low natality rates and a negative natural population change are disturbing factors in population development because they stimulate and accelerate population ageing.

Table 3: Age structure of the rural population in Bjelovar-Bilogora County (1961–2011)
Preglednica 3: Starostna struktura podeželskega prebivalstva bjelovarsko-bilogorske županije (1961–2011)

	≤19		20–59		≥60		
Year*	Total number	%	Total number	%	Total number	%	Ageing index
1961	41,671	30.1	76,766	55.4	19,781	14.3	47.5
1971	34,164	28.6	62,025	51.9	22,914	19.2	67.1
1981	25,536	24.6	56,666	54.6	20,583	19.8	80.6
1991	21,802	23.2	49,267	52.3	21,968	23.3	100.8
2001	20,239	24.1	41,949	50.0	21,360	25.5	105.5
2011	16,306	22.3	38,659	52.8	18,261	24.9	112.0

** The difference in the total population from 1961 to 2001 refers to a population of unknown age. In the 2011 census persons of unknown age are not shown.*
Sources/Viri: Popis stanovništva 1961. Knjiga XI: Pol i starost. Rezultati za naselja. Beograd, Savezni zavod za statistiku, 1965; Popis stanovništva i stanova 1971. Stanovništvo: Pol i starost. Knjiga VII – I deo. Rezultati po naseljima i opštinama. Beograd, Savezni zavod za statistiku, 1973; Popis stanovništva 1981. Tabele po naseljima. Zagreb, Republički zavod za statistiku, 1982; Popis stanovništva 1991. Stanovništvo prema spolu i starosti po naseljima. Dokumentacija 882. Zagreb, Državni zavod za statistiku, 1994; Popis stanovništva 2001. Stanovništvo prema spolu i starosti po naseljima. Zagreb, Državni zavod za statistiku, Statističko izvješće 1167, 2003; Popis stanovništva 2011. 1. Stanovništvo prema starosti i spolu po naseljima. Zagreb, Državni zavod za statistiku.

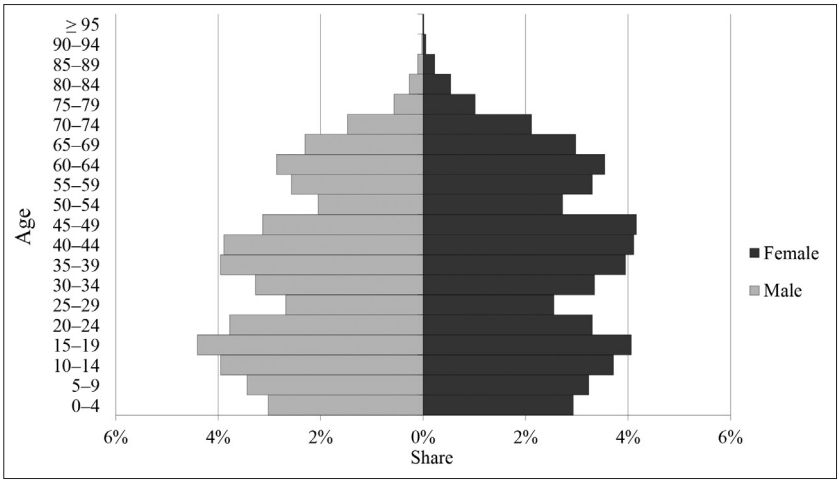
As already stated, the population of the county, due to the long-term reduction in birth rate, was characterised by a natural population decline (the number of deaths was higher than the number of live births). In such conditions, population ageing is an unavoidable process. In the period between 1961 and 2011, there were three indicators of that process: a decline in the youth coefficient (from 30.1 to 22.3), an increase in the old-age coefficient (from 14.3 to 24.9) and an increase in the ageing index (from 47.5 to 112). It is the latter indicator that shows a high degree of demographic ageing, which was present way back in 1961 (in demographic literature, an ageing index of 40 is considered as the value at which demographic ageing starts). The ageing index also shows that since 1991 the rural population of

Bjelovar-Bilogora County has had more old than young people. The first instance when the elderly of Croatia outnumbered the youngs was in 2011. The ageing process is also seen in changes in the major age groups. Between 1961 and 2011, the number of young people (19 years and younger) decreased by 60.9%, the number of mature individuals (20 to 59 years of age) by 49.6%, while the number of elderly (60 years and older) decreased by only 7.7%. In the same period, a reduction in the total population of 47.2% was seen.

Figures 6 and 7 show the age and gender pyramid for the rural population of Bjelovar-Bilogora County. The oldest data available are for 1971. It was not possible to show the gender and age pyramid for 1961 because there was no data by gender for five-year age categories for that year. In 1971, the narrowed child base or lack of children up to 15 years of age was noticed due to decreased fertility after the compensation period for higher natality after World War Two, which lasted in Croatia until 1955 (Gelo, Akrap, Čipin, 2005). In addition to that, the reduced generations 50–54 and 25–29 years can be seen. The former generation (50–54) suffered most casualties in World War Two while they were still in their twenties. This loss was significantly greater in the male population due to their greater participation in military operations. The generation aged 25–29 was born during World War Two when the birth rate was lower; at the time of the 1971 census they were mainly the children of the aforementioned less numerous 50–54 generation.

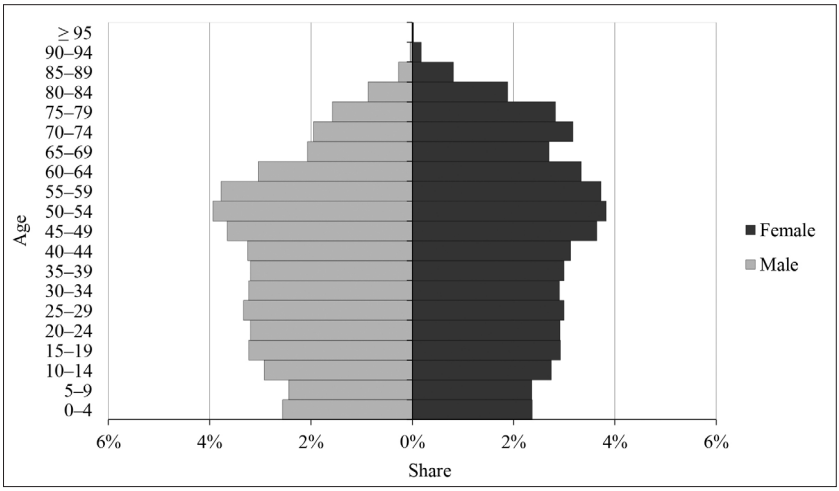
The age and sex pyramid in 2011 does not resemble a pyramid any more. It has a shape of an urn with a very narrow base (children) and the largest generational categories being 50–54 and 55–59 years. Those generations were born during the 'baby boom' period after World War Two.

Figure 6: Age and sex structure of the rural population in Bjelovar-Bilogora County (1971)
Slika 6: Starostna in spolna struktura podeželskega prebivalstva bjelovarsko-bilogorske županije (1971)



Source/Vir: Popis stanovništva i stanova 1971. Stanovništvo: Pol i starost. Knjiga VII – I deo. Rezultati po naseljima i opštinama. Beograd, Savezni zavod za statistiku, 1973

Figure 7: Age and sex structure of the rural population in Bjelovar-Bilogora County (2011)
Slika 7: Starostna in spolna struktura podeželskega prebivalstva bjelovarsko-bilogorske županije (2011)



Source/Vir: Popis stanovništva 2011. 1. Stanovništvo prema starosti i spolu po naseljima. Zagreb, Državni zavod za statistiku

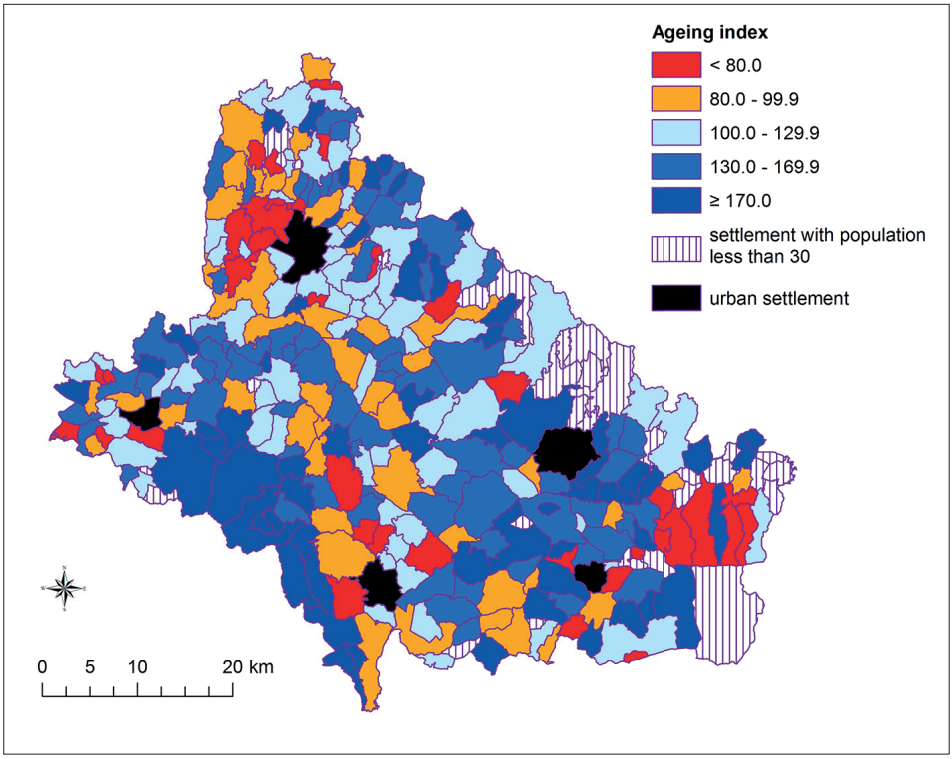
In both years, but especially in 2011, there is a disproportionate female population in older age groups. This is a result of the intensive process of ageing, and the generally accepted fact that in developed countries, women have a longer life span.

7 AGE STRUCTURE OF THE POPULATION IN RURAL SETTLEMENTS IN 2011

Figure 8 shows the rural settlements with the corresponding category from the 2011 ageing index (excluding the 31 settlements with fewer than 30 residents that could cause statistical randomness and greatly hinder conclusions[15]). Only 80 settlements (25.1% of the total number of settlements) in 2011 still had more young than old people (Figure 8), mostly the settlements near urban centres. Several of those settlements are located on the slopes of Papuk Mountain and have experienced the immigration of Croats from Kosovo in last 20 years (Pokos, 2000b).

15 For example, the Mali Miletinac settlement with a total population of 22 in 2011 where heavy depopulation was present, had eight inhabitants in the age category of 19 and less, while there were three people aged 60 and over. According to that, the ageing index would be 37.5 which would put this settlement among those with the youngest population in Bjelovar-Bilogora County. On the other hand, the Mala Ciglena settlement had a population of 17 in 2011. In that settlement there was one person in the category 19 and less, while there were eight people in 60 years plus age category. According to that, the ageing index would be 800, which would put this settlement among those with the oldest population.

Figure 8. Ageing index of rural settlements in Bjelovar-Bilogora County (2011)
Slika 8: Indeks staranja podeželskega prebivalstva v bjelovarsko-bilogorski županiji (2011)



In 2011, only six settlements in Bjelovar-Bilogora County had an ageing index equal to or less than 40, which is the threshold between the younger and older population.[16] Those settlements were Mali Bastaji, Koreničani, Puklica, Veliki Bastaji, Grabik and Mali Pašijan. As in Đulovac, the Croats from Kosovo immigrated to Veliki Bastaji in 1992. Forty-four settlements (13.8% of the total) had double the number of old people compared to young. Most of those settlements are located on the slopes of Moslavačka gora (between Čazma and Garešnica) and near Daruvar and Grubišno Polje. Among these settlements it is important to mention Gornja Vrijeska, where there was only one young resident, while there were 21 elderly inhabitants (ageing index 2100), and Bijela with two young and 31 elderly inhabitants (ageing index 1550)[17].

16 The population ageing starts when the value of the ageing index exceeds 40.

17 For the comparison, the ageing index in Croatia in 2011 was 115.

8 CONCLUSION

The rural population of Bjelovar-Bilogora County was marked by depopulation in all intercensal periods between 1961 and 2011. During this period, the total population almost halved. Positive demographic dynamics were recorded in only 18 of the 316 settlements. The total population drop between 1961 and 2011 was 65,351. Natural depopulation accounted for about 25,000 people (the exact number is unknown because there were no data for the period 1961–1963) which means that the negative migration balance was about 45,000 inhabitants. The long-term processes of natural and emigration depopulation significantly disturbed the age structure of the population which will have long-term consequences for reproduction and the general socio-economic development of the region. The population will continue to age, increasing mortality rates. The conditions necessary for increasing natality or fertility are not present.

The most difficult situation is in peripheral, hilly parts of the county where many settlements have a minimal number of inhabitants and the number of old people largely exceeds the number of young population. It is also very disadvantageous that in the central part of the county almost all settlements depopulated in the period 1961–2011. The lack of a young, vital population in the lowlands, which is an agriculturally valuable area, will lead many settlements to the brink of extinction. Those settlements are traditionally economically oriented, have very simple social structures and inadequate accessibility by road and rail. In contrast to these settlements with negative demographic dynamics, there is only a small number of settlements with positive demographic dynamics determined by a favourable position, more complex socio-economic structures and higher levels of socio-economic transformation.

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DEPOPULACIJA IN STARANJE PREBIVALSTVA NA PODEŽELSKIH OBMOČJIH BJELOVARSKO-BILOGORSKE ŽUPANIJE (1961–2011)

Povzetek

Bjelovarsko-bilogorska županija leži v osrednjem delu hrvaškega panonsko-subpanonskega prostora. Nadmorska višina v večjem delu županije ne presega 200 m, nekoliko višja je samo v njenih robnih delih. Čeprav ima za hrvaške razmere idealne fizičnogeografske razmere, so za to županijo v zadnjih 50 letih značilna zelo neugodna demografska gibanja, še posebej neugodne so demografske razmere v podeželskem delu županije. Tako se je skupno število prebivalcev podeželskih naselij v županiji med leti 1961 in 2011 zmanjšalo s 138.361 na komaj 73.709 (46,7 %). Posebej značilno je, da se je število prebivalcev v podeželskih naseljih začelo zmanjševati že v 50. letih prejšnjega stoletja, še intenzivnejše upadanje pa je bilo med letoma 1961 in 1971, ko se je število prebivalcev zmanjšalo za 13,6 %. Tudi v vseh poznejših obdobjih med popisi prebivalstva je zabeleženo upadanje števila prebivalcev, vendar nekoliko počasnejše.

Podatke o naravnem gibanju prebivalstva po naseljih lahko spremljamo šele od leta 1964 in tako pridemo do podatka, da se je v podeželskih naseljih županije že v tem začetnem letu (1964) število prebivalcev zmanjšalo za 276 (2,1 ‰), kar pomeni, da se je na nivoju celotne Hrvaške ravno tu najprej začel proces naravne depopulacije. Do leta 2011 se je naravno upadanje števila prebivalcev pospešilo na 6,1 ‰, oziroma, tega leta se je rodilo 451 živorojenih otrok manj kot je umrlo prebivalcev.

Neprestano 50-letno naravno upadanje prebivalstva je poleg negativne migracijske bilance razlog intenzivnega staranja prebivalstva podeželskih naselij v županiji. Indeks staranja se je med letoma 1961 in 2011 povečal s 47,5 na 112,2, tako da je imelo leta 2011 le še nekaj naselij več mladih kot starejših prebivalcev. Z nadaljevanjem takšnih neugodnih demografskih trendov bo v naslednjih desetletjih prišlo še do nadaljnjega staranja prebivalstva in stopnjevanja naravne depopulacije.

(Prevedel K. Natek)

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