CAPACities 5

BELA KRAJINA – SUSTAINABILITY IN A KARST LANDSCAPE

Daniela Ribeiro

CAPACities 5

BELA KRAJINA – SUSTAINABILITY IN A KARST LANDSCAPE

Daniela Ribeiro

ZALOŽBA
Z R C

CAPACities 5

BELA KRAJINA – SUSTAINABILITY IN A KARST LANDSCAPE

Daniela Ribeiro

LJUBLJANA 2020

CAPACities 5
BELA KRAJINA – SUSTAINABILITY IN A KARST LANDSCAPE
Daniela Ribeiro

Editors: Nika Razpotnik Visković, Mateja Šmid Hribar
Series Editors: Janez Nared, Drago Perko
Reviewers: Andraž Čarni, Matija Zorn
Cartographers: Daniela Ribeiro, Manca Volk Bahun
Photographers: Daniela Ribeiro, Jure Tičar
Translation of abstract: Živa Malovrh
Translation of preface: Deks d. o. o.
Proofreading: Alexander Jordan

Issued by: ZRC SAZU, Geografski inštitut Antona Melika
For the issuer: Matija Zorn
Published by: Založba ZRC
For the publisher: Oto Luthar
Editor-in-chief: Aleš Pogačnik

Cover design: Jerneja Fridl
Cover photographies: Daniela Ribeiro

DTP: SYNCOMP d. o. o., Ljubljana
Printed by: Collegium Graphicum
Print run: 250 copies
First edition, first printing.

DOI: https://doi.org/10.3986/9789610504627

arrs
JAVNA AGENCIJA ZA RAZISKOVALNO DEJAVNOST
REPUBLIKE SLOVENIJE

The CAPACities book series is being produced as a part of the research program, Geography of Slovenia (P6-0101), funded by the Slovenian Research Agency. The research is also a result of a postdoctoral project (Z7-1885) also funded by the Slovenian Research Agency.

CIP – Kataložni zapis o publikaciji
Narodna in univerzitetna knjižnica, Ljubljana

911.2:551.44(497.4Bela krajina)
711.14(497.4Bela krajina)
502.131.1(497.4Bela krajina)

RIBEIRO, Daniela
Bela krajina – sustainability in a karst landscape / Daniela Ribeiro ; [cartographers Daniela Ribeiro, Manca Volk Bahun ; photographers Daniela Ribeiro, Jure Tičar ; translation of abstract Živa Malovrh, translation of preface Deks]. – 1st ed., 1st printing. – Ljubljana : Založba ZRC, 2020. – (Knjižna zbirka Capacities, ISSN 2232-2477 ; 5)

ISBN 978-961-05-0461-0
COBISS.SI-ID 22518787

COBISS.SI -ID= 22523907
ISBN 978-961-05-0462-7 (pdf)

CAPACities 5

BELA KRAJINA – SUSTAINABILITY IN A KARST LANDSCAPE

Daniela Ribeiro

UDC: 913:551.44(497.434Bela krajina)
711.14(497.434Bela krajina)
502.131.1(497.434Bela krajina)
COBISS: 2.01

ABSTRACT

Bela krajina – Sustainability in a karst landscape

Sustainable development in karst areas should be adapted to its specificities and take into account its vulnerability. Since the assessment of the development potential and management of karst areas is of great importance in Slovenia, the author analysed the impact of landscape features on the land use and sustainable development in Bela krajina, as a study region. The monograph is divided into three main parts, essentially based on the approaches used to analyse the selected karst landscape. Firstly, an assessment of the degree of human disturbance to the karst environment in Bela krajina was done, using an environmental index specific for karst areas, referred to as the 'Karst Disturbance Index'. The Karst Disturbance Index classified the degree of disturbance in Bela krajina as low. In the second part, two case studies were selected (the settlements of Adlešiči and Bojanci) for an in-depth study of landscape changes, through land use changes, over the previous 200 years. The results of these analyses confirmed the land abandonment and overgrowth of agricultural land in both case studies, however at different rates. Socio-economic aspects were found to be the most important drivers of land use changes in these case studies. In the third part, quantitative analysis (through the use of sustainable development indicators) and qualitative analysis (through structured interviews) of the landscape features for sustainable development was performed. By means of a comparative approach the reasons for the differences in landscape structure and development in Bela krajina were discussed. According to the quantitative analysis, Semič is the most sustainably developed municipality, whilst Črnomelj was identified as the least sustainably developed municipality in the study region. The results from qualitative analysis of landscape features using interviews didn't show many differences among the municipalities. However, some differences among different stakeholders were perceived. The ways in which the karst landscape influences local development mentioned by local stakeholders were that: it hampers agriculture, hampers the building of houses and other infrastructure, and it is vulnerable to pollution. Karst landscape features affect sustainable development positively and negatively, according to local stakeholders. The positive effects were mainly connected with tourism, and the negative effects were mainly connected with hampered agriculture. Thus karst landscape features cannot only be seen as limiting factors, but also as having their own development potential.

KEY WORDS

karst landscapes, sustainable development, land use, Bela krajina, Slovenia

CAPACities 5
BELA KRAJINA – TRAJNOST V KRAŠKI POKRAJINI
Daniela Ribeiro

UDK: 913:551.44(497.434Bela krajina)
711.14(497.434Bela krajina)
502.131.1(497.434Bela krajina)
COBISS: 2.01

IZVLEČEK
Trajnostni razvoj na kraških območjih bi moral biti prilagojen posebnostim te pokrajine, posebej njeni ranljivosti. Ker je pravilno vrednotenje razvojnega potenciala in upravljanje s kraškimi območji zelo pomembno za Slovenijo, smo na primeru Bele krajine analizirali vpliv pokrajinskih prvin na rabo zemljišč in trajnostni razvoj. Raziskava je razdeljena na tri sklope, ki hkrati predstavljajo tri pristope k preučevanju pokrajine. Najprej smo s posebnim indeksom za kraške pokrajine ocenili stopnjo človekovega vpliva na kraško pokrajino (indeks obremenjenosti kraškega okolja zaradi vpliva človeka). Na njegovi podlagi smo Belo krajino opredelili kot nekoliko človeško obremenjeno, zato smo ocenili, da je raven obremenjenosti v Beli krajini nizka. V drugem sklopu smo preučili dve študiji primerov (naselji Adlešiči in Bojanci), kjer smo podrobno analizirali pokrajinske spremembe s poudarkom na rabi tal v zadnjih dveh stoletjih. Rezultati so potrdili opuščanje obdelovalnih zemljišč in zaraščanje pokrajine. Na preučevanih primerih se je pokazalo, da so najpomembnejša gonila sprememb rabe zemljišč družbeno-gospodarski vzroki. V tretjem sklopu smo opravili kvantitativno (z uporabo kazalnikov trajnostnega razvoja) in kvalitativno analizo (s strukturiranimi intervjuji) pokrajinskih prvin za trajnostni razvoj. S primerjalnim pristopom smo razpravljali o razlogih za razlike v pokrajinski strukturi in razvoju Bele krajine. Rezultati kvantitativne analize kažejo, da je Semič najbolj trajnostno razvita občina, medtem ko je bil Črnomelj opredeljen kot najmanj trajnostno razvita občina. Rezultati kvalitativne analize pokrajinskih prvin niso pokazali večjih razlik med občinami, a smo zaznali določene razlike med različnimi skupinami deležnikov. Načini, kako kraškost vpliva na lokalni razvoj so: zaviranje kmetijstva, zaviranje gradnje hiš in infrastrukture ter ranljivost na onesnaževanje. Lokalni deležniki so izpostavili, da kraški pojavi na trajnostni razvoj lahko vplivajo pozitivno ali negativno. Pozitivni so večinoma povezani s turizmom, negativni pa s kmetijstvom. Delo sklenemo s pozitivno ugotovitvijo, da kraškost ni le omejitveni dejavnik, temveč ima tudi razvojni potencial.

KLJUČNE BESEDE
kraške pokrajine, trajnosti razvoj, raba zemljišč, Bela krajina, Slovenija

CONTENT

PREFACE

During these times of accelerated and omnipresent globalisation, regionalisation processes or regional development concepts are also gaining strength as expected counterweights. These concepts derive from the modern versions of endogenous landscape development potentials of greater sustainable importance. Due to various potentials and limitations in terms of natural geography, ecosystems, social geography, economy, infrastructure, and other aspects, landscapes in which a certain landscape feature heavily determines the sustainable development and its 'survival' potential, find themselves in a special situation from the perspective of sustainable development. The author selected Bela krajina, a geographically marginal Slovenian karst landscape, as a sample model region for an empirical analysis of sustainable karst landscape capacities. She rightly posed the key research question: Can specific, endogenously important landscape features, and their own developmental and protective potentials or limitations, play a key positive or negative role in establishing sustainable regional development of the predominantly karst region of Bela krajina and its geographical areas? In evaluating the developmental and protective opportunities in shallow- or low-karst landscapes, such as Bela krajina, it needs to be additionally underlined that this type of karst landscape is exceptionally sensitive in terms of water ecology and vulnerable to human activity. In addition, it should be highlighted that due to its modest natural resources, dispersed settlements, geographical remoteness from major centres, poorly developed infrastructure, and comparatively low level of education, the marginal border region of Bela krajina has not experienced any accelerated regional development even after Slovenia's independence.

Through detailed studies of Bela krajina, including field research, in which she used various methodological approaches at various territorial levels of the selected landscape, the author convincingly explored the impact of key landscape features on land use and (un)sustainable regional development of karst landscapes. Initially, she innovatively modified and improved the index of human disturbance to karst landscapes in the pilot areas comprising the Bela krajina municipalities of Črnomelj, Metlika, and Semič. In order to determine the historically changing roles of landscape features (especially karst ones), changes in land use over the past two hundred years were analysed in detail in the settlements of Adlešiči and Bojanci. The analysis of land use changes and trends from the period of the Franciscan Cadaster onwards was complemented with detailed field mapping, which confirmed gradual abandonment of intensive agricultural land use, with highly accelerated overgrowing and afforestation of selected karst geographical areas around Adlešiči and Bojanci. The author established that a slight positive expansion of gardens could be observed in 2012, which most likely already indicates the desired orientation to greater self-sufficiency in food.

Special attention should be paid to the important research finding that the abandonment of cultivated land was fundamentally influenced by socioeconomic conditions (especially changes in the population and opportunities to find employment outside of farming) and natural karst landscape factors, whereas cultural and ethnographic factors (e.g., a different ethnic composition of the residents of Bojanci) were of secondary or marginal importance.

Based on a set of selected quantitative indicators of sustainable development and appropriate qualitative interpretation of structured interviews conducted with key stakeholder groups (i.e., farmers, resident non-farmers, professionals of nature protection, tourism professionals, and local government representatives), an original quantitative and qualitative evaluation of landscape features was performed at regional and municipal levels (Črnomelj, Metlika, and Semič). The statistical deficiency of the relatively small number of interviews conducted (i.e., thirty-two) is partially ameliorated by the representative selection of the respondents, although the results of the synthetic quantitative evaluation are somewhat surprising. Specifically, the quantitative measurements showed that the Municipality of Semič was the most sustainably developed municipality in Bela krajina, whereas the Municipality of Črnomelj turned out to be the least sustainably developed.

The results of the qualitative analysis of landscape features using structured interviews did not show any significant differences between the municipalities, but certain differences were established between the answers of various stakeholder groups. Thus, most farmers considered the karst character of the landscape to be an exceptionally important landscape features due to its negative impact on land use selection; a more pronounced karst character of the surface makes farming more expensive and more difficult. Furthermore, due to the rocky karst surface and shallow soil, farming yields are smaller, irrigation potential is modest, and the sensitivity of water ecology to agricultural pollution is substantial, including increased exposure to fires. Attention should also be drawn to the increasing view among tourism employees that Bela krajina's karst character and certain attractive karst features are tourist attractions, representing the potential for the development of tourism both currently and, increasingly in the future. The author's concern over the lack of communication and distrust among various local stakeholders is well-founded in this regard.

The author explicitly underlines that land use and the overall sustainable regional development in karst areas must be adapted to the specific karst features at the regional, municipal, and micro-local levels, which particularly applies to the exceptional water-ecology vulnerability of shallow karst areas. The development of farming and tourism based on effective and sustainable approaches adapted to karst features is key for the sustainable regional development of Bela krajina. However, the author argues that its economy cannot be built on tourism and natural beauty, or farming alone. Hence, the establishment and development of small enterprises is extremely important for the region's development, and an environmentally friendly modernisation of the road to Novo mesto (including a road tunnel through the Gorjanci Mountains) is also vital for entrepreneurship, tourism, and commuting.

Due to karst features and minimal impacts on vulnerable karst water sources, both organic farming and eco-tourism are potentially highly desirable and at the same time feasible in the region. Therefore, the author suggests that an additional set of indicators that specifically assess the limitations or developmental potential of karst features for land use and sustainable local and regional development be used for a comprehensive developmental and protective evaluation of the development potential and management of karst regions. In terms of contribution to research methodology, the author's innovative proposal for modifying the overall index of human disturbance to the karst environment (with a total of eighteen karst landscape indicators) is worthy of special mention, including her suggestion to slightly adapt certain indicators (e.g., environmental impact indicators) to the specific features of the karst area studied.

In terms of Bela krajina's development, karst features are both an advantage and a limitation to development and settlement, which depend on its (un)sustainable orientation and on the adaptability of land use and the economy to its karst character.

dr. Dušan Plut

1 Introduction

Understanding the relationship between natural and human factors that have shaped landscapes is crucial for understanding sustainability. This is even more important when discussing karst landscapes, considering the vulnerability of karst systems. Karst landscapes are particularly vulnerable to overuse and misuse due to the nature of the karst hydrological system, and once 'damaged' can be extremely difficult to 'repair'. Recognising this problem, the European Union has made efforts to protect the quality and quantity of groundwater resources (Vulnerability and Risk… 2003); the IUCN has also formulated guidelines for the protection of caves and karst (Watson et al. 1997), and for sustainable tourism in protected areas (Eagles, McCool and Haynes 2002).

Karst landscapes in Slovenia cover approximately 8800 km^2 or over 44% of the country's area. Karst landscapes are characterised by stony surfaces with dolines, collapse dolines, solution valleys, poljes, corrosion plains, and dry and blind valleys (Gams 2003). According to the geological, hydrological and morphological conditions, the Slovenian karst can be divided into: the Alpine karst, the Dinaric karst and isolated karst (Habič 1969; Gams 2003).

The Dinaric karst is the largest karst area in Slovenia, representing around two thirds of the whole karst area in the country (Gams 2003); with Bela krajina as our study region being part of it. Bela krajina is located in the south-eastern part of Slovenia, along the Slovenian-Croatian border, covering 595 km^2. The use of space, patterning and economic structure are influenced by the interlacing karst and Pannonian geographical characteristics (Plut 2008). Landscape features and scenic vistas are common across the region. However, due to modest natural resources, dispersed settlements, geographic distance from larger urban centres, badly developed infrastructure and relatively low education levels, there is a lack of even regional development (Plut 2008).

The selection of karst landscapes for this study was driven by its environmental sensitivity and vulnerability, recognisable important features at a national level, cultural and symbolic landscape identity, and natural characteristics with distinctive features limiting and directing human activities. Various studies have pointed out that the karstification of Slovenian landscapes is a distinct limiting factor for agriculture (e.g., Gams, Lovrenčak and Ingolič 1971; Kladnik and Senegačnik 1983; Kladnik 1998; Cunder 2001; Ciglič et al. 2012). Ciglič et al. (2012) identified the following limiting factors as a result of karstification: 1) terrain features: fine terrain dissection, primarily with dolines and similar corrosion features; 2) lack of surface water due to rapid drainage of water through porous karst rock, increasing the frequency of droughts and fire hazards; 3) discontinuous, rocky, shallow, loamy soil, of uneven depth and with frequent protruding rocky outcrops and rare deeper pockets; and, 4) small plots of agricultural land that hamper mechanical cultivation and the adaption of the land use structure to modern agriculture.

With this research we aim to identify and study the influence of landscape features on the sustainable development of Bela krajina, where karst landscapes prevail. In order to better understand the influence of landscape features on land use and the sustainable development of Bela krajina, an assessment of the disturbance of Bela krajina's karst landscapes was done first, followed by the analyses of land use changes and an examination of regional sustainable development.

This monograph is composed of seven chapters. The following chapter (chapter 2), presents a theoretical background with a review of the literature on sustainable development, common approaches to measuring sustainable development, the role of landscape in sustainable development, effects of policies in land use and development, the importance of public participation in sustainable development, and the relationship between karst features and sustainable development. The methodological framework is also included in chapter 2, describing data collection and preparation, and the methods utilised. Chapter 3 describes the results obtained from different approaches of the study of the karst landscape. Chapter 4 presents discussions and conclusions, providing a proposed set of indicators to measure the sustainable development of karst regions, as well as suggestions for further research. Chapter 5 contains a reference section, which is followed by a list of figures in chapter 6, and finally a list of tables in chapter 7.

2 Theoretical background and methodology

2.1 Theoretical background

Our sustainable future is threatened by increasing pressures on natural resources as well as on the natural and cultural assets of the landscape, as a result of the vicious circle of population growth and consumption (Naveh 2001). In the current cultural evolutionary trends, the only options are between the further evolution of suitable living, or its further exponential degradation towards extinction (Laszlo 1994). Therefore, sustainability and/or sustainable development is not a choice but rather a necessity, as claimed by Wu (2013).

In 1713, Hans Carl von Carlowitz published the book *Silvicultura oeconomica*, which encouraged the conservation, growth and use of wood in a continuing, stable and sustained manner (Schmithüsen 2013). This was probably the first time that the idea of sustainability was used; it was at least the first time that the term sustainability (in German, *Nachhaltigkeit*) was documented, and thus the concept of sustainability was incorporated in forestry management. For the last four decades, sustainability has been under the spotlight of scholars and politicians, however, as pointed out by Forman (1995) a truly sustainable condition may be impossible, therefore it is better to consider sustainability as a direction or trajectory. Along the same line of thought, Munro (1995, 34) claimed that sustainability *»is a continuous or iterative process, through and throughout which experience in managing complex systems is accumulated, assessed, and applied«*.

The term 'sustainable development' is very popular, as well as being vague and ambiguous (Kazana and Kazaklis 2009). It was first promoted by the International Union for Conservation of Nature (IUCN), the United Nations Environment Programme (UNEP) and the World Wildlife Fund (WWF), through the publication of the World Conservation Strategy in 1980 (1980; hereinafter, the Strategy). The Strategy refers to the sustainable utilisation of natural resources and indicates the main requirements for sustainable development. It was popularised by Our Common Future, the report of the World Commission on Environment and Development (WCED), also titled the Brundtland report, after its chairman Gro Harlem Brundtland (Our Common Future 1987). The Brundtland report defined sustainable development as *»development that meets the needs of the present without compromising the ability of future generations to meet their own needs«* (Our Common Future 1987, 41). This report also asserts that *»economics and ecology must be completely integrated in decision making and law making processes not just to protect the environment, but also to protect and promote development«* (Our Common Future 1987, 36). The concept of sustainable development has been further elaborated on in two major international documents, the successor to the World Conservation Strategy, Caring for the Earth: A Strategy for Sustainable Living (Caring for the earth… 1991), and in Agenda 21 (Earth Summit… 1992), the action plan adopted by the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992.

As the definition of sustainable development given by WCED (Our Common Future 1987) appeared to be too ambiguous, in 1991 the IUCN-UNEP-WWF defined sustainable development in Caring for the Earth: A Strategy for Sustainable Living (1991, 10) as *»improving the quality of human life while living within the carrying capacity of supporting ecosystems«*. Agenda 21 reflects the global consensus and political commitment at the highest level on development and environment cooperation (Earth Summit… 1992). The United Nations Conference on Environment and Development held in Rio de Janeiro was a significant milestone that set a new agenda for sustainable development (titled the Agenda 21). Since then, representatives of the world's nations have met at several major conferences under the auspices of the United Nations and have reaffirmed their commitment to sustainable development (World Summit… 2002). In 2015, Heads of State and Government, and High Representatives met in New York. They adopted the 2030 Agenda for Sustainable Development and its global Sustainable Development Goals (hereinafter, the 2030 Agenda) and committed to achieving sustainable develop-

ment in its three pillars – economic, social and environmental – in a balanced and integrated manner. These goals will guide decisions for the next 15 years. The 2030 Agenda acknowledges the importance of regional and subregional dimensions, regional economic integration, and interconnectivity in sustainable development. The 2030 Agenda also recognises that social and economic development depends on the sustainable management of natural resources (Transforming Our World 2015).

A nested sustainability model, considering society and economy as a subsystem, nested in the environment seems an adequate basis for approaching sustainability (Figure 1). The nested model proposes to conceptualize the three pillars: environment, society and economy, hierarchically.

The nested sustainability shows that the economy exists within the society, and both the economy and society exist within the environment. As all parts of the economy require interaction among people, the economy lies entirely within the society. Nonetheless, the society is beyond just the economy. There are many important aspects of the society that are not primarily based on exchanging goods and services (e.g., relationships, religion, and ethics). In turn, the society exists entirely within the environment, as our basic requirements (air, food, and water) come from the environment. Finally, the environment encircles the society (Hart 1999). In the earliest periods of human history, the environment shaped society to a great extent. Contemporary human activities are reshaping the environment at an ever-increasing rate (Cooper et al. 2018). However, as people need food, water and air to survive, society can never be greater than the environment (Hart 1999). In any case, the dimensions or proportions of the circles in Figure 1 are not intended to weigh the importance of any of the three pillars of sustainable development.

Notwithstanding, the word 'sustainable' is often used to refer to the processes of economic and social change. After all, the integration of the environment and development is absolutely required. No less diverse than definitions of 'sustainable' are the various notions of development. The conventionally understood term of development requires continuous economic growth (Goulet 1995) which can conflict with the principles of sustainability. In this work we use the term development as a synonym of sustainable development, which takes into account social equity, the quality of the living environment, and developed networks of economic activities and services. At this point, the question »How can we measure the sustainable development of a country, region or landscape?« arises.

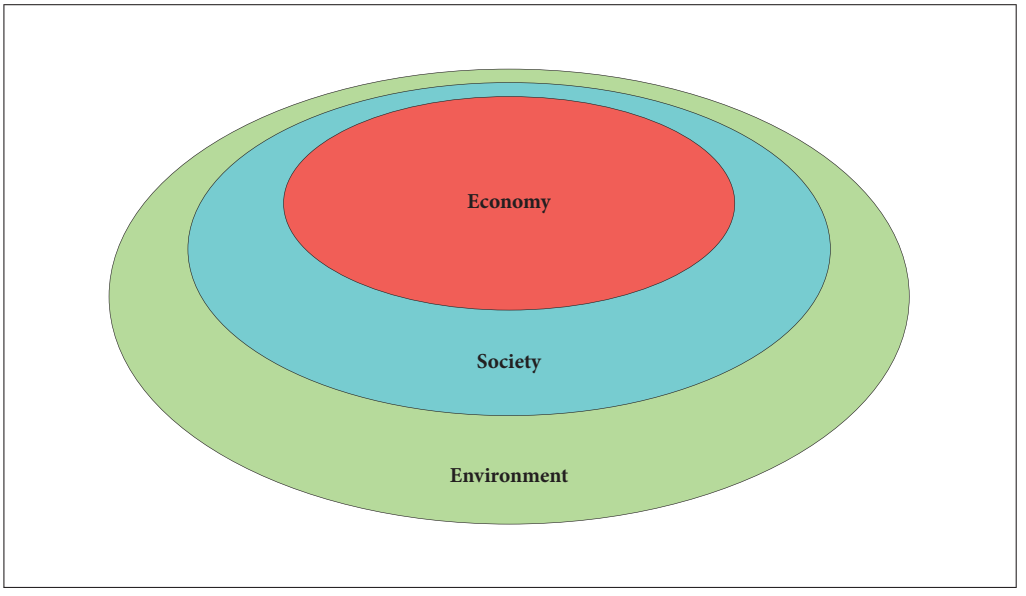


Figure 1: Nested sustainability model (adapted from Giddings, Hopwood and O'Brien 2002).

Many studies (e.g., headline indicators of the Europe 2020 strategy (Europe 2020… 2010)) have developed sets of quantitative indicators as measurements of sustainable development on different scales; however environmental indicators are usually scarce or even absent (e.g., Zuleeg 2010). This could be due to a lack of data on environmental indicators or the continuous disregard for the environmental dimension in sustainable development assessments. While social and economic indicators are bound to administrative units such as the municipality, region or country, environmental indicators usually are not. Thus, another challenge regarding the data availability of environmental indicators is the determination of their geographical area, i.e. nature goes beyond administrative borders, as do environmental problems such as pollution, water management or natural disasters. This may hamper the collection of environmental data to be included in sustainable development assessment studies.

As we believe that different areas might present different sustainable factors, a specific study of karst areas should be done through the employment of a specific set of sustainable development indicators (see subchapter 4.2). Hence, with this work we also aim to create a set of indicators to measure and monitor sustainable development in karst areas, which reflect the interface between social, economic and environmental domains, taking into account the karst specificities of the region.

2.1.1 Approaches for measuring sustainable development

2.1.1.1 Worldwide

The most popular approach to measure sustainable development is through the usage of sustainable development indicators. The overall goal of the creation of sustainable development indicators from environmental and socio-economic data is to inform policy makers and the general public about implementing sustainability actions. A major advantage is that it provides an overall picture of the state or performance of a system of interest in a simple and understandable way (Wu and Wu 2012). In this way, the set of indicators describing the development of a country, region, or landscape, is done by means of a number of representative elements which simplify the complexity of a country, region or landscape, without taking it out of context (Deelstra 1995). However, as pointed out by Wu and Wu (2012), sustainable development indicators are not always objective, precise or certain. To some extent sustainable development indicators are subjective because of the nature of the indicators themselves, and also due to the choice of specific indicators. Therefore, all indicators have a degree of uncertainty that emerges from the methods of collection and data analysis, and the unpredictable nature of the human-environmental systems (Wu and Wu 2012). As Meadows (1998, 2) wrote: »*We try to measure what we value. We come to value what we measure*«. Consequently, different studies might use different indicators given the difference of perspectives or paradigms, or being more appropriate than others for a particular region (Wu and Wu 2012). A very important aspect in the selection of indicators is that indicators are usually linked to data availability and scale (Wascher 2004).

The major development of sustainability indicators started after the Earth Summit in 1992, when the important role that indicators could play in helping countries make informed decisions concerning sustainable development was recognised (Indicators of Sustainable Development… 2007). At the present time, indicators of sustainable development suggested by various groups are very diversified (Carpenter 1995) and have been used at global, national, and local scales (Wu and Wu 2012). At the international level, there are many organisations contributing to the development of sustainability indicators, such as the Organisation for Economic Co-operation and Development (OECD), the United Nations Commission on Sustainable Development (UNCSD) and the Balaton Group. Wu and Wu (2012) have listed five types of indicator frameworks widely recognised in the literature: 1) Pressure-state-response (PSR) frameworks, 2) Theme-based frameworks, 3) Capital-based frameworks, 4) Integrated accounting frameworks and 5) Bossel's orientor framework. The Indicators of Sustainable Development (2007) described different approaches for the development of sustainable development indicators: 1) Driving force-state-response frameworks, 2) Issue- or theme-based frameworks, 3) Capital frameworks, 4)

Accounting frameworks and 5) Aggregated indicators. The PSR framework was an eminent early indicator framework, and was adapted by several organisations. It is based on a causality concept in which human activities exercise pressures on the environment and change its 'state' (quality and the quantity of natural resources). Society responds to these changes through policies ('responses') (OECD core set… 1993; Figure 2).

The Driving force-State-Response (DSR) framework, a successor to PSR, published by the UNCSD in 1996, is the most widely recognised for the selection of indicators (Wu and Wu 2012). An expanded version of the DSR framework is the Driving force-Pressure-State-Impact-Response (DPSIR) framework (Wu and Wu 2012) adopted by the European Environment Agency (EEA) acting as an integrated approach for reporting.

The DPSIR framework attempts to distinguish the cause of the pressure on the environment, human activity mainly through production and consumption, from the pressure itself. A differentiation is made between the state of the environment, of a particular resource, and the impact it has on other resources within the environment or other dimensions, however the identification of indicators in these categories is not always straightforward. This framework implicitly emphasises the environmental dimension of sustainable development (Geniaux et al. 2009). Variations of the PSR frameworks continue to be used in more environmentally orientated indicator sets, however, recent revisions of the UNCSD indicators have discontinued the DSR framework due to the following identified issues: it was not suitable to address the complex linkages among issues; the classification of indicators into 'driving force', 'state' or 'response' was often ambiguous; there were uncertainties over causal linkages; and it did not adequately emphasise the relationship between the indicators and policy issues (Indicators of Sustainable Development… 2007).

The Theme- or issue-based frameworks are based in a more flexible structure, organising the indicators in the dimensions of sustainable development and their main advantage is the ability to link indicators to policy processes and targets. These frameworks are mostly used in official national indicator sets, as well as for regional strategies and indicator programmes, such as the indicators used in the Baltic 21 Action

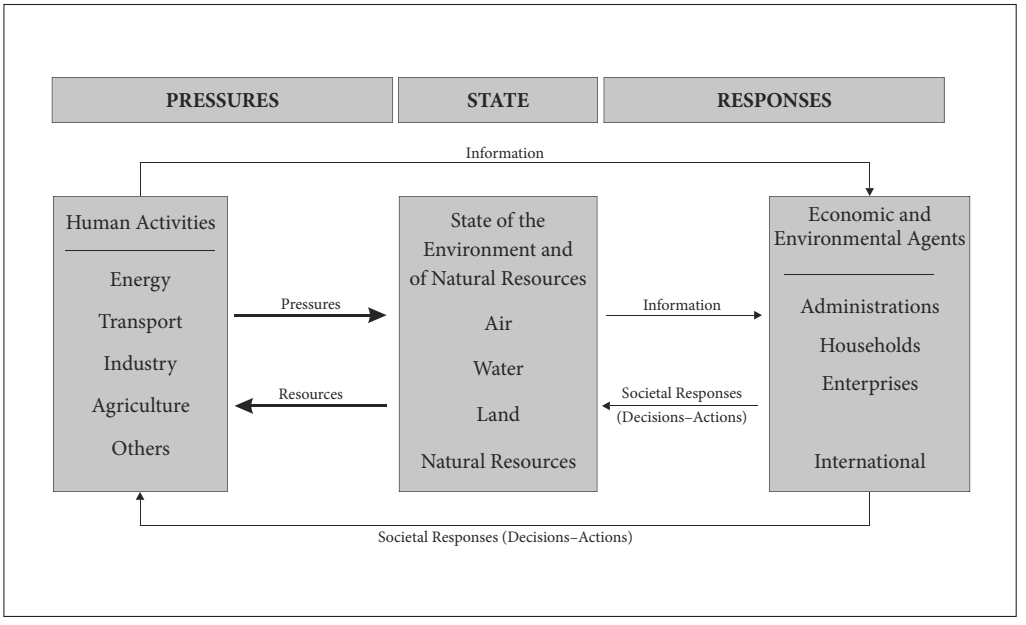


Figure 2: PSR indicator framework (adapted from OECD core set… 1993).

Programme, the Mediterranean Sustainable Development Strategy and the Sustainable Development Indicators for the European Union (Indicators of Sustainable Development… 2007). The most recognised example of a Theme-based framework is the UNCSD from 2001, revised in 2007. Capital-based frameworks attempt to calculate national wealth as a function of the sum of different kinds of capital expressed in common terms, usually in monetary terms. This approach includes several types of capital: financial capital and produced capital goods, natural capital, human capital, and social capital. The frameworks based on this approach are diverse, but, in general, they all initially try to identify what development is, and secondly, how the development can be made sustainable (Indicators of Sustainable Development… 2007). One example of a capital-based framework is Daly's Triangle-based system supported by the Balaton Group (Wu and Wu 2012). Arguments against this approach pointed out by the United Nations (Indicators of Sustainable Development… 2007) include: disagreement about how to express all forms of capital in monetary terms; issues of data availability; questions about substitution (e.g., biodiversity cannot be substituted); and concerns regarding intra-generational equity. Integrated accounting frameworks address synthesised economic and environmental spheres based on national accounting methodologies. The most prominent example is the System of Integrated Environmental and Economic Accounting (SEEA), developed by the United Nations, the European Commission, the International Monetary Fund, the World Bank, and the OECD (Indicators of Sustainable Development… 2007; Wu and Wu 2012). Several countries use the SEEA, and it is in the process of being proposed as an international statistical standard, however, integrated accounting frameworks were not specifically set up to address sustainable development and thus do not take into consideration the social (and institutional) dimension of sustainable development. The UNCSD indicators from 2007 further strengthen the relationship with the SEEA. A large number of aggregated indicators (or indices) have been developed to capture elements of sustainable development. Many of these indicators are focused on only one dimension of sustainable development, rather than offering a comprehensive view of sustainable development. Well-known examples of aggregated indicators include, among others, the Ecological Footprint, the Environmental Sustainability Index, Green GDP, and Genuine Progress Indicator (Indicators of Sustainable Development… 2007; Wu and Wu 2012).

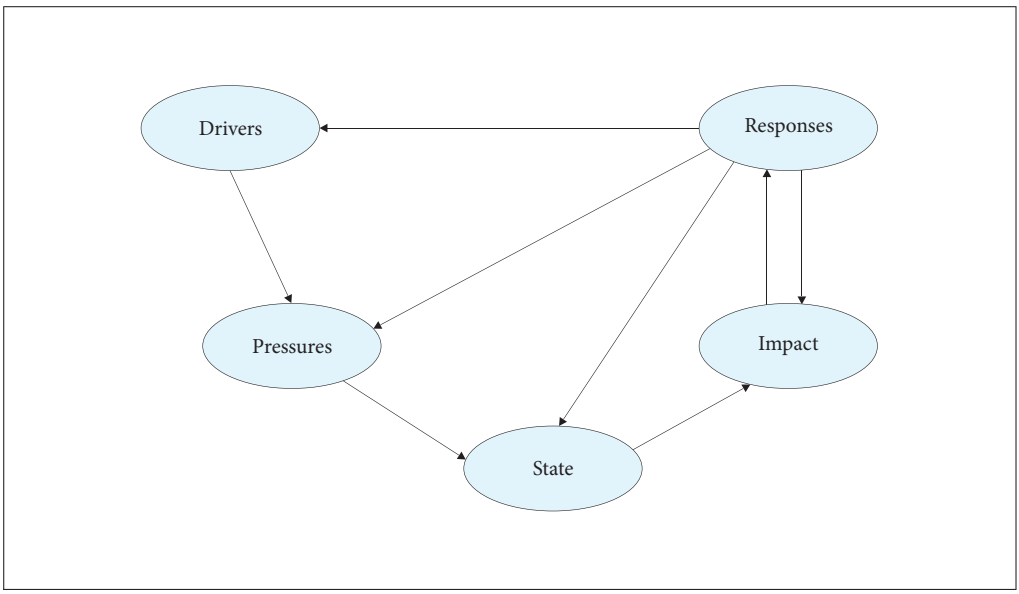


Figure 3: The DPSIR assessment framework (adapted from Environmental indicators… 1999).

There are several other approaches to using indicators for sustainable development besides the aforementioned formal frameworks. At the European level, among the most prominent indicator sets for sustainable development are the European Union Sustainable Development Indicators and the Europe 2020 indicators. The Sustainable Development Indicators approved by the European Commission in 2005 encompass 10 strategic objectives: 1) socio-economic development, 2) sustainable consumption and production, 3) social inclusion, 4) demographic changes, 5) public health, 6) climate change and energy, 7) sustainable transport, 8) natural resources, 9) global partnership and 10) good governance (for detailed information about indicators see Eurostat Archive (2020)). The Europe 2020 headline indicators encompass five main domains: 1) employment, 2) research and development, 3) climate change and energy, 4) education and 5) poverty and social exclusion. This dataset is also maintained by Eurostat, and more details about the indicators can be acquired at Eurostat. Other sets of indicators at the European level exist, however they usually only cover one domain of the three sustainability pillars (e.g., EEA indicators, covering only the environmental domain).

2.1.1.2 In Slovenia

In Slovenia, a range of studies providing development indicators exists (e.g., Ravbar 2009; 2014), although this list drastically decreases in number if we focus on sustainable development indicators (i.e. indicators based on the three pillars of sustainability).

At the national level, the implementation of Slovenia's Development Strategy is monitored through annual reports on development. The report on development from 2016 (Poročilo o razvoju 2016) included development indicators on four main themes: 1) the macroeconomic framework; 2) factors of competitiveness; 3) demographic trends and social government; and 4) environmental, regional and spatial development. Sustainable development indicators for the national level have also been defined by the Slovenian Statistical Office (Suvorov, Rutar and Žitnik 2010) and the project Indicators of Well-being in Slovenia (Kazalniki blaginje v Sloveniji 2015), which provides a general assessment of their contribution to well-being. However, the indicators mentioned are intended to be used at the national level, not taking into account regional conditions (Vintar Mally 2018). Seljak (2001) also provided a general assessment of sustainable development for the national level, and the author performed comparative analyses of sustainable development for 24 countries for 1990, 1995 and 1998. This set of indicators includes 25 themes: 1) production; 2) macroeconomic stability and country consumption; 3) factors of economic growth – capital; 4) factors of economic growth – human resources; 5) factors of economic growth – technological resources; 6) factors of economic growth – natural resources; 7) international trade; 8) consumption habits; 9) structure of production; 10) number and population structure; 11) communities, migration and regional structure; 12) economic inequality; 13) gender inequality; 14) life expectancy; 15) diseases, harmful habits of individuals and health structure; 16) education level; 17) rights, freedom and cooperation; 18) security; 19) air pollution (processes and state); 20) water pollution (processes and state); 21) soil quality; 22) noise pollution; 23) non-renewable resources; 24) renewable resources and 25) sources of electrical energy.

An assessment of well-being at the municipality level, although covering the entire country, was done by Rovan, Malešič and Bregar (2009). The authors measured geographical differences of well-being in Slovenia with quantitative social, economic, demographic and environmental indicators. Vintar (2003) has defined thirty-two indicators (six economic, twelve social, and fourteen environmental indicators), which were used to assess sustainable development in the period from 1996 to 2002. In 2009, Vintar Mally (2009) applied the same indicators to monitor sustainable regional development for the period from 2003 to 2007. In 2018, Vintar Mally (2018) proposed a slightly changed set of indicators to monitor the sustainable regional development in Slovenia between 2010 and 2014. These three studies were done at the level of statistical regions. Lampič et al. (2016) determined agricultural sustainability at the level of statistical regions. This study specifically assessed the sustainable orientation of agriculture in Slovenian regions by applying a set of indicators including the economic, environmental and social aspects

of sustainability for agriculture. Although this study did not directly assess sustainable regional development, some indicators used were also important in assessing the sustainable development of Bela krajina (see subchapter 3.3.1). Černe and Kušar (2010) proposed a list of indicators for monitoring regional development, measuring spatial potential, spatial development and environmental indicators. For monitoring regional development, the authors identified ten groups of indicators: 1) demographic structure; 2) socio-economic structure; 3) settlement structure; 4) countryside; 5) quality of living; 6) infrastructure; 7) land use; 8) protected areas; 9) degraded areas; and 10) endangered areas. Lampič, Mrak and Plut (2011) assessed the development potential for the sustainable development of protected areas in Slovenia. The authors of that study identified four types of development potential of protected areas such as environmental, cultural, social and human. The study represents an example of an assessment of sustainable development for specific areas, apart from administrative units, taking into account the characteristics of those areas, which is also the main goal of our study. Kladnik and Ravbar (2003) studied the developmental advantages and drawbacks of the Slovenian countryside, employing a set of regional development indicators through the development factors in the countryside. Development factors in the countryside according to their study include: 1) natural limitation factors; 2) land and agricultural systems; 3) property conditions; 4) population structure; 5) economic efficiency; 6) personal infrastructure; 7) frontier status; and 8) state of the environment. This study is of particular importance as it employs some parameters characteristic to karst landscapes (karstification and the occurrence of temperature inversions in concave relief forms). These were included in our proposed set of indicators to assess the sustainable development of karst regions (see subchapter 4.2).

For a better overview of the aforementioned studies carried out regarding development within Slovenia, we have summarised their focused themes in Table 1. It is important to mention that this involved certain generalisations of some themes, and some were more specifically described to allow for comparison between all studies and better understanding of the theme indicators they used. Some of the studies in Table 1 present a set of indicators that address the pillars of sustainability, others do not, therefore the overview of the sustainable development indicators presented might be subject to a certain level of subjectivity (e.g., whether to consider a certain indicator as economic or social).

From an examination of Table 1, we can see that the studies on development assessment are mostly done for administrative units. This is logical, as on the one hand data availability is mainly linked to administrative divisions, and policies are mainly directed to administrative borders. On the other hand, the majority of the studies use general indicators for the assessment of sustainable development and do not include specific indicators which concern the characteristics of a specific region/area. We contend that the characteristics of specific areas, such as karst regions, should not be neglected in the measurement and monitoring of the development of those areas, as only in this way can the development be achieved in a sustainable manner.

In order to assess the sustainable development of Bela krajina, we have used a combined set of indicators, mainly from Ravbar (2014) and Vintar Mally (2018). This set of indicators consists of the three main pillars of sustainable development: environmental, economic and social (see subchapter 3.3.1). Even though the modern sustainability movement has become more significant in recent years, from a review of the sustainability performance indicators we noted that there is a lack of specific indicators for karst regions. Some efforts have been ongoing in order to gain understanding of the implications of karst regions from an environmental perspective (e.g., van Beynen and Townsend 2005), however a holistic measure of sustainable development of karst regions is lacking. Therefore, as the prime objective of this work was to analyse the state of Bela krajina with special emphasis on regional indicators and its specificities (e.g., rural area and karst landscape) we have proposed a set of indicators for monitoring sustainable development in karst regions (see subchapter 4.2). The aim of the proposed set of indicators is to provide an approach to the development of karst regions that takes into account the values and functions of its landscapes, as well as its vulnerability.

Table 1: Overview of the thematic development indicators used in Slovenian studies.

Source	Economy	Social	Environment	Level of assessment
Seljak (2001)	• Production • Macroeconomic stability and country consumption • Capital • Human resources • Technological resources • Natural resources • International trade • Consumption habits	• Population structure • Structure of production • Communities, migration and regional structure • Economic inequality • Gender inequality • Life expectancy • Health structure • Education level • Rights, freedom and cooperation • Security	• Air pollution • Water pollution • Soil quality • Noise pollution • Non-renewable resources • Renewable resources • Sources of electrical energy	National
Kladnik and Ravbar (2003)	• Economic efficiency	• Population structure • Personal infrastructure • Frontier status	• Natural limitation factors • Land and agricultural systems • Property conditions • Agricultural burdening of the environment	Settlement
Rovan, Malešič and Bregar (2009)	• Economic activity	• Living standards • Individual well-being • Demography • Leisure time • Municipal administration • Criminality • Education • Health	• Environment	Municipal
Černe and Kušar (2010)	• Economic structure and labour market • Transport infrastructure • Telecommunication infrastructure and information society • Energetic infrastructure • Research and development	• Demographic characteristics • Social welfare and standard of living • Settlement network • Urban system connectivity • Living standard in municipal centres and regional centres • Socio-economic structure of the countryside • Education	• Environmental management • Land use • Protected areas • Degraded areas • Areas with natural hazards • Spatial identity • Functioning of system of spatial development	Regional

Source	Economy	Social	Environment	Level of assessment
Suvorov, Rutar and Žitnik (2010)	• Economic growth • Research and development • National debt	• Safety • Population, gender equality and poverty • Care for all generations	• Quality of natural resources • Natural resources (balance) • Intensity of the use of natural resources	National
Lampič, Mrak and Plut (2011)		• Immovable material cultural heritage • Movable material cultural heritage • Living heritage • Cultural potential of society • Inclusion of the population in public life of the local community • Level of trust and sense of security • Sense of belonging to the local area • Connections among family, friends and neighbours • Demographic structure • Education	• Natural values • Biodiversity • Natural resources • Ecosystem services • Land	Protected areas
Ravbar (2014)	• Labour market • Traffic-geographical accessibility • Well-being • Competitiveness and innovation	• Demographic power • Social situation		Municipal
Kazalniki blaginje v Sloveniji (2015)	• Income of the population • Property and economic security • Poverty and social exclusion • Consumption • Work and employment • Housing	• Satisfaction / happiness • Education • Health • Social climate • Personal security • Communication • Culture and leisure	• Land and ecosystems • Air • Water • Climate • Energy sources • Non-energy sources • Waste	National

Source	Economy	Social	Environment	Level of assessment
Poročilo o razvoju (2016)	• Macroeconomic stability and economic growth • Stability and quality of public finances • Financial markets and entrepreneurial indebtedness • Competitiveness of entrepreneurial sector • Labour market • Social insurance system and its long-term sustainability • Regional development	• Human capital • Innovation capacity • Role of government and institutional framework • Demographic changes • Quality of life and social risks	• Environmental development	National
Lampič et al. (2016)	• Food production and food security • Improvement of income situation and the marketing of products and services • Technological advances and increase in productivity	• Conservation of natural resources and ecological balance • Conservation of biodiversity • Use of environmentally--friendly technologies	• Increase in employment rate of the population • Improvement of demographic structure • Management of rural areas and revitalisation of rural areas	Statistical region
Vintar (2003); Vintar Mally (2009; 2018)	• Economic activity • Efforts to build the economy	• Education • Demographic structure • Social situation	• Environmental pressures • Responses to environmental issues • State of individual landscape components	Statistical region

2.1.2 Landscapes as pivotal areas for sustainable management

Over the last century, humans have changed landscapes more rapidly and extensively than at any other time in human history. This has happened to a great extent to meet growing demands for food, fresh water, timber, natural materials and fuel. Land use changes have contributed to substantial net gains in human well-being and economic development. However, these gains have been achieved at a high cost in terms of loss of biodiversity, degradation of ecosystems (Millennium Ecosystem Assessment 2005) and geodiversity (Erhartič and Zorn 2012), and can produce numerous undesirable social impacts, such as increasing capital costs to impoverished smallholders (Meyfroidt et al. 2018). Meeting the future needs of an expanding population whilst conserving natural areas, halting biodiversity loss and increasing the proportion of renewable energy will accelerate competition for available land (Lambin and Meyfroidt 2011).

To achieve sustainable development, it is certain that we should pursue human well-being and environmental protection together; and that a holistic approach is needed for management of the development process, embracing economic, social, cultural and ecological considerations. Landscapes are a framework within which this can be applied (Landscape Conservation Law 2000; Wu 2013), as they represent the place where land and people come together, addressing the spatial dimensions of culture and meanings of land (Bloemers et al. 2010). Wu (2013) contends that the landscape represents a pivotal scale domain for the research and application of sustainability, as local ecosystem-based studies tend to be spatially too small, whereas at the global scale, it is usually impossible to allow for in-depth and systematic studies. Forman (1995) also contends that landscapes represent the best operational scale for assessing and shaping the relationship between society and environment.

The sustainability of a particular landscape is greatly dependent on the way we manage the land (Wascher 2004). Therefore, the sustainable development of a region is linked to the management of its landscapes. Cultural landscapes are multifunctional landscapes which simultaneously provide and support productivity, habitat, and regulatory, social, and economic functions (De Groot 2006; O'Farrell and Anderson 2010). The extent of integration between environmental (ecological) and socio-economic functions of the landscape depends on the patterns and intensities of land use. Land use is a basic human activity that shapes socio-economic development and modifies structures and processes in the environment (Mander and Uuemaa 2010).

Due to land use changes, landscapes have undergone rapid changes. The main drivers of landscape change were identified as agriculture modernisation (Matthews and Selman 2006), in parallel with other economic activities such as urbanisation (Marušič 1995; Van Eetvelde and Antrop 2004; Matthews and Selman 2006), accessibility related to transportation modes and infrastructure (Van Eetvelde and Antrop 2004), natural and human-induced forces such as climate change (Matthews and Selman 2006), globalisation (Van Eetvelde and Antrop 2004), as well as the impact of public policies (Matthews and Selman 2006). Bender et al. (2005) state that extensively managed traditional land use is disappearing due to the intensification of agricultural production on the one hand, and the retreat of agriculture from unfavourable areas on the other hand. Matthews and Selman (2006) argue that traditional farming practices, highly valued by society in their inherited form, appear now as obsolete and are no longer viable with the development and modernisation of agriculture. Globalisation of markets and the increase in production capacity through technological progress are directing the loss of relevance and the declining economic viability of traditional products from local agriculture, particularly in marginal agricultural areas (Hobbs and Cramer 2007). Therefore, the reduction of agricultural practices and consequent land abandonment is considered a major trend of change affecting remote rural areas with poor accessibility and less favourable conditions, both social and economic. Remote rural areas are usually affected by decreasing population and agriculture is becoming less productive, or in areas of land with less favourable physical qualities, the marginalisation of land use and land abandonment is predicted to increase (Van Eetvelde and Antrop 2004). Rural depopulation leads to a loss of traditional farming knowledge (Hobbs and Cramer 2007). The loss of traditional land management practices leads to ecosystem change, which is likely to lead to the subsequent loss of important biological or cultural values (Hobbs and Cramer 2007) and functions. Once land management is lacking, the ecosystem may be transformed into other ecosystem types, and in this case ecosystem development after land abandonment is viewed as a deterioration, because the system is developing away from something that is valued (Hobbs and Cramer 2007). Nevertheless, land abandonment can be seen from two distinct perspectives, on the one hand some contend that it may contribute to the natural restoration of the landscape, towards restoration of natural ecosystems diminishing human activities and impacts on the landscape (Bowen et al. 2007; Navarro and Pereira 2012). On the other hand, abandonment of agricultural landscapes may threaten landscape diversity, in particular functional diversity associated to cultural landscapes (Plieninger et al. 2014). Most European landscape systems have been developed almost entirely by the presence of human activities, and traditional practices and management of these systems have shaped the European

landscapes (Hobbs and Cramer 2007). Slovenian cultural landscapes recognised as valuable due to their geographical and cultural diversity are probably one of the main elements of national identity in the country (Golobič and Lestan 2016). Thus, we contend that the sustainable development of landscapes, and the conservation of biodiversity and landscape diversity depend on the continuation of human intervention. In this way the traditional and highly valued landscapes can be maintained whilst also assisting with economic and social sustainable development (Ribeiro and Šmid Hribar 2019).

Moreover, as locals and non-locals decide what is meaningful for them and how to manage the landscape (Beilin, Lindborg and Queiroz 2011), landscape management is dependent on local inhabitants and their cultural context, and policies at local levels. The assessment of landscape changes must consequently be used to inform decision-making, because an understanding of what is going on in the landscape can improve its management (Sayer et al. 2013). Although the main challenge in the assessment of development at a landscape level is linked to the different landscape typology classifications, there are no precise rules regarding landscape division. Therefore, landscape classification may be subjective, and data collection on sustainable indicators at a landscape level may be difficult as these do not correspond to previously established administrative units. Moreover, regions are currently seen as having an increasingly important role in sustainable development because they are intermediaries between the national and local levels, and by the growing consensus that sustainable development is an essential benchmark within future regional development (Clement, Hansen and Bradley 2003).

The study of the links between landscape features and sustainable development is relevant for the development of policies related to land use and regional development, such as agricultural policies, regional policies and spatial planning policies (Waltert, Schulz and Schläpfer 2011). European studies on the impact of the landscape in regional development are scarce and are mainly focused on the value of protected areas to the regional economy (e.g., Getzner and Jungmeier 2002; Mayer et al. 2010; Gabrovec et al. 2017).

2.1.3 Policies vs. land use and development

Landscapes are subject to a variety of policies targeting the preservation of landscapes, securing agricultural production or preventing depopulation in remote regions. Land use regulation (e.g., landscape inventories and preservation regulations) and other amenity-related policies (e.g., agricultural subsidies) may affect regional development by influencing landscape quality and through direct impacts on production conditions and other market factors (Waltert, Schulz and Schläpfer 2011).

Some European initiatives have underlined the role of the landscape in sustainable development, recognising the need for new approaches with clear implications for the management, planning and assessment of landscapes (Wascher 2004). These are:

- the Pan-European Biological and Landscape Diversity Strategy (1995);
- the European Landscape Convention (2000);
- the European Commission's reform of the Common Agricultural Policy towards rural development and more sustainable principles (Agenda 2000 1997);
- Guiding Principles for Sustainable Spatial Development adopted by the European Conference of Ministers responsible for regional planning (2000).

The measures of European policies are transcribed to national legislation without much consideration of their impacts in local territories, when national policy on cultural landscapes is lacking (Golobič and Lestan 2016).

The impact and effects of national and supranational public policies on the landscape may have negative consequences in landscape changes as these policies are typically made far from the farmer, consumer and other affected local agents (Primdahl, Kristensena and Swaffield 2013). For instance, financial incentives (such as subsidies given for special land use) for rural landscapes are typically distant from local landscapes (Primdahl, Kristensena and Swaffield 2013) and therefore often do not take

into account the natural characteristics of the landscapes (e.g., the vulnerability of karst landscapes). Of great importance among policies that indirectly regulate the landscape are agricultural policies to which European countries and the European Union allocate large parts of their budgets (Waltert, Schulz and Schläpfer 2011). In the European Union, agricultural policies usually dictate the trajectory of land use changes and to some degree also determine the rate and the extent of land abandonment, or the change from agriculture to other land use types. Above the policies directed to agriculture at national or supranational levels, trade policies are likely to have huge impacts on local economies, leading to marginalisation of agriculture in some areas and, hence, increasing land abandonment (Hobbs and Cramer 2007).

In 2013 around 66% of the money that Slovenia received from EU funds was allocated to its regions (EU Nomenclature of Units for Territorial Statistics – NUTS 2), aiming to reduce the economic, social and territorial disparities among the regions, while 24% went to agriculture in order to support farmers and promote the production of healthy food, environmental protection and stimulation of rural economies. The remaining funds (10%) were allocated to growth and jobs; citizenship, freedom, security and justice; and administration. In 2014 a new reform came into force in order to further strengthen European agricultural competitiveness in a more environmentally friendly way, and to reduce the gap for countries like Slovenia, which receive less money than the EU average (EU budget… 2014). This is especially important when 44% of the Slovenian territory is karstic (Novak 1993). Ciglič et al. (2012) have contributed to the shortcomings of the European indicators by designing new indicators based on the characteristics of the karst terrain, especially when 44% of the Slovenian territory is karstic (Novak 1993). The authors demonstrated that approximately 22% of the agricultural land in Slovenia is considered as less suitable for agriculture due to karst characteristics.

According to the OECD definition of rural areas, the whole of Slovenia is classified under rural areas. The Rural Development Programme (RDP) for Slovenia, adopted by the European Commission in 2015, focuses mainly on three priorities: restoring, preserving and enhancing ecosystems related to agriculture and forestry; competitiveness of the agri-sector and sustainable forestry; and social inclusion and local development in rural areas (Factsheet… 2015). Challenges related to land abandonment and the status of ecosystems with pollution of surface and ground water and the pressure on biodiversity are central to the Slovenian RDP. Challenges related to the viability and competitiveness of agriculture, especially during times of economic crisis, are also considerable. The RDP claims that »*it is necessary to address the low productivity of agriculture, improve inadequate agricultural infrastructure and help young farmers to get started*« (Factsheet… 2015).

Although the range of different policies tackling development issues is diverse, the main problem comes when these policies are enacted separately from each other, creating various systems (with different interests) and therefore legal anomalies.

Despite the fact that some efforts are being made from a political point of view towards a holistic view of sustainable development, we have encountered other major issues regarding the linkages between policies and sustainable development of karst regions (for details see Ribeiro 2017). Present policies do not take into account karst specificities and its vulnerability. At a national level, the only legal act that states karst protection is the Underground Cave Protection Act (Zakon o varstvu… 2004), which regulates cave activities and cave protection, and still there is a lack of implementation of this act.

Once more, these legal gaps might drive substantial negative effects in the landscape, with direct and indirect consequences for land use and development (hampering sustainable development). In a country with 44% karst surface it is imperative that the protection of karst areas increases in importance and has priority over other land uses.

2.1.4 Public participation

»*Sustainable development can be achieved only through the involvement of all stakeholders. It links government accountability and environmental protection. It focuses on interactions between the public*

and public authorities in a democratic context and is forging a new process for public participation in the negotiation and implementation of international agreements« (Aarhus Convention 2014, 15).

The importance of public involvement in public issues or seeking public participation in decision-making processes is currently being emphasised and is a prominent theme, which is reflected in the recognition of public involvement in various European and international initiatives (e.g., the Brundtland report from 1987, the Agenda 21 from 1992, the Aarhus Convention from 1998). The challenge of sustainable development requires active public participation in public matters and the involvement of all relevant stakeholders in the decision-making process. Public participation in sustainable development provides a forum to reveal social values differing among stakeholders and may include: cultural values, employment, recreation and tourism, various values provided by landscapes (e.g., food, aesthetics), etc. Landscapes and their components have a diverse range of functions, and are valued in multiple ways by different stakeholders (Sayer et al. 2013). Additionally, social potential is considered a driving force for development, and therefore people should be given opportunities to actively participate in decision-making. Without social potential the sustainable development of an area, promoting protection on one hand and development on the other, would not be possible (Lampič, Mrak and Plut 2011). Here the scheme represented in Figure 1 helps us to understand that the economy lies entirely within society, and continuing human interventions in the environment are inevitable. Conservation at a landscape level therefore depends on management, protection, and restoration. All the activities occurring within the landscape are related to human intervention (through active management or even through the abandonment of these practices), thus public participation has a very important role towards the sustainable development of a landscape, a region or a country.

2.1.5 Karst features and sustainable development

The term 'karst' describes a particular landscape containing caves and extensive underground water systems, which develops on especially soluble rocks such as limestone, marble, and gypsum. Karst systems are composed of two closely interspersed subsystems, hydrological and geochemical, which operate upon the karstic rocks. Karst features are the products of the interplay of processes in these connected subsystems (Ford and Williams 2007). Ford and Williams (2007, 1) defined karst as *»comprising terrain with distinctive hydrology and landforms that arise from a combination of high rock solubility and well developed secondary (fracture) porosity. Such areas are characterised by sinking streams, caves, enclosed depressions, fluted rock outcrops, and large springs«*. 10–15% of the terrestrial surface of our planet is covered by carbonate rocks and 20–25% of the world's population obtain water from karst sources (Ford and Williams 2007). Karst occupies 44% of Slovenia's surface (Gams 2003), and its value is reflected in the importance of natural values and rich stocks of karst groundwater. Karst springs provide about 43% of drinking water (Lah 1998).

Karst landscapes are suited to sustainability in various ways, providing valuable ecosystem services, particularly storing pristine water, providing local building materials, and mitigating climate change. However, the sustainability of karst systems is threatened by increasing human development in these vulnerable regions (Brinkmann and Garren 2011). Karst landscapes have distinct physical, social, economic, and cultural aspects that make them significant. Karst systems contain important natural features, such as caves, springs and dolines that make them geomorphologically relevant and that set them apart from other landscapes. In some areas their beauty or uniqueness attracts tourists, and in others, their susceptibility to drought and hazardous nature makes settlement challenging. Like no other landscape, the karst environment is uniquely vulnerable to human impact due to the connectivity between the underground and surface (Brinkmann and Garren 2011). The regional development in karst areas should therefore be adapted to its specificities and take into account its vulnerability. For these reasons karst landscapes are interesting to explore from a sustainability perspective (Brinkmann and Garren 2011).

We believe that the regional development of karst areas can only be attainable through sustainable development based on endogenous development potential. Efforts have already been made to understand the implications of karst regions from an environmental viewpoint (Brinkmann and Garren 2011). Van Beynen and Townsend (2005) established a disturbance index for karst environments with the examination of a variety of factors associated with geomorphology, hydrology, biota, social aspects and artificial infrastructure. This environmental index aims to measure the degree of disturbance in karst regions and was used within the present study to assess the state of the karst landscape of Bela krajina (see subchapter 3.1).

Studies on sustainable development of karst regions are rare (e.g., Smrekar et al. 2007; Luthar et al. 2008; Sustainability of the Karst Environment 2010; Brinkmann and Garren 2011; Gabrovšek et al. 2011), and mainly address environmental degradation of karst landscapes, omitting the development potential of these areas, with a few notable exceptions (e.g., Smrekar et al. 2007). Still, the analysis of the development potential and management of karst areas is of great importance in Slovenia.

2.2 Methodology

The practical part of this research is divided into three main parts, essentially based on the three approaches to analysis of the karst landscape (subchapters 2.2.1, 2.2.2 and 2.2.3). It is important to mention that the first (subchapter 3.1) and third (subchapter 3.3) parts focus on the municipal level, whilst covering the whole region of Bela krajina, and the second part (subchapter 3.2) focuses on the settlement level (Figure 4).

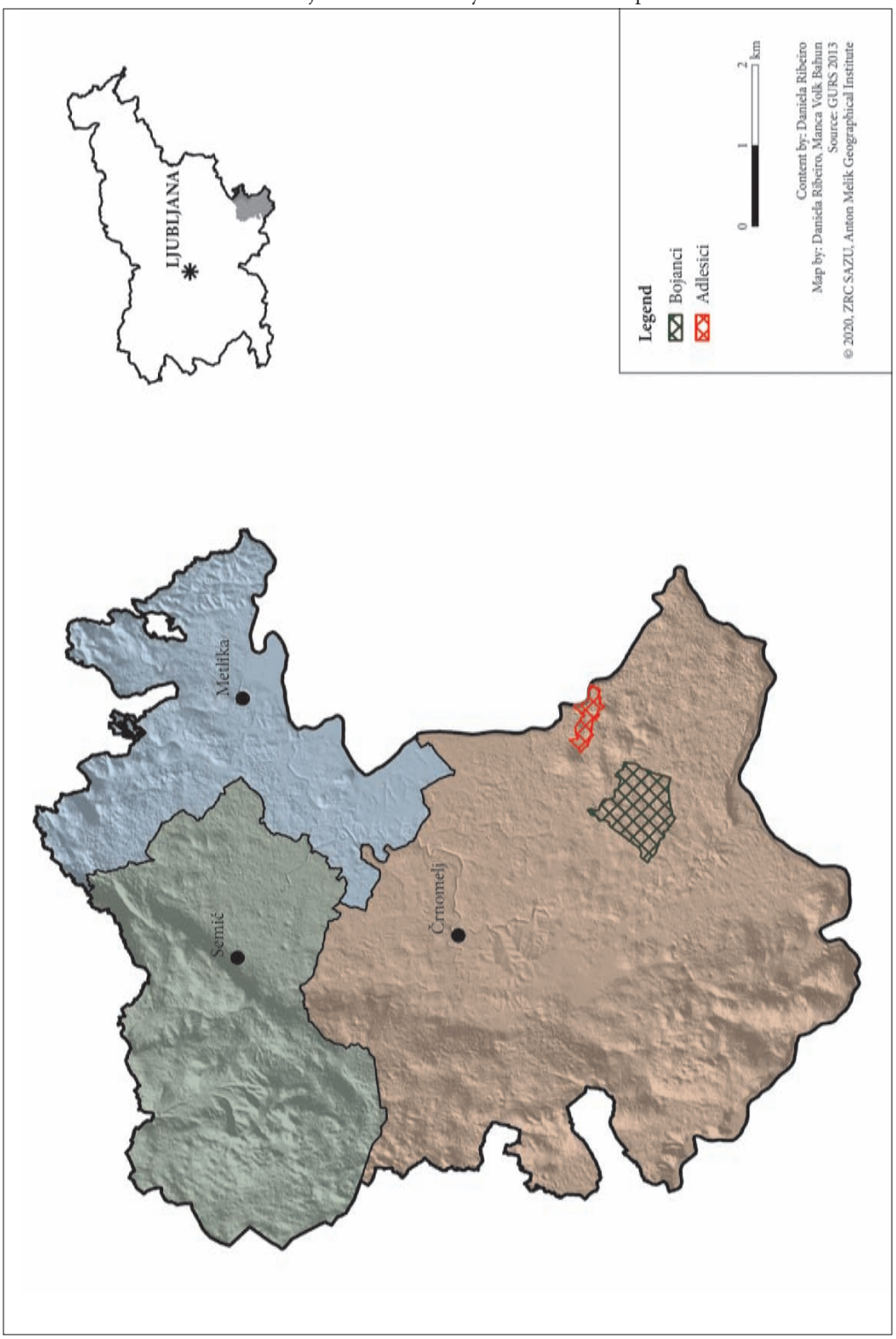
To achieve sustainable development in karst regions, we first need to assess the degree of human disturbance in these regions. Therefore, the first approach to measure the degree of human disturbance and to identify potential areas within the region that require more protection, was based on an environmental index specific for karst areas and was applied to the three municipalities of Bela krajina: Črnomelj, Metlika and Semič. The Karst Disturbance Index used was defined by van Beynen and Townsend (2005), and classifies the human disturbance of karst lands by looking at a variety of factors associated with environmental degradation of karst including pollution, cave destruction, and development. The result of this environmental index (subchapter 3.1), i.e. the level of karst disturbance, is an index indicator of sustainable development in karst areas proposed by this work in subchapter 4.2.

The aim of the second part is to better understand the landscape history and long term processes and transformations that are fundamental to the present-day perceptions of the landscape. Marcucci (2000, 68) claimed that »*The history of each landscape is unique – it is also complicated*«. The creation of the current landscape, as we see it now, is dependent on the values and activities that people had and continue to have in their environment. Today's landscapes are in part the product of historical cultural values (Marcucci 2000).

As a landscape can be seen as topological variations of vegetation cover, and it is possible to determine its diversity based on land use patterns (Palang, Mander and Luud 1998), we analysed the spatial processes and patterns across temporal and spatial scales (subchapter 3.2) to unveil the landscape changes. Structural changes in land use are symbolic of the restructuring occurring at the economic and social levels.

The term 'land use' can be defined slightly differently among different sciences (Lisec, Pišek and Drobne 2013), and here we use the term in a broader sense, which includes the social and economic purposes and contexts for land management (Ellis 2010). Spatial and temporal analyses were undertaken on two case studies which were selected for an in-depth study of landscape changes over the last 200 years, based on historical sources. The two case studies were selected to represent the settlements

Figure 4: Geographical location of the study region (Bela krajina), municipalities (Črnomelj, Metlika and Semič) and case studies (the settlements of Adlešiči in Bojanci). ►


LJUBLJANA
Legend
Bojanci
Adlesici
0
1
2
km
Content by: Daniela Ribeiro
Map by: Daniela Ribeiro, Manca Volk Bahun
Source: GURS 2013
© 2020, ZRC SAZU, Anton Melik Geographical Institute
Metlika
Črnomelj
Semič

of Adlešiči and Bojanci (subchapter 3.2), both located in the Črnomelj Municipality. The choice for these case studies was guided by the distinctive patterns of its landscapes contrasting with each other in land use and appearance. Although these locations have different management regimes, they are both affected by difficult terrain (due to karst features) and isolation.

The main purpose of the third part (subchapter 3.3), was to make quantitative and qualitative analyses (through the use of sustainable development indicators and structured interviews, respectively) of the landscape features for sustainable development. Here, the reasons for the differences in landscape structure and development in the three municipalities (Črnomelj, Metlika and Semič; Local Admistrative Unit – LAU 2) are discussed by means of a comparative approach. The first step was to explore the potential and limitations of each landscape (here represented by the municipalities) using a set of sustainable development indicators (subchapter 3.3.1). Furthermore, based on this analysis, and following a similar approach used by Filepné Kovács et al. (2015), we created a model matrix of different landscape types reflecting the population retention capacity of these landscapes in the future. In the next step we placed the municipalities within the model scenarios and, finally, we addressed future scenarios for Bela krajina based on the model scenarios attributed to each municipality (subchapter 3.3.1.4). By 'future scenarios' we mean alternative futures regarding the actual situation of each municipality. The specific objectives of this step were: to compare the landscape functions in each municipality and between the three municipalities; to create a model matrix based on the landscape functions; to place the three municipalities in the model; to identify the differences and similarities among municipalities; and to illustrate the alternative futures of the region.

As the substantive orientation of this chapter is based on the analyses of human relations with the landscape and their effects on sustainable development, the second step was to qualitatively analyse the landscapes of Bela krajina for sustainable development (subchapter 3.3.2). Data gathering in social sciences is often based on interviews. This technique is also becoming increasingly popular in different fields of natural science (e.g., MacDonald et al. 2013) as it can lead to the acquisition of information not provided by other sources. There are four types of interviews: informal, non-structured, semi-structured, and structured interviews. This classification is based on a gradation from free conversation to different forms of questioning and answering. We used a structured type of interview as we intended to get answers from different locals to the same questions. In this respect, this type of interview is similar to surveys (Muršič 2011), another method commonly used in social sciences (e.g., Polajnar Horvat 2014). Structured interviews have the advantage of having social cues, such as voice, intonation, body language etc., which can add extra information to the answers. This data-gathering method allowed for in-depth insights into the respondents' views and perspectives of a diverse group of people. Furthermore, these insights were taken into consideration in the elaboration of the proposed set of sustainable development indicators for karst regions (subchapter 4.2), which should be used together with the sustainable development indicators defined in the first step of this third part (subchapter 3.3.1). The results obtained from the quantitative and qualitative analyses of the landscape features for sustainable development were compared amongst each other in subchapter 3.3.3.

Finally, we proposed a set of sustainable development indicators (subchapter 4.2), titled 'karst specific indicators', which should be used for the measurement and monitoring of sustainable development of karst regions. It includes specificities of karst systems that are not taken into account in classical assessments of regional development.

2.2.1 Karst Disturbance Index

Human activities have been impacting on karst environments for thousands of years (Zorn, Kumer and Ferk 2015), but as human population has increased, human disturbance of the karst landscapes has also increased. Activities such as quarrying, pollution, groundwater extraction, construction and agriculture are major motivators for disturbing surface and subsurface karst. Methods to quantify this

disturbance have been created to help managers of natural resources formulate approaches to reduce anthropogenic impacts. An example of these methods is the Karst Disturbance Index introduced by van Beynen and Townsend (2005; 2011).

As mentioned by van Beynen and Townsend (2005), the assessment of human disturbance of karst environments can be complex and subjective. The original index to assess the human disturbance of karst areas was adapted to the data and specificities of the selected study region, therefore some indicators were not taken into consideration as they proved to be irrelevant for the region, while others were included instead. This process also took into consideration the availability of data and this was discussed amongst karst experts to validate its utilisation. This ecosystem approach to karst systems recognises that vegetation, soil and biota influence and are influenced by karst processes. Thus, disturbance of any component of the ecosystem is considered as an impact on karst systems (van Beynen and Townsend 2005). The Karst Disturbance Index is composed of five main categories (Table 2): 1) geomorphology, 2) atmosphere, 3) hydrology, 4) biota and 5) culture; and these categories include physical, biological, and social interactions within the landscape. In order to minimise complexity and provide a systematic approach to the evaluator, the authors of the original index created a categorical framework where the indicators are collected and ranked. The indicators indicate the degree of human disturbance for a certain parameter and each indicator is assigned a score from 0–3 according to the extent and severity of the variable being evaluated. No human impact/karst disturbance is given a rating of 0; in the case of apparent disturbance we judged whether the impact is considered localised and not severe (rating=1), widespread (rating=2), or catastrophic (rating=3) (van Beynen and Townsend 2005).

Data collection for the Karst Disturbance Index was obtained from published research articles and government reports on Bela krajina. The ratings from all the indicators were added and divided by the highest possible score to attain a value between 0 and 1. The compilation of scores and interpretation of their values can be seen in Table 3. Only those indicators applicable to each municipality can be used, if the indicator was not applicable it was removed. In the case of there being no available information/data for some indicators a 'Lack of Data' (LD) was assigned to those indicators. The Lack of Data rating is obtained by the number of LD listed in the index divided by the total number of indicators used in the study. This rating enables us to evaluate the credibility of the index. The higher the LD rating, the less confidence the degree of disturbance can have. If confidence scores less than 0.1 it means a high degree of confidence, whereas scores greater than 0.4 suggest more research is required before the application of the index is plausible for the selected study region (van Beynen and Townsend 2005).

Table 2: Indicators of Karst Disturbance Index applied in Bela krajina (adapted from van Beynen and Townsend 2005). ► *(p. 32–33)*

Table 3: Classification of the degree of human disturbance on karst environments (van Beynen and Townsend 2005).

Score	Degree of disturbance
0.80–1.00	Highly disturbed
0.60–0.79	Moderately disturbed
0.40–0.59	Disturbed
0.20–0.39	Lightly disturbed
0–0.19	Pristine

Table 2: Indicators of Karst Disturbance Index applied in Bela krajina (adapted from van Beynen and Townsend 2005).

Category	Attribute	Indicator	Rating			
			3	2	1	0
Geomorphology	Surface landforms	1. Quarrying/mining	Large open mines	Small working mines	Small scale removal of pavement	None
		2. Surface flooding (artificial surfaces)	Catastrophic areas	Frequent flooding	Rare areas of flooding	None
		3. Stormwater drainage (rated by the number of ponors where water is funnelled and their catchment area)	3	2	1	0
		4. Infilling caves (% of infilled caves)	>66%	34–66%	1–33%	None
		5. Illegal waste dumping (% area affected by illegal dumping)	>66%	34–66%	1–33%	None
	Soils	6. Erosion	Severe	High	Moderate	Natural rate
		7. Compaction due to livestock or humans (%)	>66%	34–66%	1–33%	None
	Subsurface karst	8. Subsurface flooding (human-induced cave flooding due to surface alteration	Permanent cave inundation	Increased inter-mittent flooding & filling >50%	Increased inter-mittent flooding & filling <50%	Only natural flooding due to high rainfall
		9. Cave formation, removal or vandalism	Widespread destruction	≈50% of speleothem removal	Some isolated spots of removal	Pristine
		10. Mineral and sediment removal	Most of the material removed	≈50% of cave affected	Some isolated spots	Pristine
		11. Floor sediment compaction-destruction	Most of the floor sediments and cave formations affected affected	≈50% of floor sediments and cave formation	Small trail through cave	Almost pristine, mostly rock surface
Atmosphere	Air quality	12. Desiccation	Widespread and high levels	Widespread but low levels	Isolated and very low levels	Pristine
		13. Human-induced condensation, corrosion	Widespread and high levels	Widespread but low levels	Isolated and very low levels	Pristine

Hydrology	Water quality (Surface practices)	14. Pesticides and herbicides (% areas applying)	>66%	34–66%	1–33%	None
		15. Industrial and petroleum spills or dumping (number and type)	>20 industries or severe risk of spills	10–19 industries or high risk of spills	1–9 industries or moderate risk of spills	None
	Water quality (springs)	16. Occurrences of algal blooms (% of sensitive areas due to eutrophication)	>66%	34–66%	1–33%	0
	Water quantity	17. Changes in water table (decline in meters)	>35	15	<5	Only natural variability
		18. Changes in cave drip waters	Total cessation	Long dry spells (not seasonally related)	Slight reduction	No change
Biota	Vegetation disturbance	19. Vegetation removal (% of total)	>66%	34–66%	1–33%	0
	Subsurface biota, cave	20. Species richness in caves (% decline)	>50%	20–49%	1–19%	0
		21. Population density in caves (% decline)	>50%	20–49%	1–19%	0
	Subsurface biota, ground water	22. Groundwater species richness (% decline)	>50%	20–49%	1–19%	0 or increase in numbers
		23. Groundwater population density (% decline)	>50%	20–49%	1–19%	0 or increase in numbers
Cultural	Human artefacts	24. Destruction/removal of historical artefacts (% taken)	>50%	20–49%	1–19%	0
	Stewardship of Bela krajina	25. Regulatory protection	No regulation	A few weak regulations	Statutes in place but with loopholes	Region fully protected
		26. Enforcement of regulations	Widespread destruction, no enforcement	No enforcement, but little damage done	Some infrequent enforcement	Strong enforcement
		27. Public education	None, public hostility	None, public indifference	Attempts through NGOs	Well-funded government programs
	Building infrastructure	28. Building of roads	Major highways	Some two lane roads	Some country lanes	Minor tracks
		29. Building on karst features	Large cities	Towns	Small rural settlements	No development
		30. Construction within caves	Major modification	Major tourist cave	Cave trail marked	Pristine

2.2.2 Land use analyses

As stated by Cousins (2001), land use maps corresponding to different time periods make it possible to observe the changes between land use categories, and to analyse the land use history of a specific site. The analyses of landscape change are thus based on a variety of sources, including historical maps, cadastral maps, archival data and data acquired in the field. These sources (archive and field-mapping) are part of a long tradition of studying landscapes as cultural constructions (Bloemers et al. 2010; Ribeiro, Ellis Burnet and Torkar 2013; Gabrovec, Bičík and Komac 2019).

The basis of these analyses was the delineation of land use units, from four data sources: the Franziscean Land Cadastre (1824), Revised Land Cadastre (1877), Agricultural Map (1987) and field-mapping (2012). The historical maps utilised in this study were produced during a 200-year period using different cartographical and land surveying techniques. The quality of these maps is related to their original purpose.

The Franziscean Land Cadastre became a foundation for today's land tax system. The original land cadastral maps were made to a scale of 1 : 2880 (Kačičnik Gabrič 2000; Dobernik 2002). The scanned sheets of the Franziscean Land Cadastre in Jpeg format were acquired from the Archives of the Republic of Slovenia.

In 1848 the feudal system was abolished, and due to this the relationship between ownership and taxation changed. Additionally, many spatial changes appeared (new infrastructure and other space interventions). Thus the Franziscean Land Cadastre was no longer appropriate and a new taxation survey was needed (Seručnik 2009). Between 1869 and 1887 a revision of the cadastre was performed with updated land use data. This survey is referred to as the Revised Land Cadastre (Kačičnik Gabrič 2000). The scanned sheets of the Revised Land Cadastre in Jpeg format were also acquired from the Archives of the Republic of Slovenia.

The Agricultural Map (hereinafter, Agrokarta), a map of agrarian land use from 1987 emerged from the need for qualitative evaluation of the productive capacity of agricultural land. The Agrokarta was prepared from 1986 until 1989, based on land cadastre maps (P. B. 1987). Agrokarta map sheets were created to a scale of 1 : 5000.

Data for the contemporary land use (2012) was acquired through field-mapping. Field-mapping is considered as an accurate method based on field work using cartographic methods, and allows for the obtaining of as much information as possible about the condition and structure of the habitat types in the area (Habitatni tipi Slovenije 2004). Fieldwork aiming to map the habitat types presented in the case studies was performed in 2011 and 2012. The habitat mapping followed the instructions described by Kačičnik Jančar (2011). Ortophotos were the basis for the field-mapping, done at a scale of 1 : 3000. To determine the habitat type the manual Habitatni tipi Slovenije (2011) was used. At the end of the process the field maps were digitised in ArcGIS.

The historical maps such as the Franziscean Land Cadastral, Revised Land Cadastral and Agrokarta were first scanned (except for Franziscean Land Cadastral map sheets that were previously acquired in digital format), georeferenced (Figure 5) and converted to vector format to be further analysed. In order to estimate the accuracy of the historical maps, several control points were chosen from these maps, corresponding to locations identified in digital orthophotos from 2009 (DOF 2009) aquired from the Surveying and Mapping Authority of the Republic of Slovenia, using ArcGIS software. The transformation method selected was the 1st Order Polynomial (affine), which is usually used for transformation between two projections where great distortion is not present (Podobnikar 2009), according to the methodological steps described by Petek and Fridl (2004). When the results proved to be unsatisfactory, ambiguous control points were removed, new control points were chosen and the transformation was repeated (Cousins 2001).

Possible distortions in the historical maps were visually corrected, as suggested by Bender et al. (2005). Each historical dataset was handled in a separate layer in the Geographic Information System (GIS).

In order to make comparisons over time, maps had to be thematically generalised (Ribeiro, Ellis Burnet and Torkar 2013). Table 4 shows how the land use categories were presented in the data sources used.

Given the limited amount of data in digital form and the time consuming nature of acquiring and handling the data, we have limited the in-depth part of this study to two case studies corresponding to the settlements of Adlešiči and Bojanci (see subchapter 3.2). These landscapes have been shaped by different processes (natural and cultural) and to understand them we need to analyse their history and investigate the consequences of past human activities and their influence in these two case studies.

The analyses were carried out in two steps. The first step was to create land use maps that are geometrically correct and thematically comparable (Cousins 2001). The second step was to analyse the landscape changes (through land use changes), landscape stability and transitions of land use categories over time for both case studies. The basis for these analyses is the delineation of land use units, as land use is the main object of human impact (Uuemaa et al. 2011). In general, the various maps used in this study are comparable, but they are not identical because they have been created for different purposes and the mapping methodology used was also different, therefore the land use categories vary among them. In the analysis we included data from each of the available years (1824, 1877, 1987 and 2012). As the data from 1987 (Agrokarta) did not have information for meadows and pastures individually, but only a class of grasslands (including meadows and pastures), we considered meadows and pastures as only one land use category (grasslands), and this also applies to the other three datasets (1824, 1877 and 2012). And so, we have used eight land use categories: cultivated field, garden, vineyard, grassland, overgrown, forest, inland water and built-up area. As the raw data from 1877 does not provide information about overgrown areas, we excluded this information from further analysis.

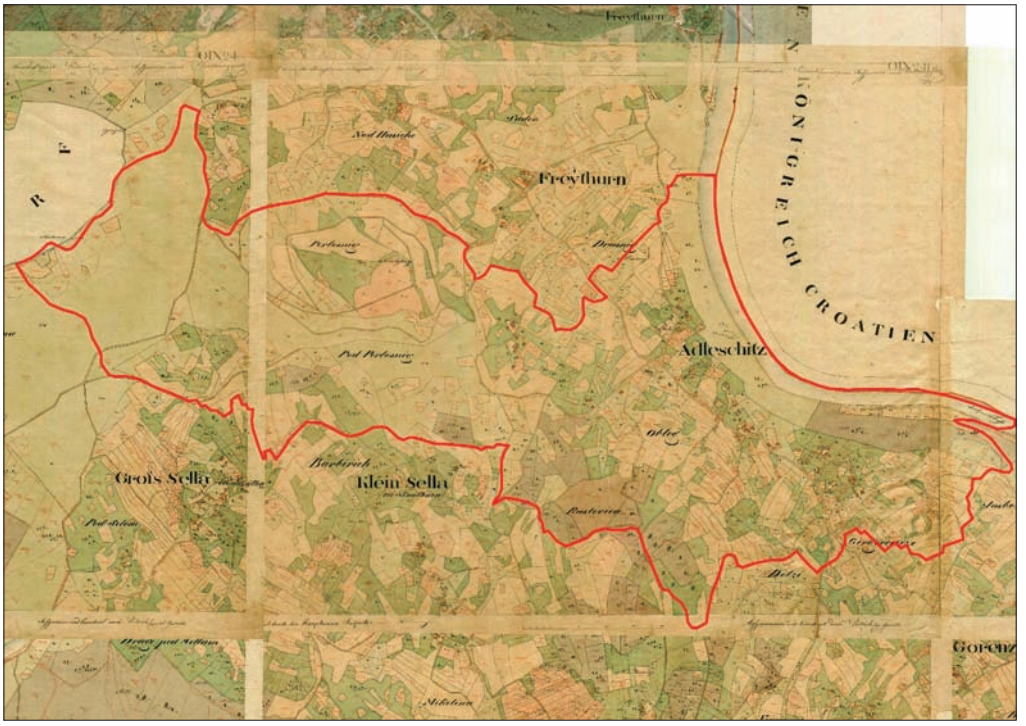
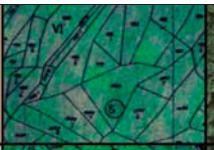
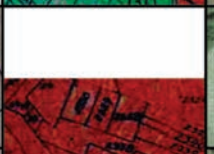
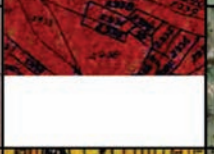
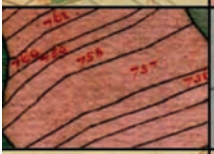
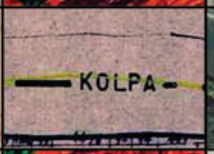


Figure 5: Franziscean Land Cadastral maps georeferenced for the settlement of Adlešiči (the red line represents the territorial border of the settlement).

Table 4: Legend keys of the data sources used.

	Franziscean Land Cadastre (1824)	Revised Land Cadastre (1877)	*Agrokarta* (1987)	Field-mapping (2012)
Forest				
Overgrown				
Meadow				
Pasture				
Vineyard				
Garden				
Cultivated field				
Inland water*				
Built-up area*				

*Data among different layers is not comparable.

The elaboration of the landscape change maps for the analysis was constructed by the successive overlaying of the various temporal spatial data layers. In such a way it is possible to visualise changes between layers. The analysis of the trajectories of change and landscape stability, based on land use dynamics, was done by the so-called 'stability mapping' approach. This approach identifies those areas which have been most prone to land use change and is based on the calculation of three indices: 'Turnover', 'Diversity' and 'Similarity', which are combined in order to derive the changed trajectory classes: 'Stable', 'Quasi-stable', 'Stepped', 'Cyclical', 'Dynamic' and 'No constant trend' (represented as NCT in the figures). 'Turnover' records the number of changes which occurred between adjacent pairs of years. 'Diversity' represents the number of different land use categories recorded for the used time periods. And, 'Similarity' gives us information about the dominance of each land use category through the time period (Swetnam 2007; Skokanóva 2009; Ribeiro, Ellis Burnet and Torkar 2013). The 'Stable class' records areas where no changes occurred, i.e. records of the same land use category in each of the time periods used in the analysis. The 'Quasi-stable class' presents only one change among one dominant land use category. The 'Stepped class' indicates areas where only one change was recorded between two dominant land categories. The 'Cyclical class' indicates frequent change between two land use categories. Frequent change among three categories is classified as the 'Dynamic class'. The 'NCT class' means that land use categories changed several times and this change has been variable (Swetnam 2007; Skokanóva 2009).

FID	shape	code 1824	code 1877	code 1987	code 2012
0	Polygon	1	1	7	6
1	Polygon	1	1	6	5
2	Polygon	1	1	6	4
3	Polygon	1	1	6	6
4	Polygon	1	1	6	6
5	Polygon	1	1	7	4
6	Polygon	1	1	7	6
7	Polygon	1	1	7	6
8	Polygon	4	4	7	6
9	Polygon	4	4	7	4
10	Polygon	4	4	7	6
11	Polygon	4	4	6	4
12	Polygon	4	4	7	4
13	Polygon	4	4	7	6
14	Polygon	1	1	6	5
15	Polygon	1	1	6	4
16	Polygon	1	1	6	6
17	Polygon	1	1	7	4
18	Polygon	4	4	6	4
19	Polygon	4	4	6	1
20	Polygon	4	4	7	4
21	Polygon	4	4	7	1
22	Polygon	4	4	7	6
23	Polygon	1	1	6	5
24	Polygon	1	1	6	4
25	Polygon	1	1	6	1

Figure 6: Attribute table of the layers from the operation 'Intersect'.

Patterns of landscape changes and landscape stability were mapped and analysed using ArcGIS 10. We coded the land use categories of all data layers from 1 to 8 (see Table 5).

Table 5: Coded land use categories.

Land use category	Code
Cultivated field	1
Garden	2
Vineyard	3
Grassland	4
Overgrown	5
Forest	6
Inland water	7
Built-up area	8

To calculate land use change trajectories, the layers representing different time periods were grouped into one using an 'Intersect' operation (Skokanóva 2010). 'Code_1824' represents the codes attributed to the land use categories for the year 1824, 'code_1877' shows the codes attributed to the land use categories for the year 1877, 'code_1987' exhibits the codes attributed to the land use categories for the year 1987, and the 'code_2012' represents the land use codes for the year 2012 (Figure 6).

We added columns for the attributes 'Turnover', 'Diversity', 'Similarity' and 'Class' to the attribute table resulting from the 'Intersect' operation. A detailed description of the calculation of these attributes is as follows:

1. Calculation of the indices 'Turnover':

We calculated the differences among the land use categories between the adjacent time periods with the help of a 'Field calculator' operation (e.g., [code_1877] – [code_1824] expresses the differences among land use categories between the years 1824 and 1877). Attributes representing these differences were named '1877_1824', '1987_1877' and '2012_1987'. The results from this operation vary from 0, when no change between the two time periods was recorded, to positive or negative values according to the codes attributed to the land use categories. We selected records with positive or negative values (using the command 'Select by attributes': 1877_1824<0 OR 1877_1824>1) and attributed them a value of 1, meaning that those records perceived changes between two time periods. This procedure was repeated for all attributes describing differences between adjacent time periods. To calculate 'Turnover' we summarised values from these attributes using the 'Field calculator' operation (Skokanóva 2010), according to the following equation:

Turnover = [1877_1824] + [1987_1877] + [2012_1987]

To calculate the frequency of each land use category we added a special attribute for each land use category, as such P_1, P_2, P_3, etc. (where 1, 2, 3… represent the codes given to the different land use categories), and we calculated the frequency of each land use category in each attribute by using the 'Field calculator' operation with the following script (example for the calculation of the frequency of land use category 1) (Skokanóva 2010):

```
Dim hh
hh = 0
if [code_1824] = 1 then hh = hh + 1
if [code_1877] = 1 then hh = hh + 1
if [code_1987] = 1 then hh = hh + 1
if [code_2012] = 1 then hh = hh + 1
```

and added hh in the last row.
Where hh represents the frequency of each land use category and [code_1824] represents the codes attributed to the land use categories for the year 1824.

2. Calculation of the indices 'Diversity':
For the calculation of 'Diversity' we used the following script in the 'Field calculator' (Skokanóva 2010):

```
Dim hh
hh = 0
if [P_1] > 0 then hh = hh + 1
if [P_2] > 0 then hh = hh + 1
if [P_3] > 0 then hh = hh + 1
if [P_4] > 0 then hh = hh + 1
if [P_5] > 0 then hh = hh + 1
if [P_6] > 0 then hh = hh + 1
if [P_7] > 0 then hh = hh + 1
if [P_8] > 0 then hh = hh + 1
```

and added hh in the last row.
Where [P_1] represents the frequency of land use category 1, i.e. cultivated fields.

3. Calculation of the indices 'Similarity':
As 'Similarity' expresses the dominance of the given land use category we calculated the maximum frequency for each land use category by using the 'Select by attributes' operation, and inserted the corresponding value (using the 'Field calculator' operation) into the attribute 'Similarity' (Skokanóva 2010). The selection goes from the lowest value (1, when the land use category appears once in the studied period) to the highest values (4, as we have used 4 data layers).
The 'Select by attributes' command for the frequency 1 is given by:

(P_1=1) or (P_2=1) or (P_3=1) or (P_4=1) or (P_5=1) or (P_6=1) or (P_7=1) or (P_8=1)

4. Calculation of the trajectories of land use change to determine landscape stability:
The trajectories of land use change (in the attribute 'Class') are determined by the combination of the three aforementioned indices using the 'Select by attributes' command (Skokanóva 2010). Different combinations of the indices result in different classes of trajectory of change (Table 6) which are the basis of classifying the landscape stability.

Table 6: Combination of the three spatial indices used in order to derive the class of trajectory of change for the four time periods.

Turnover	Diversity	Similarity	Class	Example
0	1	4	Stable	1111
1, 2	2	3	Quasi-stable	1112, 1211
1	2	2	Stepped	1122
2, 3	2	2	Cyclical	1221, 1212
3	4	1	Dynamic	1245
2, 3	3	2	NCT	1123

After this, the landscape stability was mapped for both case studies.

5. Calculation of land use changes among land use categories:

In order to visualise the land use changes among land use categories, we performed the following steps in ArcGIS:

- Created a feature class containing the polygons generated from areas enclosed by input data from 1824, 1877, 1987 and 2012 (Data management tools → Feature → Feature to polygon);
- Added a field 'Area' into the attribute table of the created feature class, where the area (m^2) of each polygon was calculated;
- Sliver polygons (polygons with an area less than 1 m^2) were eliminated by merging them with neighbouring polygons that had the largest area or the longest shared border (Data management tools → Generalisation → Eliminate);
- Created a feature class containing points generated from the representative locations of the feature class created in step 3;
- Spatially joined the information about land use from each data layer, to the feature class with the points, one at a time (Analysis tools → Overlay → Spatial join) resulting in a new feature class;
- To the feature class created in step 4, we added the fields from the feature class created in step 5 which contained information on land use for the years 1824, 1877, 1987 and 2012 (Data management tools → Joins → Join field). So in this new feature class, we got points of information about the four time periods.

The dataset was handled in the NodeXL Basic Excel Template 2014, an open-source template for Microsoft® Excel® that displays and analyses network graphs created from edge and vertex lists stored in an Excel workbook (Smith et al. 2010) (Figures 37 and 38).

2.2.3 Quantitative and qualitative analyses of the landscape features

2.2.3.1 Sustainable development indicators

Data for sustainable development indicators used for the quantitative analysis of the influence of the landscape features on sustainable development was acquired from different sources: the Statistical Office of the Republic of Slovenia, the Institute of the Republic of Slovenia for Nature Conservation, the Ministry of Agriculture, Forestry and Food, the Slovenian Environmental Agency and previous studies that have collected information for some indicators. The data acquired vary between 2010 and 2016, which was the last data available at the time of this research.

In order to quantitatively analyse the influence of the landscape features on the sustainable development of Bela krajina, we used a similar approach introduced by Filepné Kovács et al. (2015). Accordingly, landscape function analysis is a useful tool for the study of rural regions, as it explores landscape resources, potential, and limitations of the present state of the regions. We divided this approach into four main steps:

1. Selection of sustainable development indicators

In order to measure the sustainable development of Bela krajina, we have used a combined set of indicators from different studies done in Slovenia (e.g., Ravbar 2014; Vintar Mally 2018) as can be seen in Table 15, consisting in a balanced way of the three main dimensions of sustainable development: environmental, economic and social. Ravbar (2014) and Vintar Mally (2018) were the main references for the selection of indicators as they present the most up to date indicators used in the assessment of regional development. Other recent studies on the assessment of well-being in Slovenia (Rovan, Malešič and Bregar 2009; Kazalniki blaginje v Sloveniji 2015) were also taken into account, as well-being is considered to be a very important aspect for sustainable development. With the use of sustainable development indicators, Vintar Mally (2018) analysed the current conditions and trends in the Slovenian regions and assessed how much the region was approaching or drifting away from sustainable development goals. However, this analysis was done at the level of statistical regions, which we believe is not the most appropriate for our case as the state of the Dolenjska statistical region (where Bela krajina is situated) is not

representative of the whole statistical region. As Bela krajina is a marginal region within the Dolenjska statistical region, we contend that an analysis for Bela krajina itself is needed. Ravbar (2014) tried to identify development potentials, at the municipality level, as key factors on the basis of demographic strength, well-being and the social situation, the labour market, transport and geographical accessibility, and competitiveness and innovation. The main drawback of this study is that it does not include environmental indicators. Consequently, for the purpose of this study, and to have a balance between economic, environmental and social indicators, we have selected economic and social indicators from Ravbar (2014), and environmental indicators from Vintar Mally (2018). However, the final selection of indicators to be used at the municipal level was considerably influenced by the availability of data, which is lower than that for statistical regions and the national level.

2. Measuring the sustainable development of the three municipalities using the selected sustainable development indicators

The selected sustainable development indicators were collected for the three municipalities, for the average of the whole of Bela krajina and the average of the whole of Slovenia. The average for Bela krajina was calculated for the comparison of the three municipalities. The analysis of these indicators allowed a description of the present state of the three municipalities and the Bela krajina region. For the comparison of the study region with the national level, we used the same indicators and identified the relative 'position' of Bela krajina in relation to the whole country. A rating was assigned to the values of each indicator regarding their contribution to sustainable development. We calculated the mean value of the indicators ranked according to theme, and then by the domain of sustainable development. Finally, we calculated the final sum of the values to get an indication of the sustainable development for each municipality and compared it among each municipality as well as with the national average. Three ratings were possible for each indicator: 1 for a positive contribution to sustainable development, –1 for a negative impact on sustainable development, and zero if the scores equal the average of Bela krajina.

3. The creation of a model matrix of different landscape types reflecting their population retention capacity in the future

The model matrix of different landscape types and its population retention capacity was based on the model proposed by Filepné Kovács et al. (2015). According to the relations between the three dimensions, represented by sustainable development indicators, landscape types were identified and scenarios regarding the population retention capacity were described. The three dimensions are rated as low, medium and high according to their contribution to sustainable development as evaluated in step 2. 'Low' means that more than half of the indicators were rated below the average, whilst 'medium' means that half of the indicators were negatively rated and the other half positively rated. A 'high' scale means that more than half of the indicators used to assess the domain are positively rated. This model matrix was created in order to be specific to karst areas but also general enough to be applied in other karst regions. The main goal of this matrix was to identify whether a certain region (in our case the municipalities) is being managed in a sustainable manner. Here we only took into consideration rural landscapes, and although a range of other landscape types exist, they are not relevant for this study.

4. Placing the three municipalities in the model matrix

We identified characteristic landscape features within the municipalities, and estimated the long-term population retention capacity for each of them based on the scenarios described in the model matrix (step 3).

5. Creating future scenarios for Bela krajina

A 'scenario' can be defined »*as a description of the current situation, of a possible or desirable future state as well as a series of events that could lead from the current state of affairs to this future state*« (Veeneklaas and Van den Berg 1995, 11). There are two types of scenarios: exploratory (projective) and

normative (prospective). Exploratory scenarios begin with the present as the starting point, and move forward to the future. Normative scenarios start with a preliminary view of a possible or desirable future that goes back to the present situation (Schoonenboom 1995). The basic approach used in our study might not perfectly fit either of these two types; it is in fact a mixture of both, or rather a prediction which describes the most probable future that can be expected. Therefore, it may not follow the framework of scenarios used in different disciplines such as landscape ecology (e.g., Gantar and Golobič 2015). However, the created scenarios take into account the current state of the landscape and project their potential future state. Based on the model matrix of different landscape types attributed to each of the three municipalities (step 4) we thus created future scenarios for Bela krajina, which show how the cultural landscape will be and consequently its continued development if the current trends continue. The questionnaire for the qualitative analysis of the landscape features for sustainable development included a question (see subchapter 2.2.3.2) to explore what the respondents want for the future of the region in the next 15 years. The idea behind this was that their answers could be used as guidelines for the creation of future scenarios for the study region.

2.2.3.2 Structured interviews

Data gathering on the qualitative analysis of the landscape features for sustainable development was based on interviews. We conducted structured interviews with a total of 32 respondents, encompassing farmers, resident non-farmers, and professionals of nature protection, tourism and regional development. The interviews were carried out by these local stakeholders as they represent inter-linkages with land management on one side and with the endowment for socio-economic welfare on the other. Some respondents were selected according to their particular area of expertise and others through snowball sampling. This means that some respondents were nominated through their social networks, and on the basis of their potential contribution to the study. Potential respondents were contacted via telephone in advance, and the basic research objectives were outlined and interviews were agreed at a scheduled date. Interviews were carried out in June and July 2016. As we selected structured interviews, the interviewer guided the conversation and respondents answered the questions. We used open-ended questions; this means that the respondents formulated their own answers (Muršič 2011).

The respondents' profiles and their residence locations in the municipalities are presented in Table 7. Three different types of questionnaires were prepared according to the target stakeholder: one type of

Table 7: Respondents' profile and their residence location in the municipalities.

Pilot area	Questionnaire A		Questionnaire B		Questionnaire C
	Resident non-farmers	Farmers	Professionals of nature protection	Tourism professionals	Representatives of local governments
Črnomelj	JJ JG	VŠ JK	BG NŠ	TJ BR AK LB VV	GA VK
Metlika	MB MM	JV MP	–	MiP MK MaP	JN IŠ
Semič	DM AP AK	PM SM BP	MI SŽ	–	BJ MK

Table 8: List of all the questions from the interviews and target stakeholder to whom the questions were addressed.

Questions	Farmers	Resident non-farmers	Professionals of nature protection	Tourism professionals	Representatives of local governments
1. What does the landscape provide you with?	✓	✓	✗	✗	✗
2. What makes this landscape attractive?	✓	✓	✓	✓	✓
3. Does the landscape contribute to your well-being? How?	✓	✓	✗	✗	✗
4. What are the characteristics of this landscape that distinguish this place from other landscapes?	✗	✗	✓	✓	✗
5. Has the landscape changed from the past until now? Has it changed for better or worse, how and why?	✓	✓	✓	✓	✓
6. What are the main factors that influence landscape change?	✓	✓	✓	✓	✓
7. What role do you play in landscape management?	✓	✓	✓	✓	✓
8. What do you consider to be a valuable landscape?	✓	✓	✓	✓	✗
9. Do you think that agricultural activities affect the appearance of this landscape?	✓	✓	✗	✗	✓
10. Do you recognise the overgrowth of the agricultural landscape?	✓	✓	✗	✗	✓
11. Do the karst features of the landscape influence your activities?	✓	✓	✗	✗	✗
12. Do you think that the karst characteristics of this landscape influence local development?	✓	✓	✓	✓	✗
13. Do you think that nature protection influences your activities?	✓	✓	✗	✗	✗
14. Do you think that nature protection influences local development?	✗	✗	✓	✓	✗
15. In your opinion is this landscape developed? Why?	✗	✗	✓	✓	✓
16. What is the goal of the regional development process?	✗	✗	✗	✗	✓
17. What problems have you encountered in reaching this goal?	✗	✗	✗	✗	✓
18. Do you think that it is important to involve local stakeholders in decision-making processes on landscape management?	✗	✗	✗	✗	✓
19. Are local stakeholders involved in the decision-making processes on landscape practices or management? How?	✗	✗	✗	✗	✓
20. Do you see the increase in self-sufficiency in food* as an employment opportunity for rural development?	✓	✓	✗	✗	✓
21. How do you see this landscape in 2030?	✓	✓	✓	✓	✓

* »*The concept of food self-sufficiency is generally taken to mean the extent to which a country can satisfy its food needs from its own domestic production*« (Implications of economic policy… 1999).

questionnaire was prepared for farmers and resident non-farmers; another type of questionnaire was prepared for tourism professionals and professionals of nature protection (including NGOs and managers of protected areas), and a third type of questionnaire was designed for representatives of local governments (municipal government representatives) (Table 7). Some questions were the same in all three questionnaires, whilst others differed among them (Table 8).

The process started with the selection of potential respondents and was then conducted through snowballing. With 32 interviews we got a noticeable repetition of items mentioned by respondents, although we are aware that the answers from the interviews carried out might not represent the views of all locals in the whole region. Most interviews were conducted at the respondent's home or place of work. After a brief introduction of the interviewer and the research topic, people were asked between 10 to 14 questions, depending on the target stakeholder. Each respondent was allocated a 2-hour visit, although interviews ranged from 10 minutes to more than 60 minutes in length, whilst the longest visit lasted for four hours, where the respondent showed us the landscape where he lived and worked. Interviews were recorded, with the permission of the respondent and transcribed later. Bieling et al. (2014) performed similar research using a similar approach. Interviews were done in Slovene language.

The transcripts provide an extensive overview of the collected views and perspectives of a diverse group of local stakeholders and provide a useful tool for comparison, either among different groups of stakeholders or among different study areas. In this study the transcriptions of the interviews represent a collection of views and discussions which the local stakeholders involved in landscape management hold toward regional development and functions provided by the landscape. As the transcripts resulted in an enormous amount of qualitative data, there was a need for separation and sorting of the text, and therefore segments of text were concisely coded. The coding allows for organisation and summarising of the qualitative data for further analysis (MacDonald et al. 2013). Thus the codes were analysed and used to identify key ideas, and were later used to calculate sum scores for each answer given.

3 Results

3.1 Karst Disturbance Index

1. Quarrying/mining:

The locations of some disused quarries were identified first from a map of quarrying and mining activities in Bela krajina from 1984 (Bukovac et al. 1984) and then these locations were verified with Lidar data from 2014 and DOF from 2014/2015. We prepared visualisations of the locations of disused quarries, as well as their appearance in the current landscape (Figures 7 to 19). The size of non-active quarries was measured with the help of GIS.

All the identified quarrying and mining activities in the region are considered to be of small size and are located in:

- Črnomelj Municipality:
  1) Hrast pri Vinici I – active quarry of dolomite, approximate size 0.2 ha;
  2) Hrast pri Vinici II – active quarry of dolomite, approximate size 3.2 ha;
  3) Suhor pri Vinici – active quarry of limestone, approximate size 13.5 ha;
  4) Kanižarica – a large abandoned coal mine of lignite, approximate size 80 ha;
  5) Veliki Nerajec (Figure 7) – disused quarry of dolomite, approximate size 2.6 ha;
  6) Mali Nerajec (Figure 8) – disused quarry of dolomite, approximate size 1.9 ha;
  7) Stari trg (Figures 9 and 10) – disused quarry of dolomite, approximate size 0.6 ha;
  8) Golek (Figure 11) – disused quarry of lignite, approximate size 1.1 ha;
  9) Črnomelj (Figure 12) – disused quarry of limestone, approximate size 1.3 ha;
  10) Dragovanja vas (Figure 13) – disused quarry of limestone, approximate size 0.7 ha;

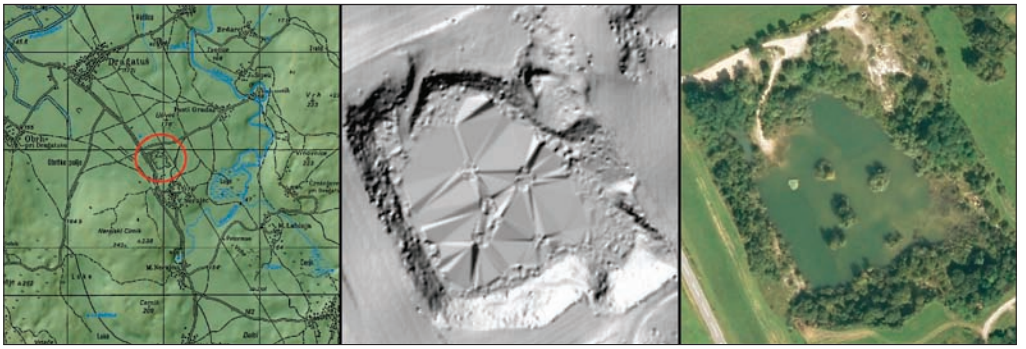


Figure 7: Disused quarry located in the Veliki Nerajec settlement. On the left the identification on the topographic map from 1996, in the centre its visualisation from Lidar data from 2014, and on the right how the abandoned location looks on DOF from 2014/2015 (Atlas okolja 2016).

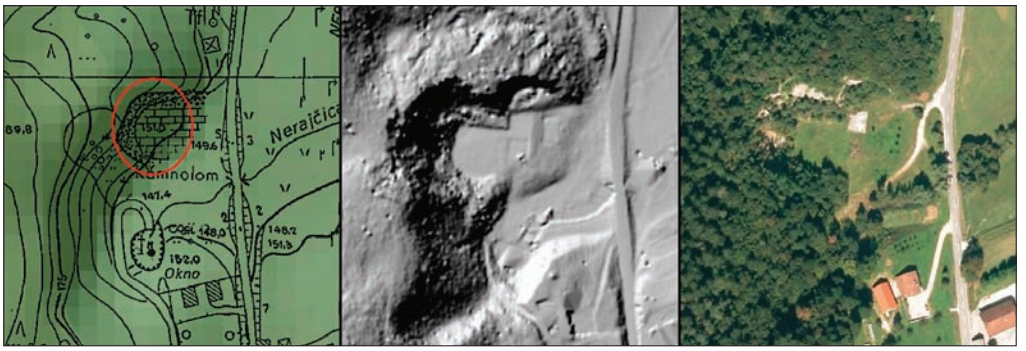


Figure 8: Disused quarry located in the Mali Nerajec settlement. On the left the identification on the topographic map from 1971, in the centre its visualisation from Lidar data from 2014, and on the right how the abandoned location looks on DOF from 2014/2015 (Atlas okolja 2016).

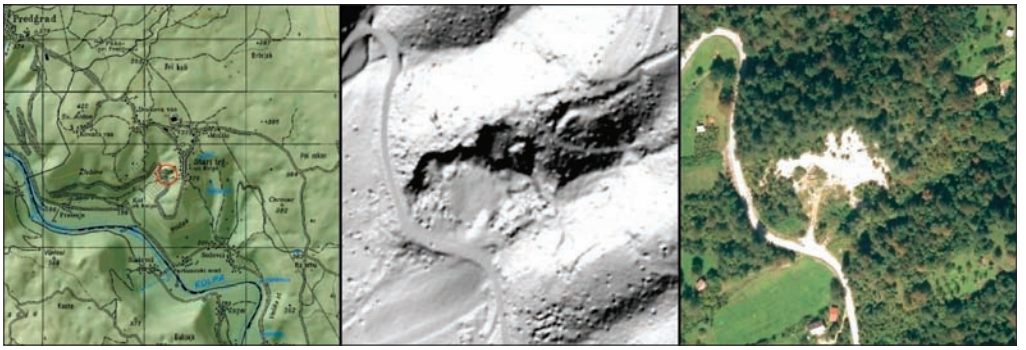


Figure 9: Disused quarry located in the Stari trg settlement. On the left the identification on the topographic map from 1996, in the centre its visualisation from Lidar data from 2014, and on the right how the abandoned location looks on DOF from 2014/2015 (Atlas okolja 2016).

- Metlika Municipality:
  11) Bereča vas – active quarry of dolomite, approximate size 2.4 ha;
  12) Kučar (Figure 14) – disused quarry of limestone, approximate size 1.2 ha;
  13) Gornja Lokvica (Figure 15) – disused quarry of dolomite, approximate size 1.5 ha;

- Semič Municipality:
  14) Brezovica pri Črmošnjicah – active quarry of dolomite, approximate size 3.8 ha;
  15) Vrčice – active quarry of dolomite, approximate size 3.3 ha;
  16) Topli vrh – active quarry of dolomite, approximate size 2.1 ha;
  17) Gradnik (Figure 16) – disused quarry of limestone, approximate size 0.1 ha;
  18) Ribnik (Figure 17) – disused quarry of dolomite, approximate size 0.3 ha;

JURE TIČAR

Figure 10: External view of the disused quarry; on the ground it can be seen how this abandoned location has been used as a construction and demolition waste disposal site.

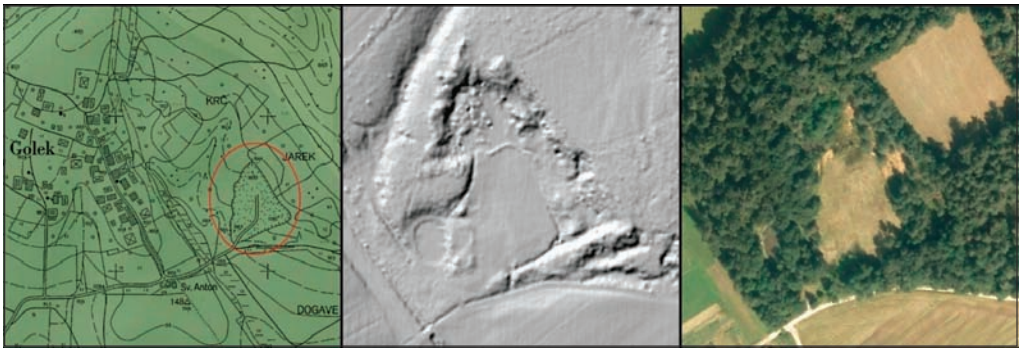


Figure 11: Disused quarry located in the Golek settlement. On the left the identification on the topographic map from 1976, in the centre its visualisation from Lidar data from 2014, and on the right how the abandoned location looks on DOF from 2014/2015 (Atlas okolja 2016).

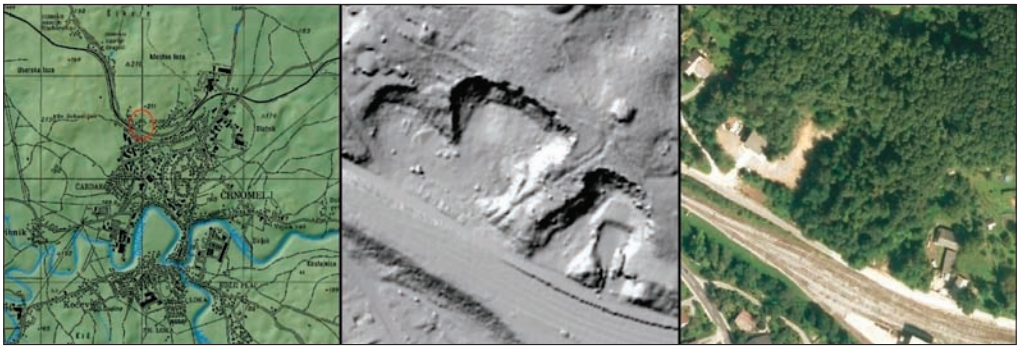


Figure 12: Disused quarry located in the town of Črnomelj. On the left the identification on the topographic map from 1996, in the centre its visualisation from Lidar data from 2014, and on the right how the abandoned location looks on DOF from 2014/2015 (Atlas okolja 2016).

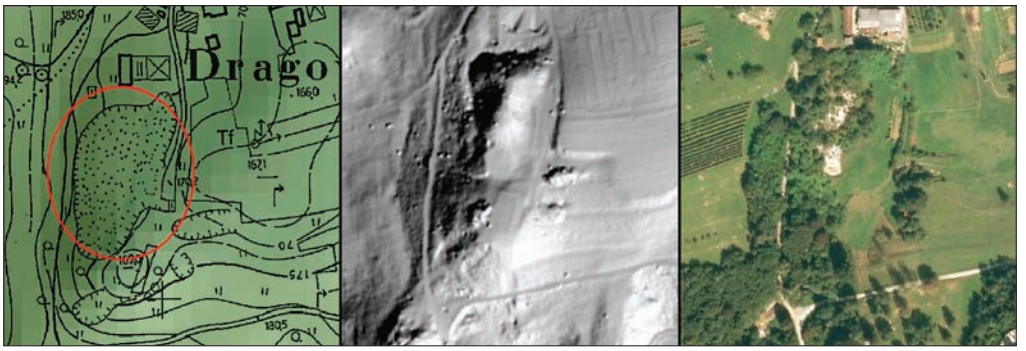


Figure 13: Disused quarry located in the Dragovanja vas settlement. On the left the identification on the topographic map from 1976, in the centre its visualisation from Lidar data from 2014, and on the right how the abandoned location looks on DOF from 2014/2015 (Atlas okolja 2016).

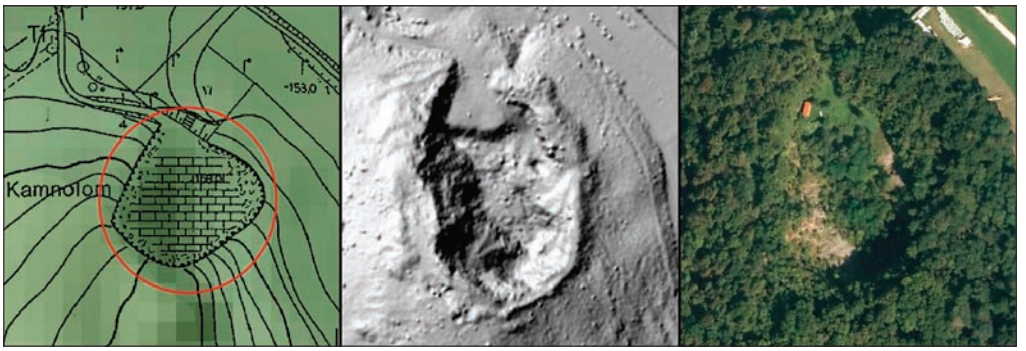


Figure 14: Disused quarry located in the Kučar settlement. On the left the identification on the topographic map from 1971, in the centre its visualisation from Lidar data from 2014, and on the right how the abandoned location looks on DOF from 2014/2015 (Atlas okolja 2016).

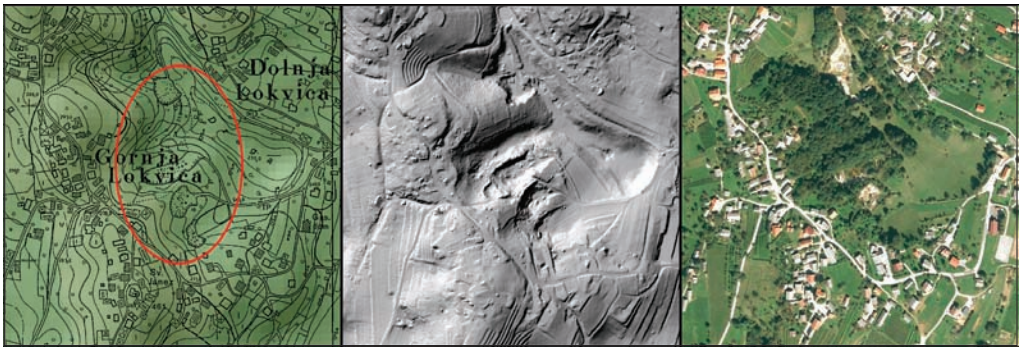


Figure 15: Disused quarry located in the Gornja Lokvica settlement. On the left the identification on the topographic map from 1976, in the centre its visualisation from Lidar data from 2014, and on the right how the abandoned location looks on DOF from 2014/2015 (Atlas okolja 2016).

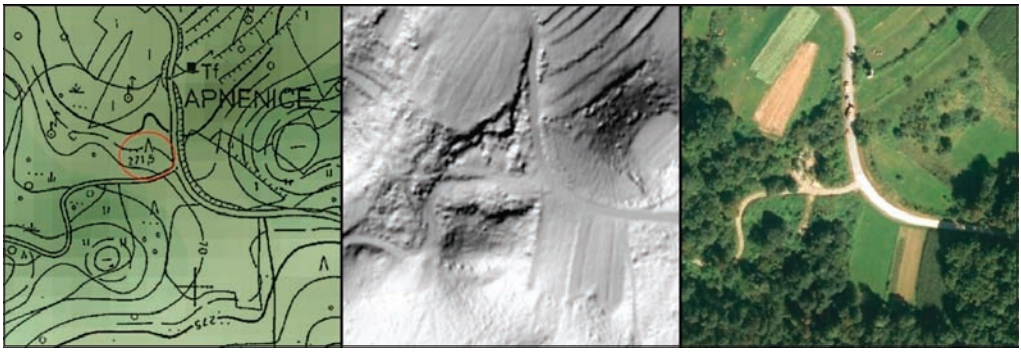


Figure 16: Disused quarry located in the Gradnik settlement. On the left the identification on the topographic map from 1976, in the centre its visualisation from Lidar data from 2014, and on the right how the abandoned location looks on DOF from 2014/2015 (Atlas okolja 2016).

Figure 17: Disused quarry located in the Ribnik settlement. On the left the identification on the topographic map from 1998, in the centre its visualisation from Lidar data from 2014, and on the right how the abandoned location looks on DOF from 2014/2015 (Atlas okolja 2016).

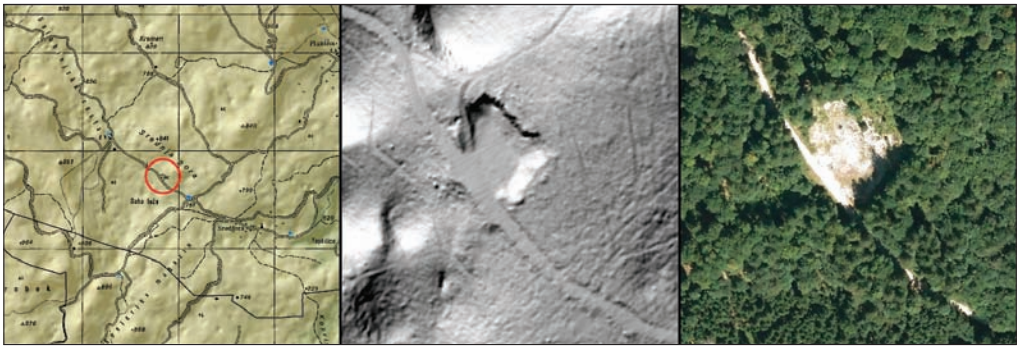


Figure 18: Disused quarry located in the Srednja Gora settlement. On the left the identification on the topographic map from 1996, in the centre its visualisation from Lidar data from 2014, and on the right how the abandoned location looks on DOF from 2014/2015 (Atlas okolja 2016).

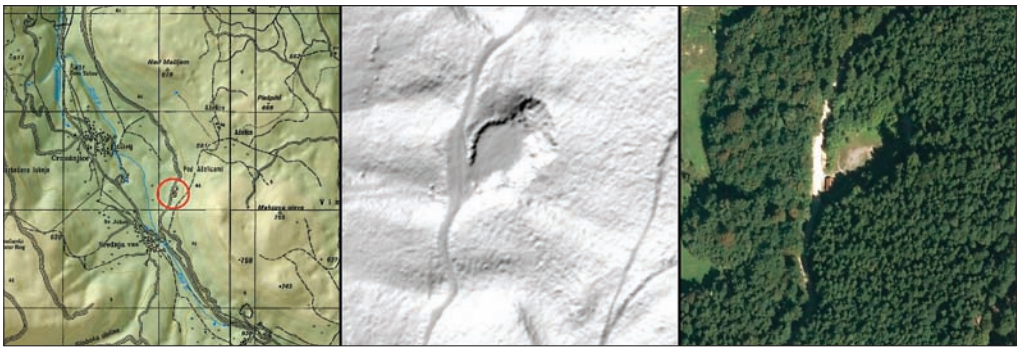


Figure 19: Disused quarry located in the Srednja vas settlement. On the left the identification on the topographic map from 1998, in the centre its visualisation from Lidar data from 2014, and on the right how the abandoned location looks on DOF from 2014/2015 (Atlas okolja 2016).

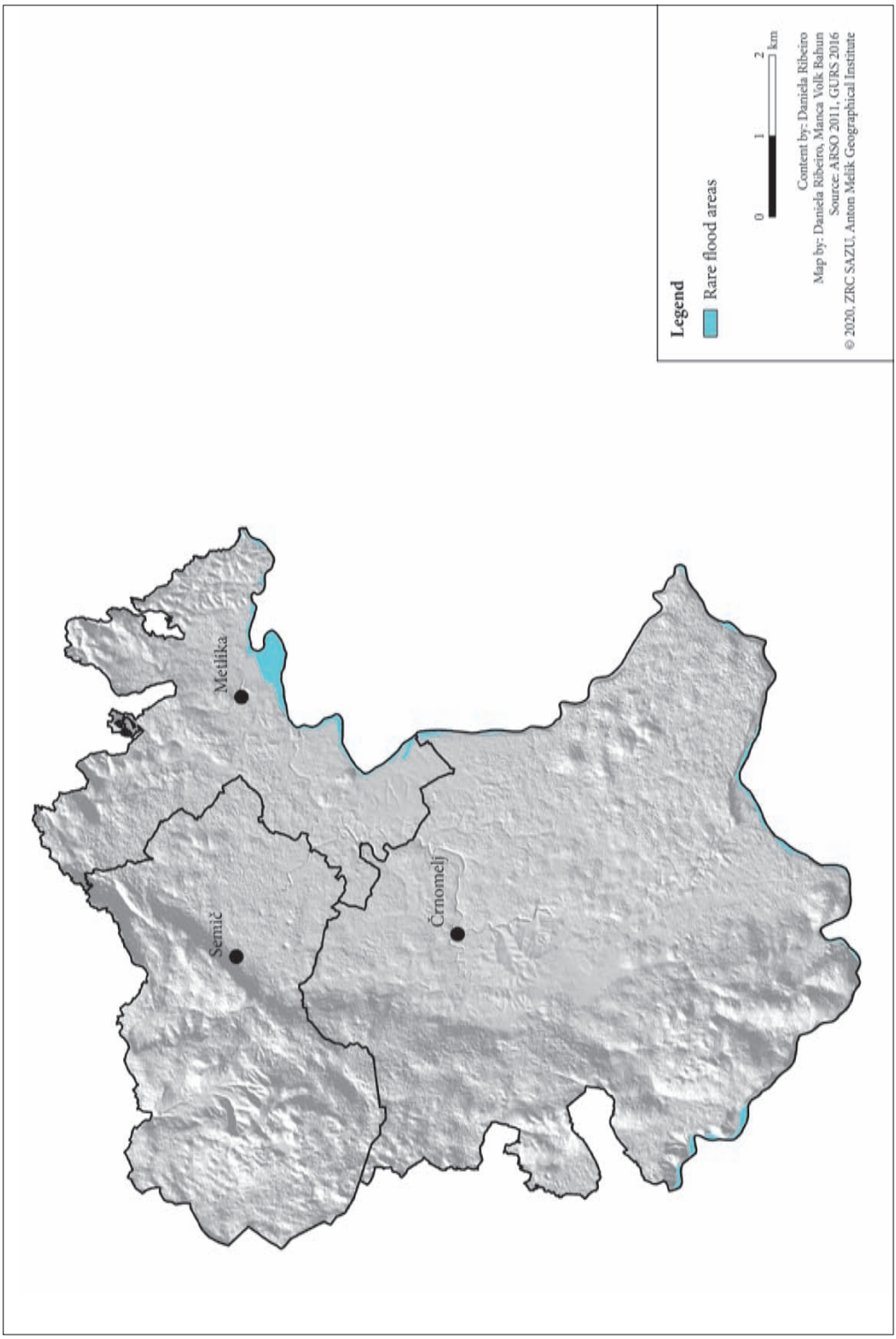
19) Srednja Gora (Figure 18) – disused quarry of dolomite, approximate size 0.2 ha;
20) Srednja vas (Figure 19) – disused quarry of limestone, approximate size 0.3 ha.

A rating of 3 was assigned to this indicator for the Črnomelj Municipality where ten sites of quarrying/mining are located, with a large coal mine. There are seven small sites of quarrying within the Semič Municipality; therefore, we attributed a rating of 2 to this indicator. In the Metlika Municipality there are three small scale quarries, so we attributed a rating of 1 (Table 11).

2. Surface flooding (artificial surfaces):

From observations of the map (Figure 20), we concluded that there was no catastrophic or frequent flooding in Bela krajina, only some occasional flooding. Thus this indicator is 0 in all three municipalities (Table 11).

Figure 20: Flood hazard maps for rare floods. ► *(p. 50)*


Metlika
Semič
Črnomelj
Legend
Rare flood areas
0
1
2
km
Content by: Daniela Ribeiro
Map by: Daniela Ribeiro, Manca Volk Bahun
Source: ARSO 2011, GURS 2016
© 2020, ZRC SAZU, Anton Melik Geographical Institute

3. Storm water drainage:

From the classification of registered caves, we identified eight ponors within the study region (Kataster jam 2016). However, it is important to note that all water bodies in the study region are of small size and none of these eight ponors have a high disturbance impact, thus the maximum rating is 2 (Table 11).

1) Požiralnik Bajer (Cave Registry Number (hereinafter, CRN) 8176, Semič Municipality): This cave is located close to a railway line and main road, thus it could potentially contribute to water pollution; we assigned a rating of 2.
2) Gadina (CRN 235, Črnomelj Municipality): This ponor could have a potentially negative effect on groundwater as it is located directly beneath the settlement, southwest of Črnomelj; it was rated with 2.
3) Džud (CRN 3341, Črnomelj Municipality): Although it is considered as a ponor, it does not offer any impact on groundwater, as there are no roads or any other urban infrastructure in its vicinity.
4) Jama v Topličicah (CRN 1809, Semič Municipality): The only road in the vicinity of this cave is a forest path, therefore its impact is considered to be 0.
5) Vučji dol 5 (CRN 10789, Črnomelj Municipality): Its impact for storm water drainage is null as it is located in the middle of a forest and there is no urban infrastructure nearby.
6) Mlinška jama (CRN 850, Metlika Municipality; Figure 21): This cave is a permanent ponor with a relatively large catchment area, and it is located close to a road which connects the nearby villages, therefore it was rated with 2.
7) Pečenevka (CRN 851, Metlika Municipality): When there is a lot of water and Mlinška jama is flooded, the water might run into this ponor, therefore its impact was considered to be 1.
8) Požiralnik pri Leščah (CRN 864, Metlika Municipality): The catchment area of the stream is large, this ponor is located close to main roads and populated areas; it works as a ponor only temporarily, thus its potential impact is 2.

DANIELA RIBEIRO

Figure 21: The permanent ponor Mlinška jama.

4. Infilling caves:

Bela krajina has 622 registered caves (Kataster jam 2016). Almost 19% (118) of Bela krajina's caves are considered degraded (destroyed and polluted), of these 1.4% are destroyed and 17.5% polluted. 70 degraded caves are located within the Črnomelj Municipality, 15 are located in the Metlika Municipality (e.g., Figure 22) and 33 degraded caves within the Semič Municipality. In all three municipalities the percentage of degraded caves are included on a scale of 1–33%, so this indicator was rated 1 for all three of them (Table 11).

JURE TIČAR

Figure 22: Polluted cave Kipina jama (CRN 853), located in Metlika Municipality.

5. Illegal waste dumping:

We assumed that data about the number and size of known, active, illegal landfills is currently the same as it was for the year 2012 as no new data on illegal dumping sites exists.

Črnomelj has 98 illegal landfills, which cover a total of 20,755 m^2, corresponding to 0.006% of the Črnomelj Municipality. Metlika has 32 illegal landfills, covering 2870 m^2 or 0.003% of the municipality territory. In Semič, 57 illegal dumps were identified, covering a total of 16,834 m^2 (Register divjih odlagališč 2013) or 0.011% of the municipality territory. From these numbers we assigned a score of 1 to Črnomelj and Metlika, and 2 to Semič, as this municipality has a comparatively higher number of areas affected by waste disposal than the other two municipalities (Table 11). In reality this number could be higher than reported as there could be many more illegal landfills (e.g., Figure 23) that have not yet been identified/mapped. However, these numbers are a good estimate for the environmental impact that this activity might have in the study region.

6. Erosion:

Figures 24, 25 and 26 show the results from the calculation of erosion for cultivated areas in Črnomelj, Metlika and Semič, respectively. More than 38% of the cultivated areas within the Črnomelj Municipality (Figure 24) present a severe erosion risk due to their slope (shown in red). Only around 8% are considered to have a low erosion risk (shown in green) and slightly more than 25% a moderate erosion risk (shown in yellow). Approximately the same percentage of the area has a high erosion risk (shown in orange).

DANIELA RIBEIRO

Figure 23: Illegal waste disposal close to Malikovec cave in the Semič Municipality.

Figure 24: Erosion risk according to slope in cultivated areas of the Črnomelj Municipality. ► *(p. 54)*
Figure 25: Erosion risk according to slope in cultivated areas of the Metlika Municipality. ► *(p. 55)*
Figure 26: Erosion risk according to slope in cultivated areas of the Semič Municipality. ► *(p. 56)*

Approximately 42% of the cultivated areas within the Metlika Municipality (Figure 25) are located in areas considered to have a severe erosion risk (shown in red), while 12% have a low erosion risk (shown in green). 25% of the cultivated areas have a moderate erosion risk (shown in yellow) and 21% a high erosion risk (shown in orange). These values are very similar to the ones for Črnomelj Municipality, so both municipalities were assigned a high erosion risk (considering that around 40% of cultivated areas present a severe erosion risk) (Table 11).

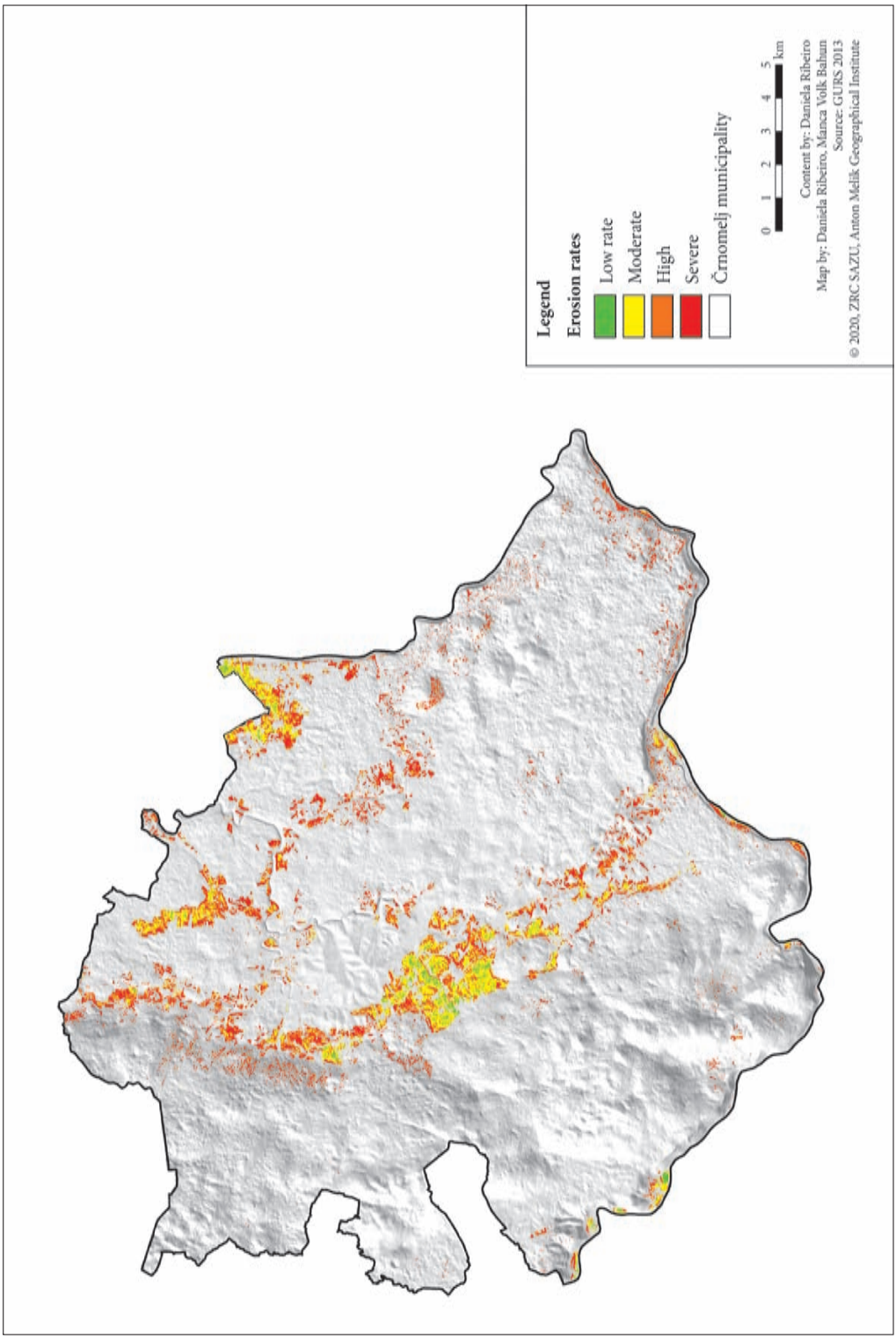
According to erosion indicators, Semič is the most affected municipality in the region (Figure 26), with almost 75% of the cultivated areas located in places with a severe erosion risk (shown in red). Only slightly more than 1% have a low erosion risk (shown in green), around 8% moderate erosion risk (shown in yellow) and the rest have a high erosion risk (shown in orange). Therefore, this municipality was assigned a rating 3 (Table 11).

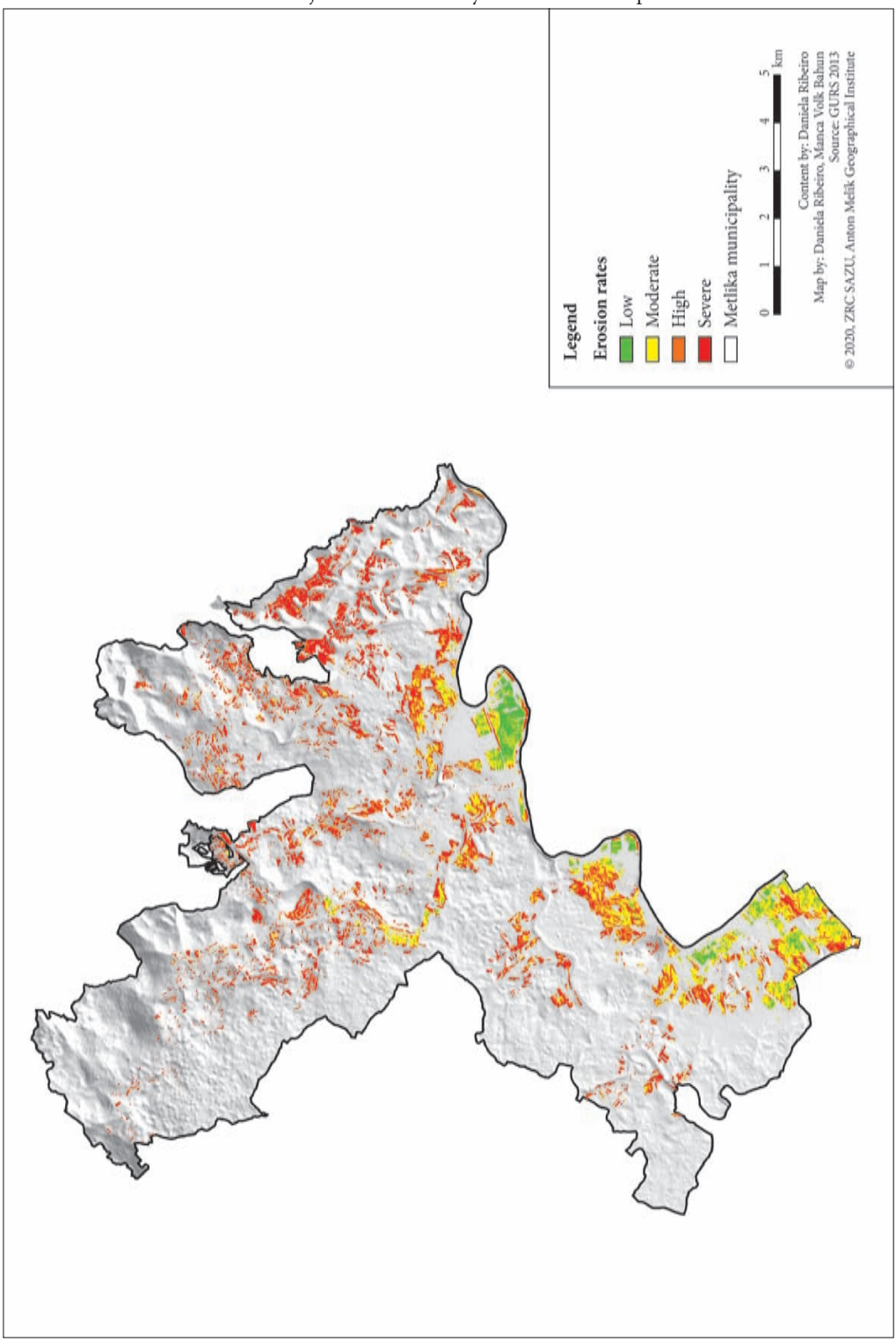
7. Compaction due to livestock or humans:

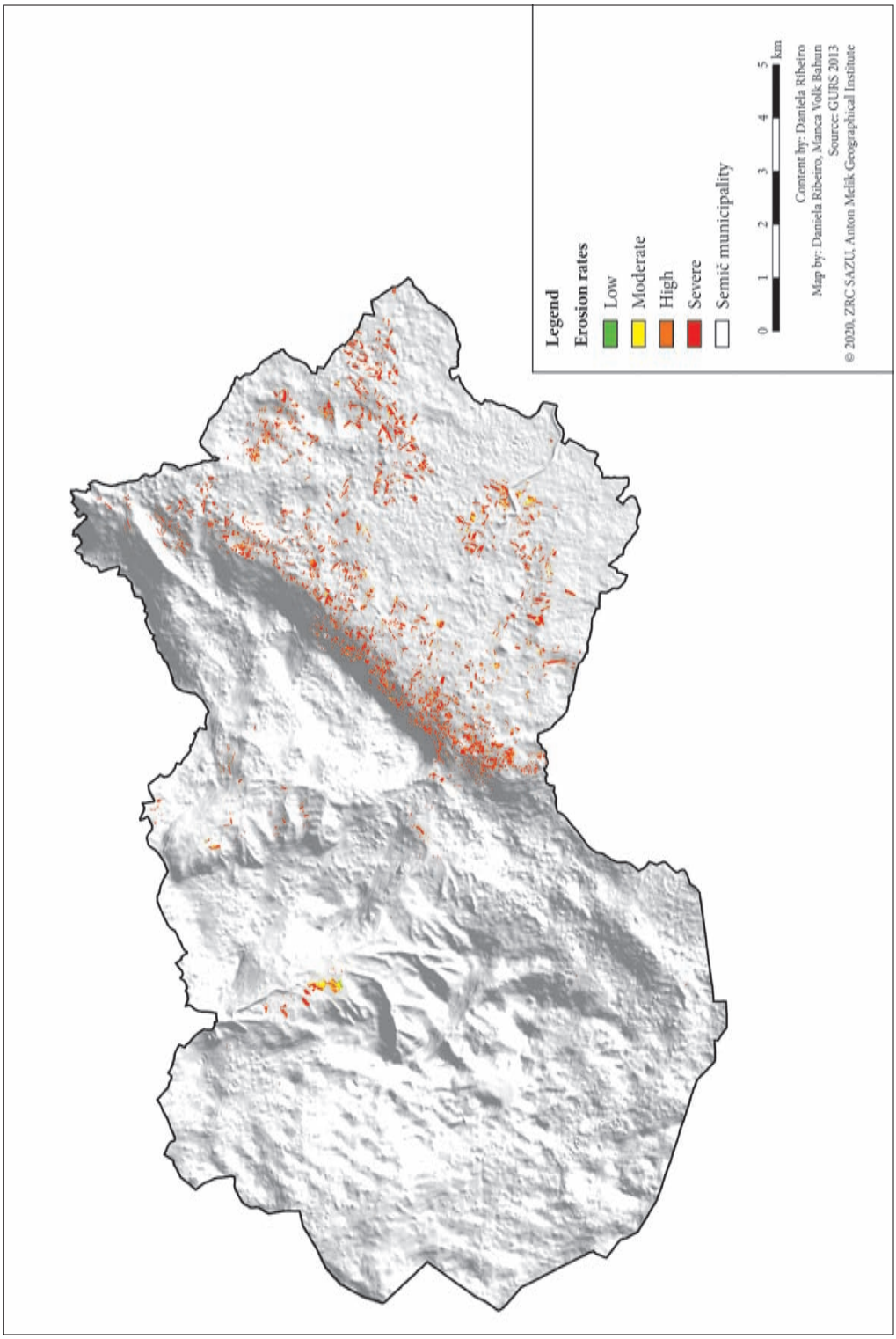
The proportion of land use activities causing soil compaction (in pastures and built-up areas) is quite similar in all three municipalities, being around 2.9% in Črnomelj, 4.6% in Metlika and 2.2% in Semič. All three municipalities have a proportion of pastures and urban infrastructure between 1–33%, therefore all of them were rated with 1 (Table 11), which corresponds to a few isolated concentrated areas of compaction due to livestock and humans.

8. Subsurface flooding (human-induced cave flooding due to surface alteration):

There are no dams built in the study region. Natural flooding events occur due to high rainfall, but not due to dam sites, therefore this indicator is zero in all three municipalities (Table 11).


Legend
Erosion rates
Low rate
Moderate
High
Severe
Črnomelj municipality
0 1 2 3 4 5 km
Content by: Daniela Ribeiro
Map by: Daniela Ribeiro, Manca Volk Bahun
Source: GURS 2013
© 2020, ZRC SAZU, Anton Melik Geographical Institute


Legend
Erosion rates
Low
Moderate
High
Severe
Metlika municipality
0 1 2 3 4 5 km
Content by: Daniela Ribeiro
Map by: Daniela Ribeiro, Manca Volk Bahun
Source: GURS 2013
© 2020, ZRC SAZU, Anton Melik Geographical Institute


Legend
Erosion rates
Low
Moderate
High
Severe
Semič municipality
0 1 2 3 4 5 km
Content by: Daniela Ribeiro
Map by: Daniela Ribeiro, Manca Volk Bahun
Source: GURS 2013
© 2020, ZRC SAZU, Anton Melik Geographical Institute

9. Cave formation removal or vandalism:

Many of the registered caves in the study region had recently been discovered and had never been visited before; at least there was no evidence of human intervention in these newly-registered caves. Tourism through the use of caves is not a major economic activity in Bela krajina. There is one known tourist cave, Malikovec cave (CRN 2316), located in the Semič Municipality.

Nevertheless, through examination of the Cave Registry (Kataster jam 2016), a few cases of speleothem removal were found within all three municipalities. In Črnomelj six caves with removal of speleothems were found: Grdanji skedenj (CRN 831), Jurinovka (CRN 1825), Lesina (CRN 1811), Luknja pri Žlaniku (CRN 2959), Mausarjeva jama (CRN 1806) and Špirov kot (CRN 1213). In the Semič Municipality only one cave affected by cave formation removal was identified: Kapniška jama v Drvodelniku (CRN 4768). One cave with cave formation removal was also identified in Metlika, the Kopelc cave (CRN 1798). As these mentioned cases are isolated examples of removal in comparison to the total number of existent caves within the study region, this indicator was rated with 1 for all three municipalities (Table 11).

10. Mineral and sediment removal:

In Slovenia, mineral and sediment removal from caves for economic reasons is prohibited (Zakon o varstvu… 2004), nevertheless, from the examination of the cave records we found one case where sediment removal had taken place, i.e. the Vuzelnica cave (CRN 6272), located in Metlika Municipality. Thus we assigned 1 for Metlika Municipality. The other two municipalities were considered as pristine regarding mineral and sediment removal (Table 11).

11. Floor sediment compaction-destruction:

This indicator is zero for all three municipalities (Table 11). As only one cave can be considered as touristic (Malikovec cave) within the study region, the trail through the Malikovec cave is not confined to a single small trail used by cave visitors, rather the whole cave floor was damaged or even destroyed, as can be seen in Figure 27. However, its impact can be omitted regarding its importance to the municipality/region floor sediment compaction-destruction rating.

DANIELA RIBEIRO

Figure 27: Floor sediment compaction-destruction in Malikovec cave, located in the Semič Municipality.

12. Desiccation:

Only the Malikovec cave was taken into consideration as a touristic cave which might be affected by desiccation. As there are no artificial entrances in the Malikovec cave that influence the desiccation of the cave, this indicator was assigned 0 for Semič Municipality (where this cave is located), as well as for the other two municipalities due to the absence of touristic caves where this impact is usually greater (Table 11).

13. Human-induced condensation, corrosion:

This indicator is rated zero for all three municipalities (Table 11) for the same reasons as the four previous indicators.

14. Pesticides and herbicides:

If we consider the impact of this indicator only through the proportion of cultivated fields, orchards and vineyards, the proportion of land where herbicides and pesticides are applied in Črnomelj is 7.2%, in Metlika 13.7% and in Semič 1.8%. Thus, in all three municipalities this proportion is less than 33% and we therefore considered these values to show little chemical use in all three municipalities, and hence they rated as 1. However, through literature searches we discovered information about one pig farm, located in the Črnomelj Municipality. This pig farm is considered to be problematic due to the application of slurry, which results in an unbearable odour (Stanje območij… 2016). Even though there is no evidence (monitoring) of groundwater pollution, it is possible that this activity can cause groundwater pollution (this issue has been covered by the media, e.g., Rajšek 2016). Thus for Črnomelj Municipality this indicator was rated 2.

15. Industrial and petroleum spills or dumping:

We summarised all wastewater treatment plants in Table 9, according to their location within the three municipalities. All existent industries were summarised in Table 10.

Table 9: The location of wastewater treatment plants in the municipalities.

Črnomelj Municipality	Metlika Municipality	Semič Municipality
• Dragatuš • Griblje • Kanižarica • Radenci • Stari trg • Vojna vas	• Drašiči • Gradac • Krasinec • Metlika • Podzemelj • Rosalnice • Suhor • TPV Suhor	• Črmošnjice • Krvavčji vrh

Table 10: Industries existent in the municipalities.

Črnomelj Municipality	Metlika Municipality	Semič Municipality
• Javno podjetje komunala Črnomelj d. o. o. • KZ Krka z. o. o. • Livar D. D. Ivančna Gorica • SECOP Kompresorji d. o. o. • PETROL D. D., BIOPLINARNA Črnomelj	• Beti holding D. D. • CGP Družba za gradbeništvo, inž., proizvodnjo in vzdrževanje cest D. D. • Galvanizacija Jože Slanc s. p. • Kmetijska zadruga Metlika z. o. o. • Komunala Metlika d. o. o.	• Iskra, D. D. PE Kondenzatorji • Kambič Laboratorijska oprema d. o. o.

With the data from Tables 9 and 10 as the basis for this indicator, Črnomelj was rated with 2 as it has 11 facilities of wastewater treatment and industry that present potential spills and dumping threats. Metlika was also rated with 2 as there are 13 facilities within the municipality. Although only 4 facilities are located in Semič, we attributed the highest score to this municipality (Table 11). An anthropogenic disaster in the mid-1980s due to the improper handling of hazardous PCBs from the dumping of condensers in the unprotected karst hinterland of the Krupa River has slowly been leaching PCBs into the ground, which later resurface in the Krupa spring. Long-term monitoring measurements show that the pollution of Bela krajina with PCBs has gradually reduced, but the concentration in the area of the Krupa River and in the immediate vicinity of the Iskra factory in Semič, and in individual elements of the food chain are still high. The River Krupa is still the main source of PCB emissions into the environment through water evaporation (Plut 1996).

16. Occurrence of algal blooms:

According to the Map of Sensitive Areas Due to Eutrophication, the study region has no sensitive areas due to eutrophication, therefore this indicator was assigned as 0 for the three municipalities (Table 11).

17. Changes in water table:

The variability of water levels was not possible to calculate as national hydrological monitoring data from the Slovenian Environmental Agency is not complete, so the comparison of these values between different years is not possible. Hence there is a lack of data for this indicator (Table 11).

18. Changes in cave drip waters:

We do not have available data for this indicator, as there are no studies on the relationship between land use activities outside caves and cave drip water in Slovenian caves; this type of monitoring has not been done in Slovenia to date. Kogovšek (1995) demonstrated that run-off water, after precipitation, that reached karst waters was polluted due to the proximity of a highway. However, this study did not take place in Bela krajina, and therefore a 'Lack of Data' was assigned to this indicator for the three municipalities (Table 11).

19. Vegetation removal:

Since »*Clear cutting as a way of forest management is prohibited*« in Slovenia (Zakon o gozdovih 1993, Article 22), and there had been no fires in any of the three municipalities in recent times, this indicator was assigned 0 for all three municipalities (Table 11).

20. Species richness in caves:

The number of cave-dwelling species in Slovenia is among the highest in the world (Hudoklin 2011; Culver et al. 2004). The study of caves and cave fauna has a long history in Slovenia (Sket 1996), dating back to the 17th century with the work of Johann W. Valvasor (Valvasor 1689). The most famous cave dweller is the proteus or olm (*Proteus anguinus*), an endemic amphibian of the subterranean waters of the Dinaric Karst (Hudoklin 2011; Aljančič et al. 2014). In Bela krajina two subspecies of proteus can be found, the white olm (*Proteus anguinus anguinus*) and the black olm (*Proteus anguinus parkelj*). The latter subspecies is rare and endemic to and only known in the Bela krajina region (Hudoklin 2011). As a result of this, it is included on the Slovenian Red List of endangered animal species (Sket 1992). Culver et al. (2004) studied species richness patterns in Slovenian caves. The authors noted an increase in species richness in the region of Bela krajina from 1940 to 2000, however comparisons between years are difficult as new caves and new species are constantly being discovered (Culver et al. 2004), hampering the monitoring process. As there are no studies of species richness available that are separated by decades for the study region, which could show some degree of disturbance, a 'Lack of Data' was assigned (Table 11).

21. Population density in caves:

As the olm is a habitat specialist among cave fauna, it would be a suitable indicator species for the state of subterranean habitats (Hudoklin 2011). Therefore, we could use population data for this species as an indicator, as it is an umbrella species; nevertheless, at the national level, and particularly for the study region, there is no systematic monitoring of groundwater quality confined to locations of olm or other cave fauna (Hudoklin 2011), so a 'Lack of Data' was also assigned here for the three municipalities (Table 11).

22. Groundwater species richness:

Slovenia has a remarkable concentration of groundwater fauna compared to other countries (Culver and Sket 2000). Studies on groundwater species in Slovenia do exist, although they do not take into consideration the temporal variation of numbers of species and these studies have not been done for the study region. Therefore, we assigned 'Lack of Data' (Table 11) for the same reason as the previous two indicators.

23. Groundwater population density:

Although there are several studies on population diversity (e.g., Sket 1996; 1999) we were not able to find any studies that monitor the changes of groundwater population density, therefore this indicator was assigned with 'Lack of Data' due to data unavailability (Table 11).

24. Destruction/removal of historical artefacts:

This indicator refers to historical artefacts being removed from their original locations. Through literature searches (e.g., Plut 2008) we found two cases located in the Črnomelj Municipality. The Sepulchral mound cemetery, Veliki Nerajec, originally had at least seven mounds, however currently only two partially ploughed ones remain. In Šipek cemetery, locals have ploughed over various objects, thus ruining and dispersing them (Plut 2008). There are probably more cases of destruction or removal of historical artefacts, although only these two cases were identified. We attributed a rating 2 to Črnomelj Municipality and 0 to the other two municipalities (Table 11).

25. Regulatory protection:

Although the whole region is not fully protected, all three municipalities have protected areas that directly or indirectly protect the karst environment; therefore, for all municipalities the indicator of Regulatory protection was assigned 1 (Table 11). Regulatory protection existent in the study region is as follows:

- Natura 2000;
- Lahinja Landscape Park;
- Kolpa Landscape Park;
- The Law on the Protection of Underground Caves.

26. Enforcement of regulations:

Through literature searches we were not able to find any information for this indicator. During fieldwork we noted some information boards next to protected areas and some caves. However, no additional enforcements were found, therefore we assigned 2 to all three municipalities regarding this issue (Table 11).

27. Public education:

While doing this research we had contact with many people from the region, and we found that many people from Bela krajina are also active in nature protection. Several non-profit organisations related to nature protection exist (Proteus, Eko društvo Krupa, various caving clubs). The NGO Proteus

was established to participate in environmental protection and to intervene in cases and procedures that are harmful to nature in Bela krajina. Caving clubs that are active in Bela krajina include Novo mesto Caving Club, Krka Caving Club and Črnomelj Caving Club, which organise annual caving schools, specially designed for students (Figure 28). This educational program aims to teach people about karst and karst phenomena with an emphasis on the characteristics of the Dolenjska karst; the living world of caves and faunal features of the Dolenjska karst; along with the risks to and protection of karst and the Underground Cave Protection Act (Jamarski klub Novo mesto 2016; Zakon o varstvu… 2004). These topics are also covered in some subjects included in the school curriculum where pupils learn about karst features and the vulnerability of the karst environment (e.g., Križnik and Purkat 2008; Štrukelj 2011). Thus, due to the aforementioned initiatives, we attributed a rating of 1 to all three municipalities, as we believe more activities could take place with local inhabitants.

JURE TIČAR

Figure 28: Presentation by the Brežice Caving Club at an open day at OŠ Sava Kladnika Sevnica primary school, where cave explorers talked about karst and karst phenomena, and its importance for nature protection. The presentation did not take place in the study region, but the photograph is representative of such activities.

28. Building of roads:

The rating for this indicator increases with the size of the roads present in the region. In Bela krajina there are no highways, only national and regional roads. It is important to mention that in Slovenia, roads also have major impacts on the environment in winter time due to the heavy use of road salt in icy conditions (Kogovšek and Petrič 2002). In the summer months traffic in Bela krajina greatly increases, as Bela krajina is a border region with Croatia, allowing the passage of people towards the coast. Therefore, we assigned 1 to all three municipalities, as all three are affected by roads and traffic in similar ways (Table 11).

29. Building on karst features:

The highest rating of this indicator (3) represents the presence of large cities, but as only towns and villages are present in the three municipalities, this indicator was rated as 2 for all three locations (Table 11).

30. Construction within caves:

Although there is a trail through the Malikovec cave, its impact can be omitted when compared to its importance to the municipality where it is located, therefore this indicator was assigned 0 for Črnomelj Municipality and the other two municipalities (Table 11), where construction within caves is not recorded.

The compilation of ratings and interpretation of values through the degree of karst disturbance for each municipality is summarised in Table 12. The results show that the karst environment of all three municipalities in Bela krajina has low disturbance.

Table 11: Karst Disturbance Index ranking of individual indicators for the three municipalities.

N°	Indicator	Črnomelj	Metlika	Semič
1	Quarrying/mining	3	1	2
2	Surface flooding (artificial surfaces)	0	0	0
3	Stormwater drainage (% of total stormwater funnelled into ponors)	1	2	1
4	Infilling caves (% of infilled caves)	1	1	1
5	Illegal waste dumping	1	1	2
6	Erosion	2	2	3
7	Compaction due to livestock or humans	1	1	1
8	Subsurface flooding (human-induced cave flooding due to surface alteration)	0	0	0
9	Cave formation removal or vandalism	1	1	1
10	Mineral and sediment removal	0	1	0
11	Floor sediment compaction-destruction	0	0	0
12	Desiccation	0	0	0
13	Human-induced condensation, corrosion	0	0	0
14	Pesticides and herbicides	2	1	1
15	Industrial and petroleum spills or dumping	2	2	3
16	Occurrences of algal blooms	0	0	0
17	Changes in water table (decline in meters)	LD*	LD	LD
18	Changes in cave drip waters	LD	LD	LD
19	Vegetation removal (% of total)	0	0	0
20	Species richness in caves (% decline)	LD	LD	LD
21	Population density in caves (% decline)	LD	LD	LD
22	Groundwater species richness (% decline)	LD	LD	LD
23	Groundwater population density (% decline)	LD	LD	LD
24	Destruction/removal of historical artefacts (% taken)	2	0	0
25	Regulatory protection	1	1	1
26	Enforcement of regulations	2	2	2
27	Public education	1	1	1
28	Building of roads	1	1	1
29	Building on karst features	2	2	2
30	Construction within caves	0	0	0

*LD = Lack of Data

Table 12: Classification of karst disturbance for the three municipalities.

Pilot area	Rating	Degree of disturbance
Črnomelj	0.26	Low disturbance
Metlika	0.22	Low disturbance
Semič	0.22	Low disturbance

The evaluation of the credibility of the index was done through the 'Lack of Data' rating. As we had LD for six indicators for the three municipalities, the LD rating was 0.2. This means that a fifth of the indicators had insufficient data to allow ratings, which equates to moderate confidence in the index.

The assessment of landscape conditions via the Karst Disturbance Index showed that all three municipalities were considered as low disturbance, thus we can say that the karst landscapes of Bela krajina in general have low disturbance as a result of human activities. A minor difference was noticed between the three municipalities, showing that Črnomelj has slightly more disturbance than Metlika and Semič. This could be accentuated because this municipality has recently been exposed to human activities with major impacts on the karst environment (e.g., Bio-gas plant, pig farming) or because it has been covered by the media more and therefore more attention was given to such activities.

This assessment was not done in other karst regions in Slovenia to a wider comparison. Nevertheless, based on studies describing the human impact in other karst regions (e.g., Prelovšek and Zupan Hajna 2011), we can say that other Slovenian karst regions seem to be under greater pressure (or at least on a larger scale) than the karst landscapes of Bela krajina. The application of the approach described in subchapter 2.2.1 to other karst regions would improve our knowledge of human impacts on karst as well as allowing greater comparison among regions.

The first step to act against the negative impact of human activities in karst systems is to improve public awareness of the vulnerability of these systems to human pressures, which have impacts not only on the environment but also on the health of the population and consequently on the sustainable development of these areas.

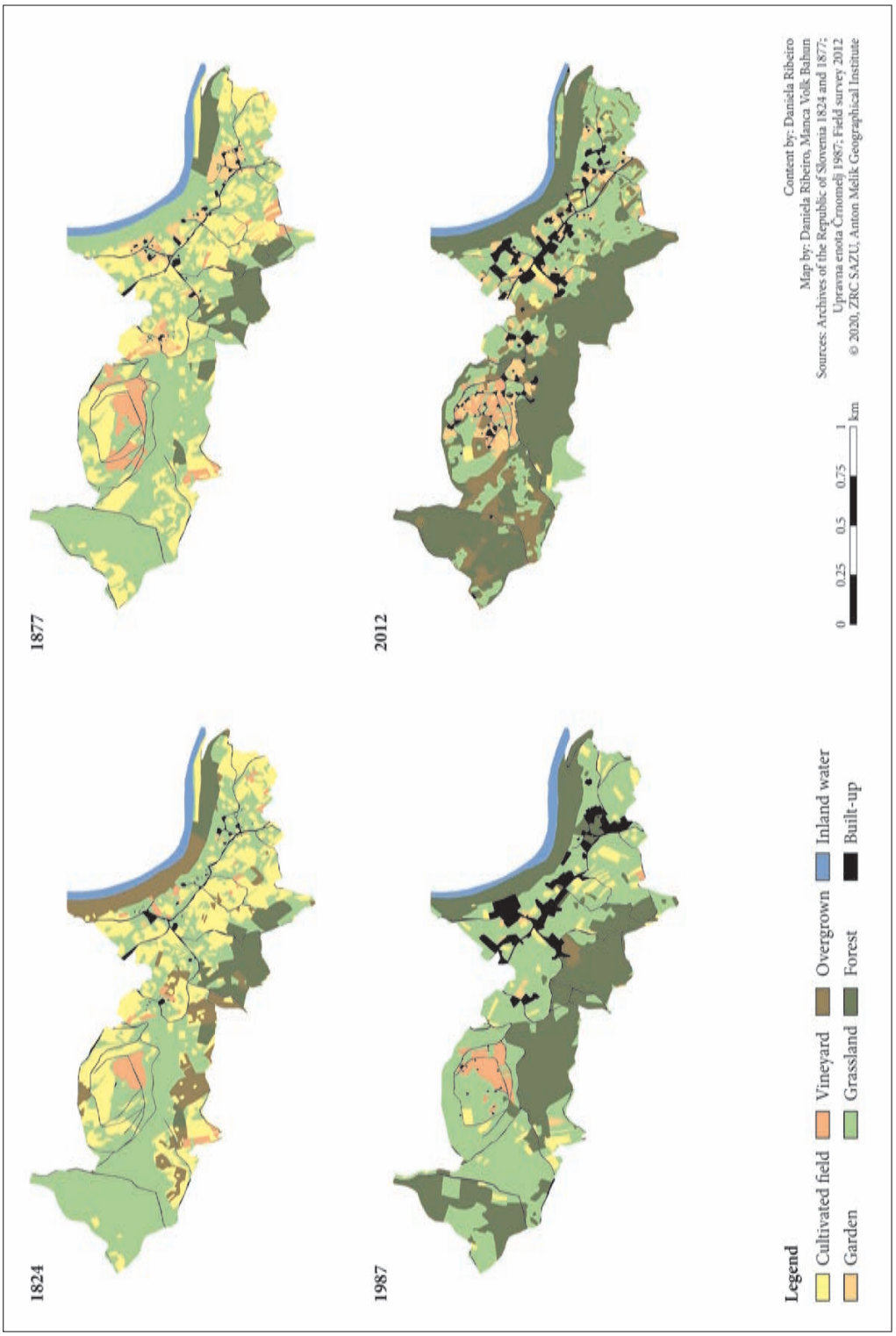
From this assessment we can ascertain that the lack of legislative provisions in Slovenia concerning the protection of karst systems, which take into account its specificities and vulnerability, contributes to the current situation in the study region to a certain degree.

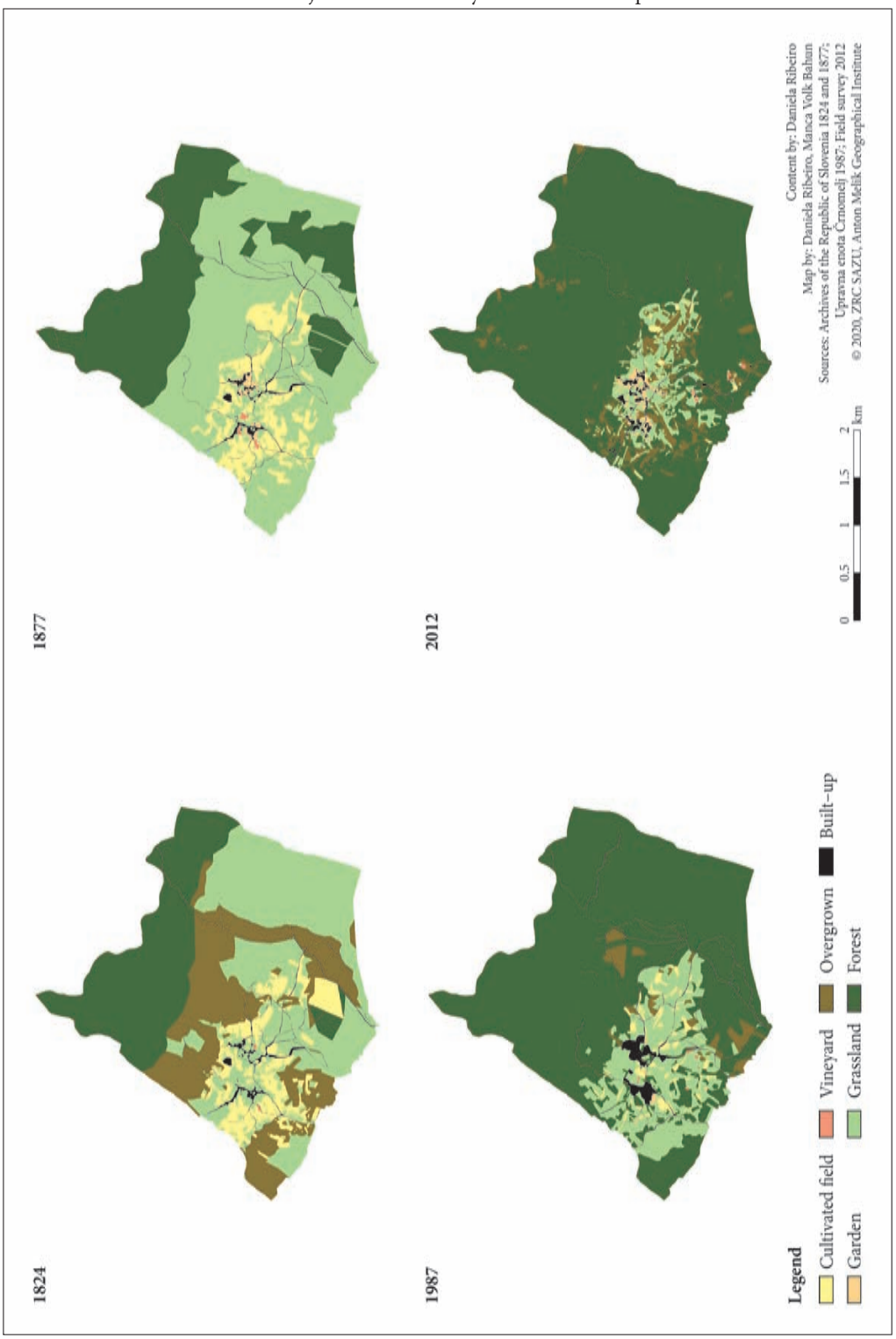
3.2 Land use analyses: Adlešiči and Bojanci case studies

3.2.1 Land use changes

The maps utilised in this study were produced using different cartographical and land surveying techniques, and they were produced for different purposes. As their original purpose was different, the mapping criteria was also different, influencing the quality of these maps. For these reasons land use categories were differently mapped in the maps used. Data from each of the available years (1824, 1877, 1987 and 2012) was included in the analysis. It is important to emphasise that our main objective in these analyses was to study the changes in agricultural and forested areas, and thus less attention was paid to built-up and inland water areas. Data for these two land use categories might not be comparable among different sources (spatial data layers) due to different mapping criteria. For the analyses we produced a map of the land use changes, a graph depicting the changes in land use categories over time, and a table with the coverage of land use categories (in ha) for the time periods included.

Figure 29: Changes in land use categories over time for the Adlešiči case study. ➤ *(p. 64)*
Figure 30: Changes in land use categories over time for the Bojanci case study. ➤ *(p. 65)*


1824
1877
1987
2012
Legend
Cultivated field
Vineyard
Overgrown
Inland water
Garden
Grassland
Forest
Built-up
0
0,25
0,5
0,75
1
km
Content by: Daniela Ribeiro
Map by: Daniela Ribeiro, Manca Volk Bahun
Sources: Archives of the Republic of Slovenia 1824 and 1877;
Upravna enota Črnomelj 1987; Field survey 2012
© 2020, ZRC SAZU, Anton Melik Geographical Institute


1824
1877
1987
2012
Legend
Cultivated field
Vineyard
Overgrown
Built-up
Garden
Grassland
Forest
0
0.5
1
1.5
2
km
Content by: Daniela Ribeiro
Map by: Daniela Ribeiro, Manca Volk Bahun
Sources: Archives of the Republic of Slovenia 1824 and 1877;
Upravna enota Črnomelj 1987; Field survey 2012
© 2020, ZRC SAZU, Anton Melik Geographical Institute

From observation of Figure 29, major changes over time can be noted for the land use categories: cultivated fields, grasslands and forests. From observation of Figure 30, major changes over time can be noted for the land use categories: cultivated fields, grasslands, overgrown and forests. It should also be noted that in both case studies, areas mapped in 1824 as overgrown were grasslands in 1877. This suggests that the category 'overgrown' was not mapped at all in 1877. As most of these areas were mapped as forests in 1987, it also suggests a cartographic error of this dataset (Revised Land Cadastre), as it is less likely that overgrown areas were converted to grasslands (1824–1877) and from grasslands to forests (1877–1987). However, the period between 1877 and 1987 is long enough to allow for changes in the landscape, which due to lack of data for this period were not perceived.

Cultivated fields in Adlešiči showed a slight increase from 1824 to 1877 but a significant reduction from 1877 to 2012 (Figure 31; row 2 in Table 13). The areas occupied by gardens in Adlešiči experienced

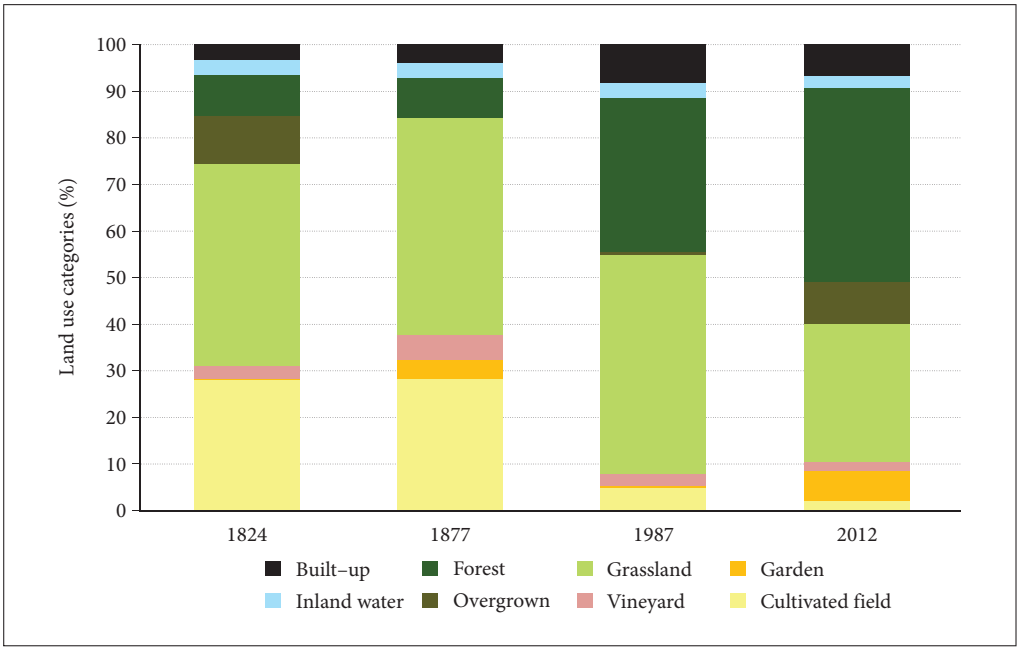


Figure 31: Changes in land use category proportions over time for Adlešiči.

Table 13: Coverage of land use categories (ha) in the Adlešiči case study.

Land use category	1824	1877	1987	2012
Cultivated field	44.23	44.89	7.67	3.48
Garden	0.32	6.32	1.01	10.02
Vineyard	4.49	8.40	3.80	2.83
Grassland	68.55	73.25	74.16	46.93
Overgrown	16.06	0.00	0.93	14.35
Forest	13.67	13.59	52.04	65.37
Inland water	4.99	4.99	4.95	4.21
Built-up	5.32	6.19	13.07	10.44

fluctuations for the timespan studied (Figure 31; row 3 in Table 13). Vineyards in Adlešiči show an increase until 1877 and from then a reduction (Figure 31; row 4 in Table 13). Grasslands in Adlešiči show a slight increase in area until 1987, but after this period the area was reduced due to an increase in forests (Figure 31; row 5 in Table 13). Overgrown areas in Adlešiči do not appear to occur in 1877, but after this period they increased (Figure 31; row 6 in Table 13). The forest areas in Adlešiči slightly decreased from 1824 to 1877 but significantly expanded from 1877 to 2012 (Figure 31; row 7 in Table 13). Over all of the map series, inland waters in Adlešiči appear constant with only minor variations (Figure 31; row 8 in Table 13). Built-up areas in Adlešiči doubled in size from 1824 to 2012 (Figure 31; row 9 in Table 13).

Cultivated fields in Bojanci showed a dramatic decrease from 1824 to 2012, although this change is more evident from 1877 to 1987 (Figure 32; row 2 in Table 14). The areas occupied by gardens experienced fluctuations for the timespan studied (Figure 32; row 3 in Table 14), as in Adlešiči. In Bojanci

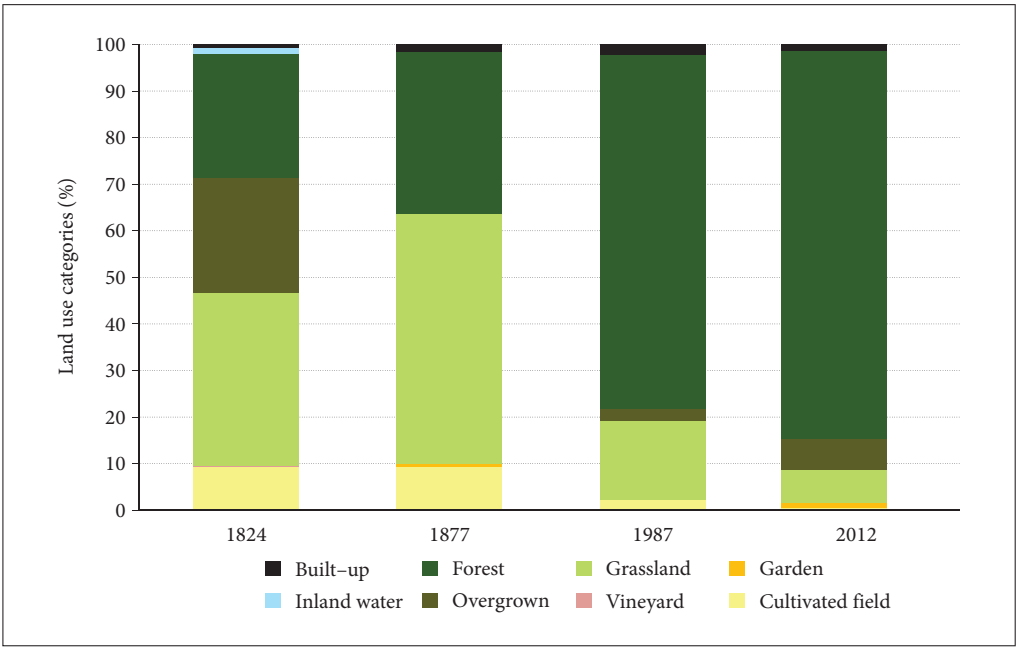


Figure 32: Changes in land use category proportions over time for Bojanci.

Table 14: Coverage of land use categories (ha) in Bojanci case study.

Land use category	1824	1877	1987	2012
Cultivated field	71.05	70.76	15.15	2.89
Garden	0.25	4.24	1.20	8.08
Vineyard	0.25	1.00	0.56	0.94
Grassland	283.51	405.50	128.31	54.01
Overgrown	186.33	0.00	19.53	49.24
Forest	202.95	262.65	573.84	631.35
Inland water	0.12	0.12	0.0	0.0
Built-up	11.66	11.85	17.53	9.61

the area of vineyards is almost negligible and as with gardens, this land use category also experienced slight fluctuations from 1824 to 2012 (Figure 32; row 4 in Table 14). In 1824 grasslands dominated in Bojanci, and this area significantly increased until 1877. After this period the area was reduced due to the increase in forests (Figure 32; row 5 in Table 14). Overgrown areas in Bojanci occupied an extensive area in 1824; in 1877 this land use category does not appear to occur, then from 1877 to 2012 it increased, although to a smaller proportion than the initial area (Figure 32; row 6 in Table 14). Even though forest area was already quite extensive in 1824, the afforested land significantly expanded over time (Figure 32; row 7 in Table 14). In Bojanci, inland waters were represented by a negligible area in 1824 and 1877, corresponding to ponds, and after this period these areas do not appear to occur (Figure 32; row 8 in Table 14). Urban expansion occurred in Bojanci from 1824 to 1987, but after this period built-up areas show a slight reduction (Figure 32; row 9 in Table 14). The results from land use changes show that the spread of forests is a general phenomenon. However, differences between the two case studies are obvious. This trend is much more pronounced in Bojanci (Figures 30 and 32) than in Adlešiči (Figures 29 and 31). Similar trends can be seen in other cadastral municipalities in Bela krajina-for example Preloka and Žuniči, where the increase in forests and decrease in cultivated fields were noted (Knific 2003).

In both case studies major landscape changes took place between 1877 and 1987. It was also reported that a major peak of emigration from Bela krajina was reached between 1912 and 1927, and thus it was expected that the amount of abandoned land would increase as a result of out-migration. In this period the amount of cultivated fields declined in both case studies. Gardens also decreased in both case studies between 1877 and 1987. In 1987 there was an increase in built-up areas in both case studies (Figures 31 and 32) suggesting that these areas were only approximately mapped in the Agrokarta, since the surface covered with urban areas decreased again in 2012. The assessment of the relationship between abandonment of agricultural land (through changes in the areas occupied by cultivated fields) and population dynamics for the time span between 1824 and 2012 is shown in the Figure 33.

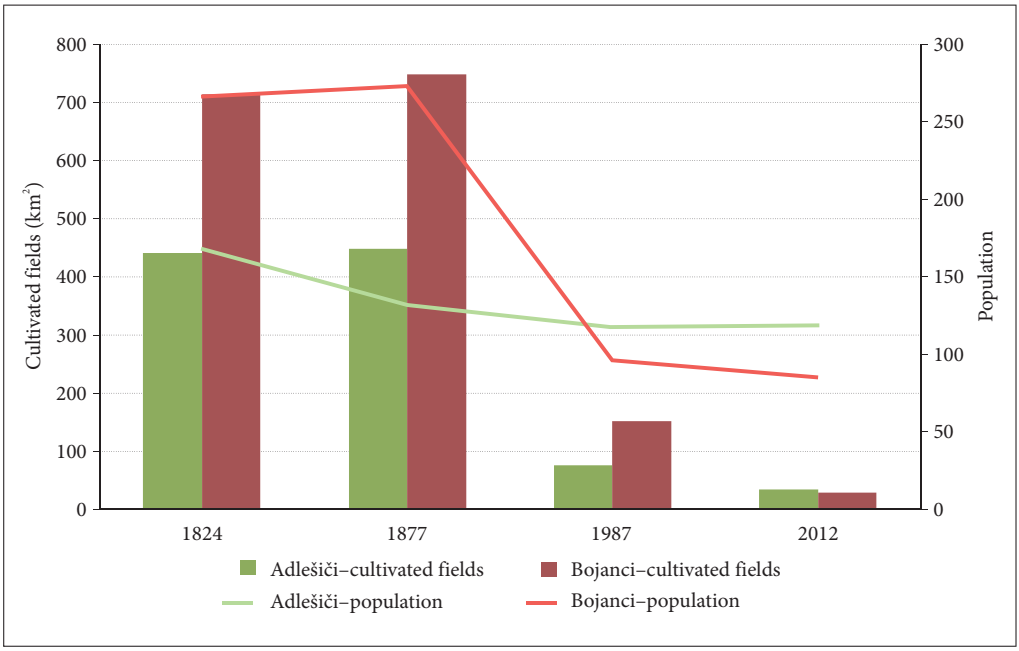


Figure 33: Changes in the areas of cultivated fields and demographic fluctuation between 1824 and 2012 for both case studies.

The changes in cultivated fields are closely related to the demographic changes in Bojanci (shown in brown, Figure 33). The slight increase in these areas between 1824 and 1877 was accompanied by an increase in the number of inhabitants in Bojanci for the same period. The pronounced decline in cultivated fields between 1877 and 1987 is parallel to a pronounced decline in population due to emigration, continuing to 2012. This connection between changes in cultivated fields and population dynamics is not seen in Adlešiči (shown in green, Figure 33). A slight expansion of cultivated fields from 1824 to 1877 is not followed by an increase in the number of inhabitants in Adlešiči. Actually, demographic fluctuation is not so obvious in this case study. Nevertheless, the area here covered by cultivated fields also immensely diminished in the analysed time period. From this we can conclude that the landscape changes are closely related to the demographic situation, however, differences between the demographic structure of the population of Adlešiči and Bojanci might have played an even more important role in landscape changes. The decrease in agricultural land use and depopulation was also verified by Gams, Lovrenčak and Ingolič (1971). As Dular (1985) also mentioned, before the 1st World War and during the inter-war years, the inhabitants of Adlešiči were predominantly a peasant population who lived from agriculture, animal husbandry and partly from viticulture. After 1955, many inhabitants of Adlešiči started working in Črnomelj (at the Belsad and Belt factories), and in Semič (in the Iskra factory) after 1970. This led to a change in the professional structure of the population that could be the main cause of agriculture abandonment in the settlement, and perhaps not the out-migration as seen in the Bojanci case study. It is likely that major changes emerged from the transformation of the social structure to non-agrarian jobs and depopulation as the result of industrialisation and de-agrarianisation. Nonetheless the timespan between 1877 and 1987 is considerable (more than 100 years), compared to the time span between the other adjacent time series, and other changes could have taken place in this period that were not assessed in this study due to a lack of available data. In both case studies, from 1987 and 2012, forests and overgrown areas continued to increase, while grasslands and cultivated fields continued to decrease. In 2012 there was a slight expansion of gardens, suggesting a recourse towards homestead food self-sufficiency.

3.2.2 Landscape stability

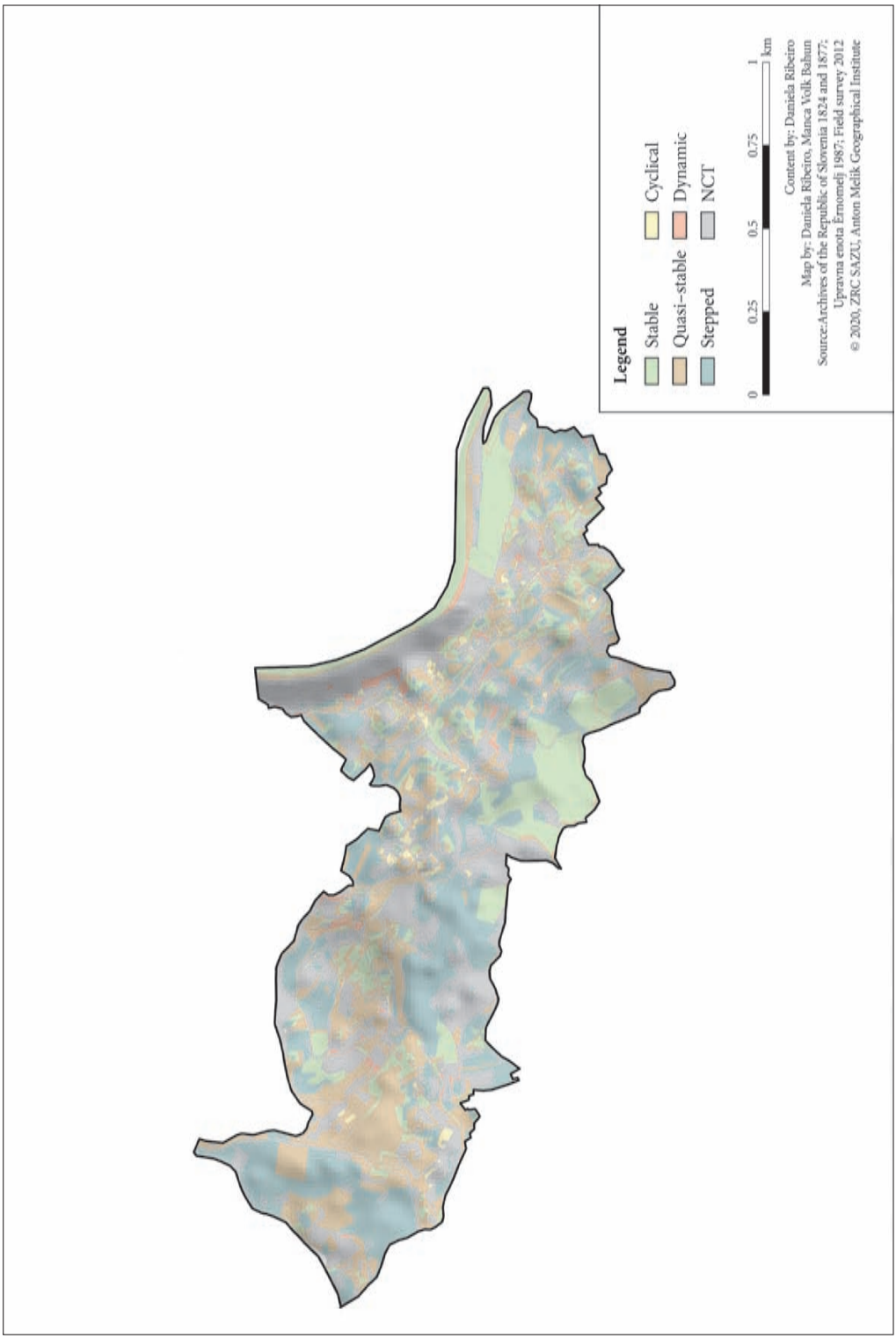
In both case studies most of the areas mapped as 'stable' belong to forest areas, and this shows that forests already mapped in 1824 are still forests today. The proportion of stability is higher in Bojanci than in Adlešiči, and the proportion of forest areas in Bojanci was higher in 1824 than in Adlešiči. Forest is the most 'stable' land use category. The stability map for the Adlešiči case study shows a mosaic of all trajectories of change without a clear dominant condition (Figure 34); whilst this mosaic of trajectories of change in Bojanci appears only around the village (Figure 35). 'Cyclical' and 'dynamic' changes have been identified in smaller areas of both case studies. Both case studies present quite extensive areas mapped as 'NCT' (no clear trend). 'NCT' includes those areas with variable changes in categories occurring several times without a clear trajectory of change. This could also be a result of the use of only 4 data layers.

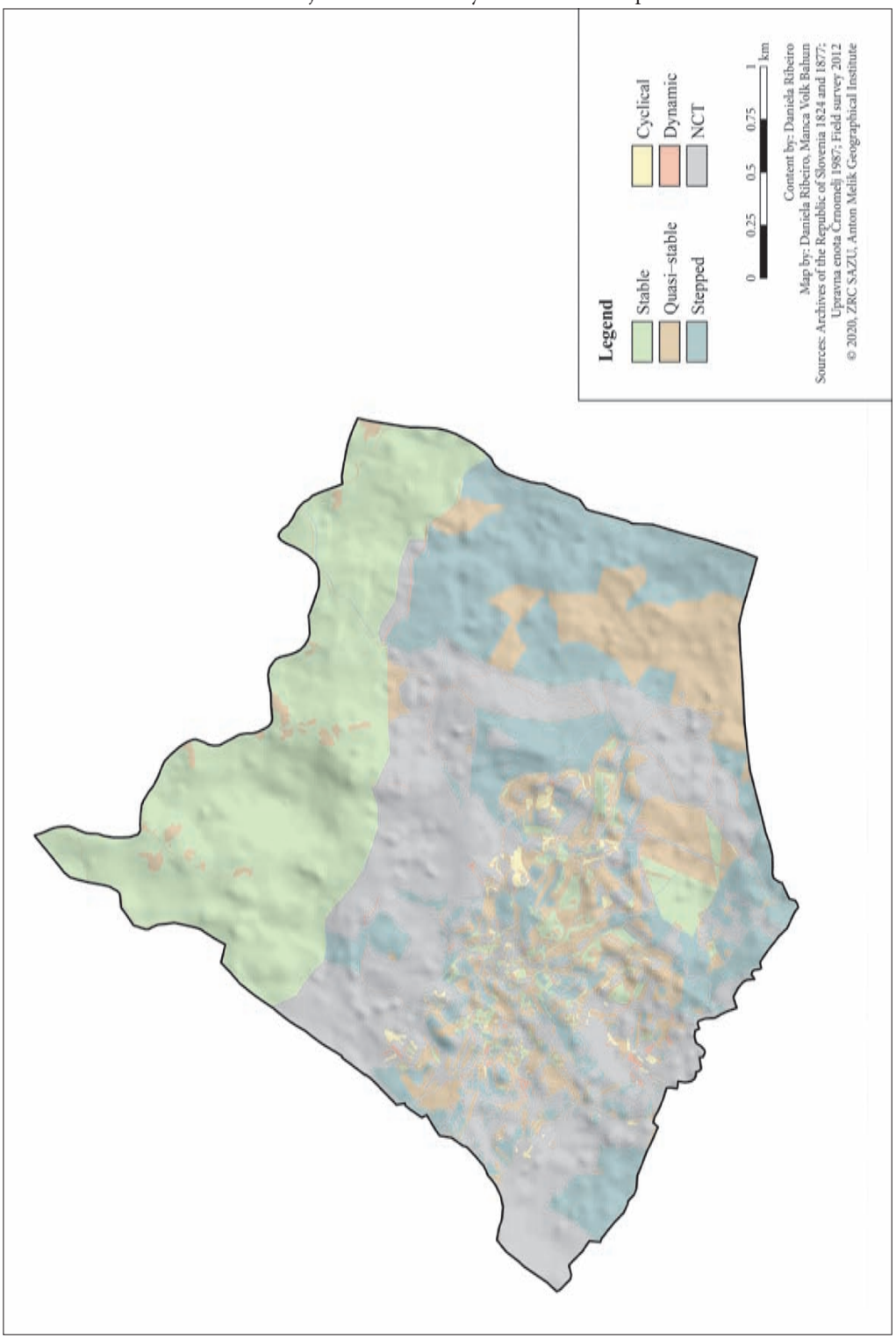
3.2.3 Land use categories over time

Figures 36 and 37 show the transitions of land use categories over time for both case studies. The box-size of land use in each time layer is proportional to land use distribution, and the size and the boldness of the arrows show the magnitude of change.

In general, arable lands are being abandoned; the cultivated fields are gradually being turned into grasslands, and grasslands to forests (in smaller areas grasslands are being converted to overgrown). Grassland was the dominant land use category in 1824 in both case studies. However, grassland areas

Figure 34: Stability map showing the trajectories of change for the Adlešiči case study. ➤ (str. 70)
Figure 35: Stability map showing the trajectories of change for the Bojanci case study. ➤ (str. 71)


Legend
Stable
Cyclical
Quasi-stable
Dynamic
Stepped
NCT
0
0.25
0.5
0.75
1
km
Content by: Daniela Ribeiro
Map by: Daniela Ribeiro, Manca Volk Bahun
Source: Archives of the Republic of Slovenia 1824 and 1877;
Upravna enota Ormoţ 1987; Field survey 2012
© 2020, ZRC SAZU, Anton Melik Geographical Institute


Legend
Stable
Quasi-stable
Stepped
Cyclical
Dynamic
NCT
0
0.25
0.5
0.75
1
km
Content by: Daniela Ribeiro
Map by: Daniela Ribeiro, Manca Volk Bahun
Sources: Archives of the Republic of Slovenia 1824 and 1877;
Upravna enota Črnomelj 1987; Field survey 2012
© 2020, ZRC SAZU, Anton Melik Geographical Institute

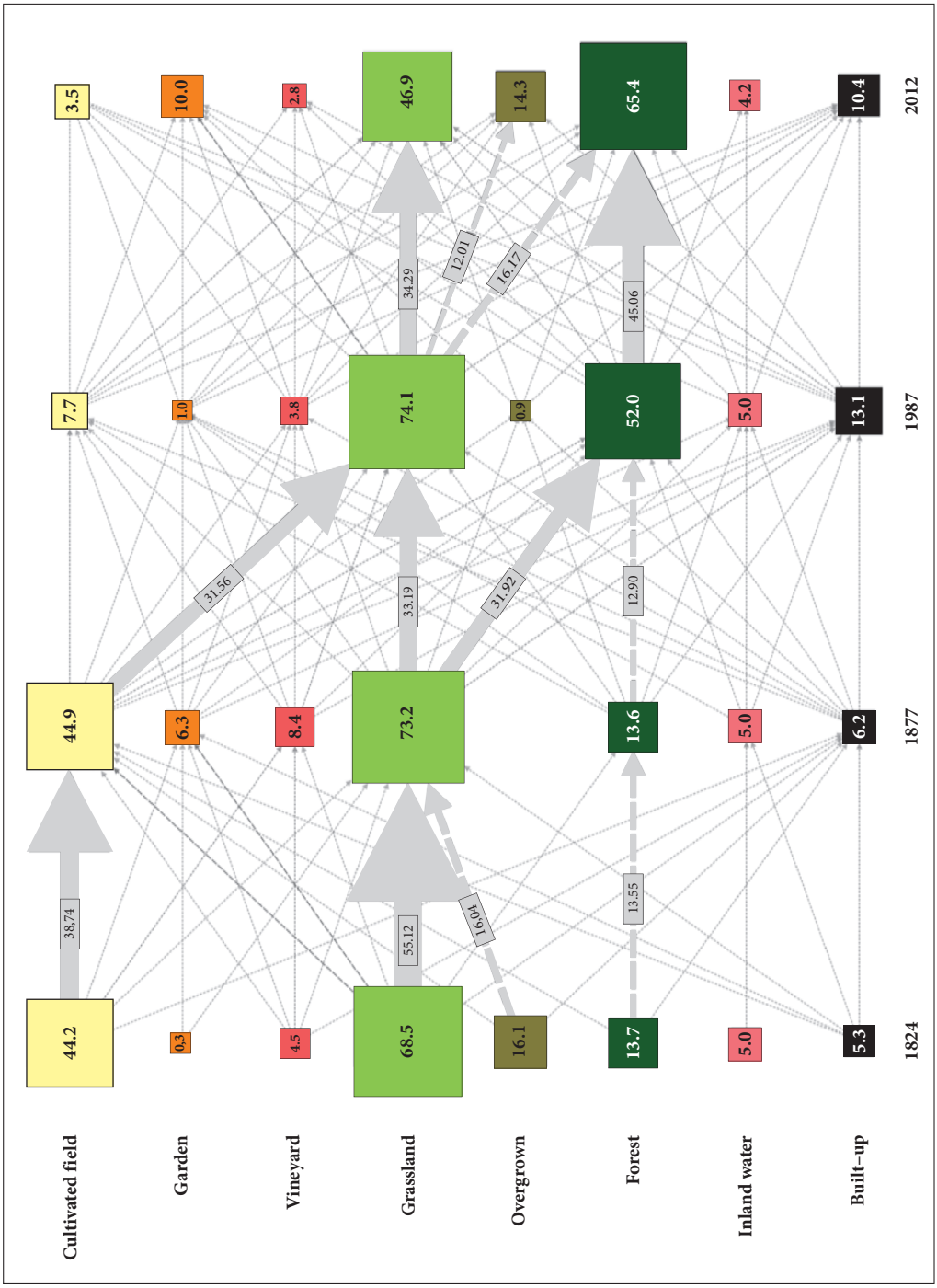


Figure 36: Transitions of land use categories (ha) over time for the Adlešiči case study.

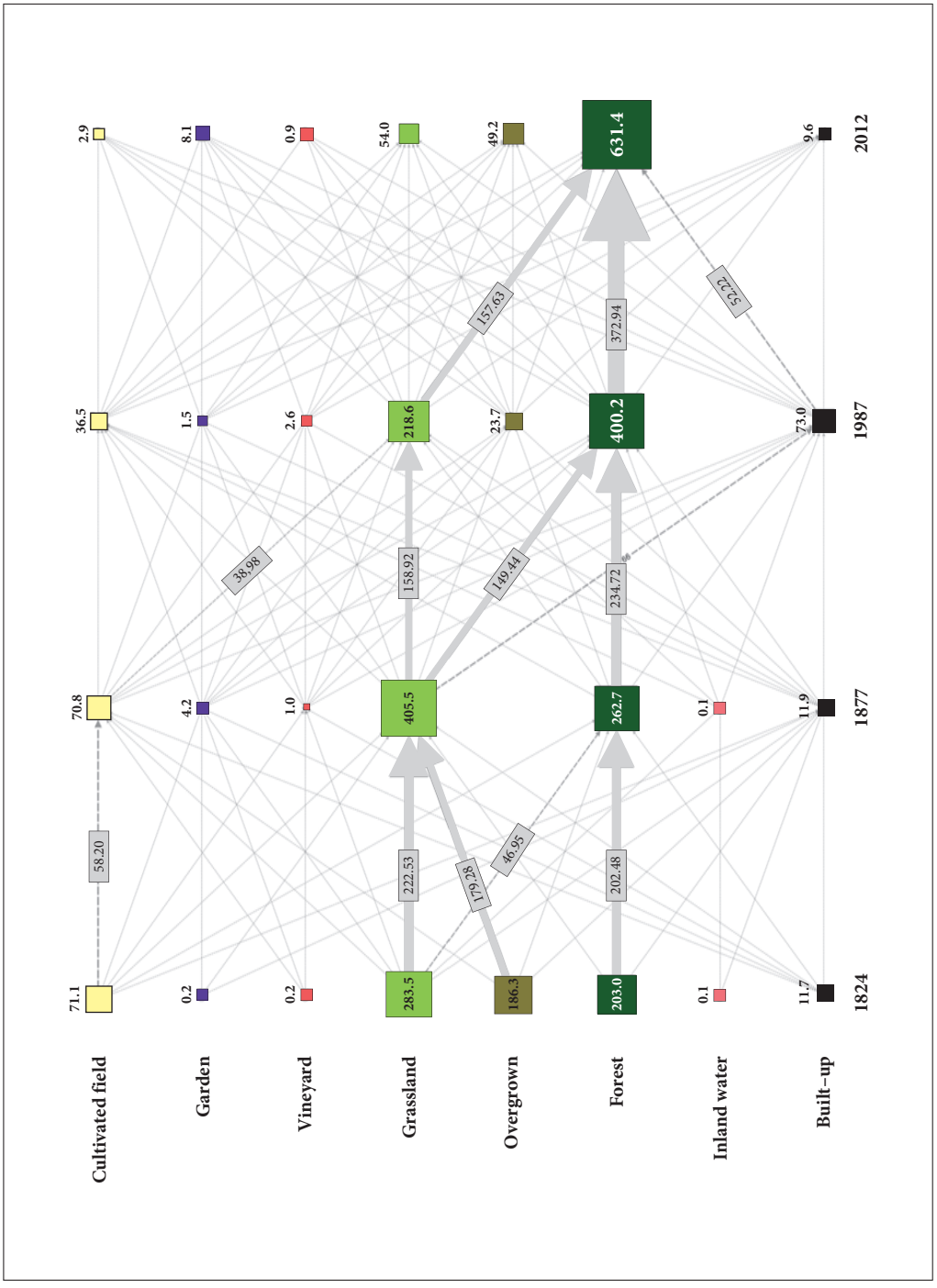


Figure 37: Transitions of land use categories (ha) over time for the Bojanci case study.

decreased from 1824 to 2012, as they were mostly converted to forest land. In both case studies forest land dramatically increased. In Bojanci the forest area increased by more than 3 times from the early 1800s, while in Adlešiči this corresponds to an almost five-fold increase. From observation of Figures 36 and 37 it is obvious that overgrown areas were mapped as grasslands in 1877. Therefore, the proportion of grasslands increased in both case studies from 1824 to 1877. In both case studies, an increase in urban areas in 1987 was followed by a decline in 2012, suggesting that this land use category was inaccurately mapped in the Agrokarta. In Adlešiči, the dominant land use categories were grasslands and cultivated fields in 1824, whilst in 2012 forests and grasslands were dominant. Meanwhile in Bojanci the dominant land use categories in 1824 were grasslands, forests and overgrown, whilst in 2012 forest land use was mostly dominant. Therefore, both case study areas suffer from land abandonment, however the landscape changes are different. In the 1800s cultivated fields had a more important role in Adlešiči than in Bojanci, as can be seen by the proportion of this land use category in each case study. However, this role disappeared in the period between 1877 and 1987.

3.3 Quantitative and qualitative analyses of the Landscape Features

3.3.1 Sustainable development indicators

3.3.1.1 Selection

For the selection of sustainable development indicators at the regional level, we were faced with a lack of common methodological frameworks, which hampers the comparison of results among different studies. Due to the previously mentioned reasons in the methods section (see subchapter 2.2.3.1) the measurement of development for the three municipalities, which cover the entire Bela krajina region, was done with the employment of a set of sustainable development indicators as represented in Table 15. With the analyses of this set of indicators, we intended to study the differences between the three municipalities as well as to identify the most representative characteristics of each municipality, in order to place them into the model scenarios of subchapter 3.3.1.3.

The economic characteristics of development in the three municipalities were examined based on 12 indicators, encompassed in three themes: 1) welfare, 2) labour market and 3) traffic/geographical accessibility. The selection of these indicators is based on the assumption that greater economic activity has a positive impact on the economy, as people have better employment opportunities. On the other hand, economic development is usually connected with increasing environmental pressures (Rovan, Malešič and Bregar 2009; Vintar Mally 2018). Nevertheless, economic indicators were interpreted only from an economic point of view, as the related social or environmental impacts are monitored by other indicators as suggested by Vintar Mally (2018).

In the following paragraphs, economic indicators (Table 15) are briefly described:

1. 'Purchasing power per capita' indicated by the gross taxable income per capita in € in 2015. This indicator was calculated by the Institute of Macroeconomic Analysis and Development, data source for calculation was acquired from the Financial Administration of the Republic of Slovenia and the Statistical Office of the Republic of Slovenia.
2. 'Added value per employee' is the most common measure of productivity. In general, the increase in added value per employee suggests an increase in productivity. The primary data source for this indicator for the year 2014 is Agency of the Republic of Slovenia for Public Legal Records and Related Services, and the calculation was made by the Institute of Macroeconomic Analysis and Development.
3. 'Average annual gross salary per employee' refers to the remuneration received for their work and includes social contributions payable by the employee. It generally represents their main source of income and therefore has a major impact on their ability to spend or save (Wages and labour costs 2016). Average annual gross salary for 2015 was calculated based on data for average monthly earnings and was acquired from the Statistical Office of the Republic of Slovenia.

4. The inclusion of the indicator 'gross investment in new fixed assets' in this assessment is extremely important, because the new forms of investment are, as a general rule, directly related to the educational structure of the population in a certain area (Ravbar and Razpotnik 2007). In this respect, new investment is usually identified with new knowledge, most often through new products, innovations and new technological or organisational approaches (Ravbar 2009). Gross investment in new fixed assets per 1000 inhabitants was based on the average gross investment in new fixed assets between 2012 and 2015, data source acquired from the Statistical Office of the Republic of Slovenia.
5. 'Job density' is expressed by the number of jobs in each municipality (in 2015) divided by its resident population of working age (15 to 64 years). This indicator was calculated based on data from the Statistical Office of the Republic of Slovenia.
6. 'Location divergence' gives an indication of the differences between workplaces and employees in a particular area, which provides the basis for insights into the socio-economic structure of the settlement network (Bole 2008). It is calculated by the ratio of the number of economically active population by place of work, and the number of economically active population by place of residence, multiplied by 100 (Ravbar and Kozina 2012). If location divergence is 100, the number of jobs and employees in the municipality is balanced, if it is greater than 100, there is an excess of job opportunities, if less than 100, there is a surplus of employees (Ravbar 2014). Source data for this indicator is from the year 2015 and was gathered at the Statistical Office of the Republic of Slovenia.
7. 'Registered unemployment rate' and changes in the number of registered unemployed also mark the contemporary situation of the components in the municipality, especially during the economic crisis (Ravbar 2014). This indicator is reflected by the proportion of registered unemployed persons among the active population by place of residence (Kozina 2013). Data for this indicator is from 2016 and was acquired from the Statistical Office of the Republic of Slovenia.
8. 'Proportion of population with service occupations', by place of residence shows professions related to trade, catering, tourism, transport and communications, community, social and personal services, finance, real estate, public administration, education and health (Kozina 2016). According to Klemenčič (1989), Slovenia reached a tertiary stage of the socio-economic transition process, and thus the proportion of the population with service occupations positively contributes to the development of the region. This is especially so in a remote rural region such as Bela krajina, where the population with service occupations represent the vast majority of the work force. When the highest degree of socio-economic development is centralised, out-migration from remote rural areas is expected. This indicator was prepared by the Statistical Office of the Republic of Slovenia, data source for the calculation is from the Statistical Register of Employment (Statistični register… 2015).
9. 'Proportion of population with tertiary education' shows the rate of graduates in relation to the total number of inhabitants. Tertiary education comprises post-secondary vocational, higher undergraduate, and postgraduate studies, conducted at public and private higher vocational schools and higher education institutions (Kozina 2013). According to Kozina (2016), a higher concentration of creative people occurs predominantly in more developed regions. Thus higher values for this indicator contribute to better conditions towards sustainable development. The data source for this indicator is from the year 2015 and was acquired from the Statistical Office of the Republic of Slovenia.
10. 'Average travel time by car to the nearest accessible regional centre' measures transport accessibility to regional centres and it is defined as the average travel time by car taken by residents of the municipality to the nearest accessible regional centres (Kozina 2013). The distance of the municipality to the nearest regional centre, here expressed as car travel time in minutes, is a significant indicator to the attractiveness of the municipality as a residential or commuting location (Gramm et al. 2008). As Bela krajina is a border region, Croatian regional centres close to the study region were also taken into account for the calculation of this indicator. Novo mesto and Karlovac were taken as regional centres for the calculation of this indicator. Information for this indicator was acquired through the web-based service Google Maps.

11. 'Average travel time by car to the nearest accessible motorway or highway connection' is another measure of transport accessibility and is defined as the average travel time by car taken by residents of the municipality to the nearest accessible motorway or highway connection. Access to significant traffic routes in marginal regions, such as Bela krajina, is a key factor of economic (as well as demographic) development. Easy access to motorways or highways offers the population greater choice of employment, residence and provisions of comodities (Razpotnik 2008). Croatian roads were also taken into account here. The accessibility and distance from the centre of each municipality to the closest motorway or highway was calculated by the distance in travel time by car in minutes through the web-based service Google Maps.
12. 'Proportion of population living within a radius of 0.5 km from the nearest public transport stop' measures accessibility to public transport. This is reflected by the proportion of the population living within a radius of 500m from public transport stops in the year 2015 (%). The data source for the calculation of this indicator was based on the public transport stations and stops within the study area (eDaljinar 2016) and number of people per house number (Evidenca hišnih številk 2015).

The environmental dimension is represented by 14 indicators, outlining the environmental pressures caused by human activities, social responses to environmental issues, and the state of some landscape elements (Vintar Mally 2018). These indicators were grouped into five themes: 1) agriculture, 2) infrastructure/technology, 3) livestock, 4) protected areas and 5) management of natural resources. Nevertheless, only 8 of them were used in the analyses due to data unavailability at municipality level.

In the following paragraphs, environmental indicators (Table 15) are briefly described:

1. 'Organically farmed land' is defined as the proportion of total utilised agricultural area occupied by organic farming. Some studies (e.g., Slabe et al. 2010; Slabe, Lampič and Juvančič 2011; Lampič and Slabe 2013) have addressed the need for organic farming for the development of the local and regional economy, enhancing the role of organic farming in improving the local/regional food supply. Organic farming reduces the impact of agriculture on karst systems, enhancing the region's sustainability. Data for this indicator was provided by the Agency for Agricultural Markets and Rural Development (Površine zemljišč… 2015).
2. Data for 'wooded areas' was acquired from land records of agricultural and forestry uses from the Ministry of Agriculture, Forestry and Food from 2016 (Evidenca dejanske rabe… 2016); from this dataset we include as wooded areas the areas classified as: plantation of forest trees, trees and shrubs, and forest. Higher values for this indicator represent better conditions towards environmental sustainability, as forests are one of the main landscape features in Slovenia, and in particular in Bela krajina.
3. 'Intensively farmed land' is represented in this study by the ratio between the area of cultivated fields (including permanent crops) and the area occupied by grasslands (meadows and pastures). Lower values indicate a predominance of grasslands, which is favourable both in terms of preserving natural resources and maintaining ecological balance. Cultivated fields and permanent crops usually refer to more intensive use of the land, and management of grasslands is usually more extensive, therefore ratios in favour of grasslands have a positive impact on environmental sustainability (Lampič et al. 2016). The data was acquired from the Statistical Office of the Republic of Slovenia for 2010 (last data available). Karst regions face a duality of challenges, on the one hand is the preservation of karst systems, which are very vulnerable and sensitive to external disturbance. On the other hand, is the relationship between nature and culture which results in valuable and unique landscapes. Intensive agriculture in karst areas goes against the principles of sustainable development in these areas. Thus the intensification of land use has negative impacts in karst systems, leading to contamination of groundwater and soil compaction and erosion.
4. 'Built-up areas' comprise different types of land use such as housing developments, industrial and commercial use, sports and leisure facilities. They also include transport infrastructure such as road and rail networks. The expansion of built-up areas is considered here as an environmental pressure, having an ecological impact. Data for built-up areas was acquired from land records of agricultural

and forestry use from the Ministry of Agriculture, Forestry and Food from 2016 (Evidenca dejanske rabe… 2016); from this dataset the records classified as 'Built-up and related land' (code 3000) were used.

5. 'Housing with district heating' refers to the proportion of buildings connected to district heating. District heating based on low-carbon energy is identified as a key technology for the transition to a low-carbon economy (Lizana et al. 2017) and thus towards sustainable energy development. This indicator is based on data from 2015, acquired from the Statistical Office of the Republic of Slovenia.
6. 'Road freight transport growth index' refers to the environmental impact that road traffic has, especially regarding emissions from this activity. However, data for this indicator is unavailable at municipal level; therefore, we were not able to include it in the analysis.
7. 'Motorisation rate' is defined as the number of passenger cars per 100 inhabitants. This indicator refers to data from 2014, acquired from the Statistical Office of the Republic of Slovenia.
8. 'Livestock density index' provides the average number of livestock units per hectare of utilised agricultural area for the year 2010 (latest data available), gathered from the Statistical Office of the Republic of Slovenia.
9. 'Natura 2000 sites' refer to the proportion of Natura 2000 sites of the total area. Data for this indicator refers to the year 2013 and was acquired from the Institute of the Republic of Slovenia for Nature Conservation. Some studies (Lampič and Mrak 2008; Lampič, Mrak and Plut 2011; The Economic benefits… 2013) have proved that the Natura 2000 network, besides providing protection to biodiversity in Europe, also imparts a range of benefits to society and the economy through recreation benefits (value of the recreational experience) and tourism (economic impacts that expenditure by visitors delivers to local economies).
10. 'Average expenditure on environmental protection (% GDP)' is an indicator which shows the social response to environment issues (Vintar Mally 2018). However, data for this indicator is not available at the municipal level and therefore this was not included in the analyses. Data is available at the statistical region level (NUTS 3), and can be acquired from the Statistical Office of the Republic of Slovenia.
11. 'Water consumption' shows the household consumption of water per capita. Due to data unavailability for the municipal level, this indicator could not be included in the analyses. Data for the level of statistical regions (NUTS 3) or watershed management can be acquired from the Statistical Office of the Republic of Slovenia.
12. 'Treated wastewater' is an indicator of the social responses to an environmental issue (wastewater production) (Vintar Mally 2018). As with the previous indicator, this indicator is only available at the statistical region (NUTS 3) or watershed management levels, therefore was not included in the analyses.
13. Efforts have been made to collect data referring to 'air quality'. However, air quality data was unavailable for Bela krajina, as there are no monitoring stations in the study region.
14. 'Municipal waste' refers to the municipal waste generated in 2015 per capita. The data source for this indicator comes from the Ministry of the Environment and Spatial Planning, however information for this indicator was calculated and acquired from the Statistical Office of the Republic of Slovenia.

The 8 indicators selected to represent the societal status of the three municipalities were grouped into two themes: 1) demographic strength and 2) social situation. Demographic indicators show the characteristics and population dynamics in the municipality, which is the main bearer of development initiatives in local communities (Ravbar 2014). We assume that a positive rate of population growth and its components are generally characteristic of areas with higher development (at least in social aspects).

In the following paragraphs, social indicators (Table 15) are briefly described:

1. 'Population density' shows the number of inhabitants per km^2 in each municipality in 2015, and is important for examining the status of the municipality. Here we consider that lower values of population density in the municipality means that these municipalities are more exposed to pressures from public administration or private interest groups (Zumaglini 2008). Data for this indicator was gathered at the Statistical Office of the Republic of Slovenia.

Table 15: The set of sustainable development indicators used to measure the sustainable development of the municipalities, presented by themes and respective domains of sustainable development. The column 'source' gives information about similar studies which have used the same or comparable indicators.

Domain	Theme	Numbering in the text	Indicator	Source
Economic	Welfare	1	Purchasing power per capita (€)	Rovan, Malešič, Bregar (2009); Ravbar (2014)
		2	Added value per employee (€)	Rovan, Malešič and Bregar (2009); Ravbar (2014); Vintar Mally (2018)
		3	Average annual gross salary per employee (€)	Potočnik Slavič (2010); Ravbar (2014); Vintar Mally (2018)
		4	Gross investment in new fixed assets per 1000 inhabitants (in 1000 €)	Ravbar (2014); Vintar Mally (2018)
	Labour market	5	Job density (number of jobs per 1000 inhabitants)	Potočnik Slavič (2010); Ravbar (2014)
		6	Location divergence	Ravbar (2014)
		7	Registered unemployment rate (%)	Rovan, Malešič and Bregar (2009); Ravbar (2014); Kazalniki blaginje v Sloveniji (2015)
		8	Proportion of population with service occupations, by place of residence (%)	Ravbar (2014)
		9	Proportion of population with tertiary education (%)	Rovan, Malešič, Bregar (2009); Ravbar (2014); Kazalniki blaginje v Sloveniji (2015)
	Traffic-geographical accessibility	10	Average travel time by car to the nearest accessible regional centre (minutes)	Ravbar (2014)
		11	Average travel time by car to the nearest accessible motorway or highway connection (minutes)	Ravbar (2014)
		12	Proportion of population living within a radius of 0.5 km from the nearest public transport stop (%)	Ravbar (2014)
Environ-mental	Agriculture	1	Organically farmed land (%)	Lampič et al. (2016); Vintar Mally (2018)
		2	Wooded areas (m^2/capita)	Vintar Mally (2018)
		3	Intensively farmed land (cropland/grassland)	Lampič et al. (2016); Vintar Mally (2018)

	Infrastructure / technology	4	Built-up areas (%)	Kazalniki blaginje v Sloveniji (2015); Vintar Mally (2018)
		5	Housing with district heating (%)	Vintar Mally (2018)
		6	Road freight transport growth index	Vintar Mally (2018)
		7	Motorisation rate (cars/100 people)	Rovan, Malešič and Bregar (2009); Vintar Mally (2018)
	Livestock	8	Livestock density index (LSU/ha)	Lampič et al. (2016); Vintar Mally (2018)
	Protected areas	9	Natura 2000 sites (%)	Kazalniki blaginje v Sloveniji (2015); Vintar Mally (2018)
		10	Average expenditure on environmental protection (% GDP)	Rovan, Malešič, Bregar (2009); Vintar Mally (2018)
	Management of natural resources	11	Water consumption (m^3/capita)	Kazalniki blaginje v Sloveniji (2015); Vintar Mally (2018)
		12	Treated wastewater (m^3/capita)	Kazalniki blaginje v Sloveniji (2015); Vintar Mally (2018)
		13	Air quality (assessment)	Kazalniki blaginje v Sloveniji (2015); Vintar Mally (2018)
		14	Municipal waste (kg/capita)	Rovan, Malešič and Bregar (2009); Kazalniki blaginje v Sloveniji (2015); Vintar Mally (2018)
Social	Demographic strength	1	Population density (people/km^2)	Ravbar (2014); Vintar Mally (2018)
		2	Ageing index	Rovan, Malešič and Bregar (2009); Ravbar (2014); Vintar Mally (2018)
		3	Natality (births per 1000 inhabitants)	Ravbar (2014)
		4	Population growth (population index between 2010 and 2015)	Rovan, Malešič and Bregar (2009); Ravbar (2014); Vintar Mally (2018)
		5	Migration balance (%)	Rovan, Malešič and Bregar (2009); Potočnik Slavič (2010); Ravbar (2014)
		6	Proportion of economically active population among inhabitants, by place of residence (%)	Ravbar (2014)
	Social situation	7	Proportion of population which receives social assistance (number of recipients/1000 people)	Rovan, Malešič and Bregar (2009); Potočnik Slavič (2010); Ravbar (2014); Vintar Mally (2018)
		8	Number of associations per 1000 inhabitants	Potočnik Slavič (2010); Ravbar (2014)

2. 'Ageing index' gives information on the population structure of the municipality. Data for this indicator regards 2015 and was acquired from the Statistical Office of the Republic of Slovenia.
3. 'Natality' refers to live births per 1000 inhabitants in 2015. Data for this indicator was acquired from the Statistical Office of the Republic of Slovenia.
4. 'Population growth' shows the rate of regeneration within a population. Here it shows the trend of population change between 2010 and 2015. The data source for this indicator was acquired from the Statistical Office of the Republic of Slovenia.
5. 'Migration balance' is the ratio between immigrants to and emigrants from an area. This indicator shows the total net migration per 1000 inhabitants in 2015 and was acquired from the Statistical Office of the Republic of Slovenia.
6. 'Proportion of economically active population among inhabitants' comprises the proportion of population aged between 15 and 64 who were employed or unemployed for at least six months in 2015 and was gathered at the Statistical Office of the Republic of Slovenia.
7. 'Proportion of population which receives social assistance' shows the number of recipients of financial social assistance per 1000 inhabitants for 2011 (latest available data) and was gathered at the Statistical Office of the Republic of Slovenia.
8. 'Number of associations per 1000 inhabitants' refers to the number of voluntary non-profit organisations, including NGOs, political or social organisations registered in the municipality per 1000 inhabitants. This indicator plays a positive role in regional development as it shows the organisation of the civil society in local communities (Ravbar 2014). The number of associations was acquired from the Register of Associations, Institutions and Political Parties (Društva, politične stranke in ustanove 2017).

3.3.1.2 Measuring sustainable development

The measurement of the sustainable development of the three municipalities using sustainable development indicators presented in Tables 16, 17 and 18 was done by the comparison of each indicator with the average for the study region. If the value was lower than the average in the study region a minus (–) was assigned; if the value was the same or was not significantly different from the average for the study region an equals (=) was assigned and, if the value was higher than the average for the study region a plus (+) was assigned. For the comparison between the study region and the average for Slovenia we used numbers (Columns 7 and 8 in Tables 16, 17 and 18).

According to the analysis of economic indicators, Semič is the most developed municipality in the study region, while Črnomelj is the least developed.

According to the environmental indicators, both Črnomelj and Semič are in a favourable position in the area of environmental sustainability, however Semič is in a relatively better position, followed by Črnomelj and then Metlika.

In accordance with social indicators, Semič has achieved higher development, followed by Metlika and finally Črnomelj.

The quantitative analysis of the landscape features for sustainable development, through the application of classic sustainable development indicators for the three municipalities, shows that there are differences among the three municipalities (Tables 16, 17 and 18). The most favourable domain in the Črnomelj Municipality is environmental, and the least developed is social (Column 2 in Table 19). In Metlika the most developed domain is economic, while the environmental and social domains are less developed (Column 3 in Table 19). In Semič, all three pillars of sustainable development in this municipality are above the average for Bela krajina. The most favourable domain of sustainability is environmental, followed by economic, and finally the social domain (Column 4 in Table 19).

Considering the above, it is possible to state that we found differences in structure with regard to the economy, population and environment within Bela krajina. Taking into account the 3 domains and comparing all three municipalities, we can conclude that Semič is the most sustainably developed municipality in Bela krajina, and Črnomelj is the least sustainably developed municipality in Bela krajina, with Metlika

Table 16: Values attributed to the economic indicators for the three municipalities, as well as averages for the study region and Slovenia.

Theme	Numbering in the text	Indicator	Črnomelj	Metlika	Semič	Bela krajina	Slovenia
Welfare	1	Purchasing power per capita (€)	=	–	+	6906.7	8007.0
	2	Added value per employee (€)	–	–	+	31,165.7	41,124.0
	3	Average annual gross salary per employee (€)	+	–	–	1276.9	1555.7
	4	Gross investment in new fixed assets per 1000 inhabitants (in 1000 €)	–	+	+	5705.6	9517.0
Labour market	5	Job density (number of jobs per 1000 inhabitants)	–	=	+	357.3	378.9
	6	Location divergence	–	+	+	88.6	102.8
	7	Registered unemployment rate (%)	–	+	+	17.6	12.3
	8	Proportion of population with service occupations, by place of residence (%)	+	+	–	45.1	45.4
	9	Proportion of population with tertiary education (%)	+	=	–	9.5	12.6
Traffic-geographical accessibility	10	Average travel time by car to the nearest accessible regional centre (minutes)	–	+	+	32	22
	11	Average travel time by car to the nearest accessible motorway or highway connection (minutes)	=	+	–	29	19
	12	Proportion of population living within a radius of 0.5 km from the nearest public transport stop (%)	+	–	–	71.6	76.5

Table 17: Values attributed to the environmental indicators for the three municipalities, as well as averages for the study region and for Slovenia.

Theme	Numbering in the text	Indicator	Črnomelj	Metlika	Semič	Bela krajina	Slovenia
Agriculture	1	Organically farmed land (%)	–	–	+	18.1	8.8
	2	Wooded areas (m^2/capita)	–	–	+	22,077.2	5953.1
	3	Intensively farmed land (cropland/grassland)	–	–	+	0.70	0.71
Infrastructure / technology	4	Built-up areas (%)	+	–	+	3.8	5.4
	5	Housing with district heating (%)	+	+	–	8.3	13.9
	6	Road freight transport growth index	/*	/	/	/	/
	7	Motorisation rate (cars/100 people)	+	=	–	52	52
Livestock	8	Livestock density index (LSU/ha)	–	+	=	0.54	0.89
Protected areas	9	Natura 2000 sites (%)	+	–	+	43.4	37.2
	10	Average expenditure on environmental protection (% GDP)	/	/	/	/	1.15
Management of natural resources	11	Water consumption (m^3/capita)	/	/	/	/	38.1
	12	Treated wastewater (m^3/capita)	/	/	/	/	787.6
	12	Air quality (monitoring parameters)	/	/	/	/	/
	14	Municipal waste (kg/capita)	+	–	=	378.7	451.0

* No data.

Table 18: Values attributed to the social indicators for the three municipalities, as well as averages for the study region and Slovenia.

Theme	Numbering in the text	Indicator	Črnomelj	Metlika	Semič	Bela krajina	Slovenia
Demographic strength	1	Population density (people/km^2)	–	+	–	48.6	102.0
	2	Ageing index	–	–	+	126.4	122.7
	3	Natality (births per 1000 inhabitants)	–	=	+	9.4	10.0
	4	Population growth (population index between 2010 and 2015)	=	+	=	99.0	100.7
	5	Migration balance (%)	–	+	–	–3.4	0.2
	6	Proportion of economically active population among inhabitants, by place of residence (%)	–	=	+	38.6	38.9
Social situation	7	Proportion of population which receives social assistance (number of recipients/ 1000 people)	–	–	+	37.3	42.0
	8	Number of associations per 1000 inhabitants	=	+	–	13.5	11.5

in between. These results follow, to a certain extent, the trends of the municipality development coefficient presented in Figure 38. The value of the development coefficient for the Semič Municipality is slightly above the value of the same indices for the Črnomelj Municipality. However, as our results showed that the local development of the Metlika Municipality is lower than the local development of the Semič Municipality, this is not proved by the municipality development coefficient (Figure 38).

Table 19: Sustainable development in the three municipalities.

Domain of sustainable development	Črnomelj	Metlika	Semič
Economic	−2	+2	+2
Environmental	+1	−3	+3
Social	−6	−2	+1
Total score (sum)	−7	−3	+6

Table 20: Comparison of the sustainable development in the study region with the national level.

Domain of sustainable development	Bela krajina	Slovenia
Economic	−11	+11
Environmental	+5	−5
Social	−3	+3
Total score (sum)	−9	+9

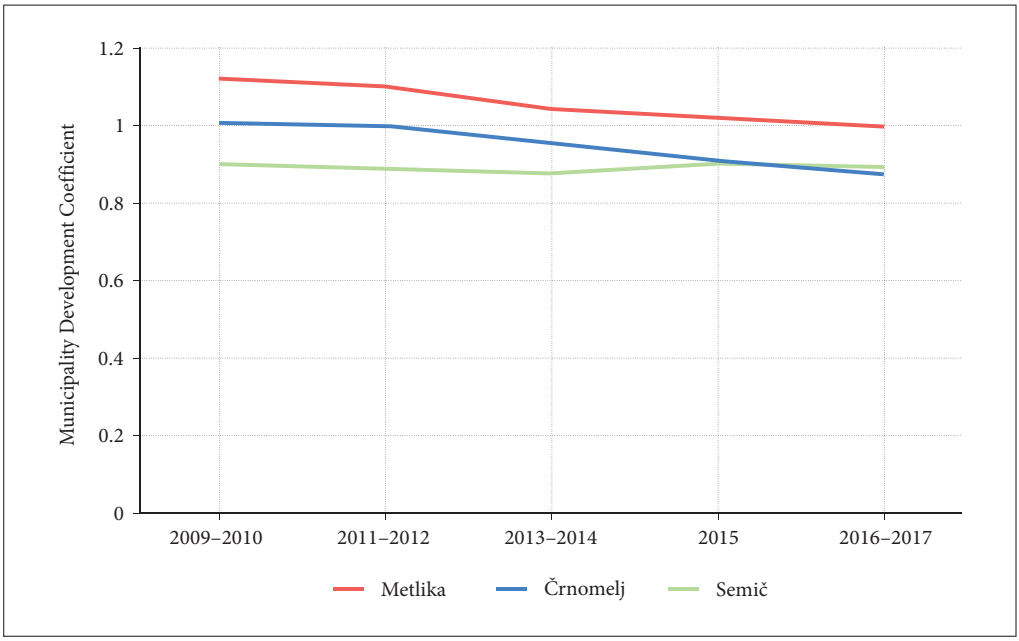


Figure 38: The development of the three municipalities of Bela krajina according to the 'Municipality Development Coefficient' (Koeficient razvitosti občin 2016).

Comparing Bela krajina with Slovenia (Table 20), according to 17 out of 29 indicators the study region is lagging behind the national average, which was previously demonstrated by other studies (e.g., Rovan, Malešič in Bregar 2009; Ravbar 2014). Of these 17 indicators, 11 belong to the economic domain, 5 to the social domain and only 1 indicator is environmental. However, with regard to eight indicators (organically farmed land, wooded areas, built-up areas, livestock density index, Natura 2000 sites, municipal waste, proportion of population which receives social assistance and number of associations) the study region is above the Slovenian average. Curiously, six of these indicators are environmental indicators. This corroborates with our argument, that the inclusion of environmental indicators in measuring sustainable development is crucial to obtaining a holistic interpretation of the development status of a certain area. In summation, the economic and social domains of Bela krajina are below the national average, while the environmental domain in Bela krajina is more favourable than the Slovenian average.

3.3.1.3 Model Matrix

Based on the sustainable development indicators presented in Tables 16, 17 and 18, we created a model matrix of landscape types reflecting their population retention capacity, which shows an important factor for sustainable regional development (Table 21).

Table 21: Model matrix of landscape types reflecting their population retention capacity.

Economic value	Environmental value	Social value	Landscape type	Population retention capacity
Low	Low	Low	Degraded landscape	Low population retention capacity
Low	High	Low	Natural landscape	/
Low	High	High	Traditional landscape of extensive agriculture and low industry. Agriculture is not retreating to a great extent but farms run extensively. Resulting in a traditional agricultural landscape.	Low population retention in the long-term due to low profitability
Low	Medium/High	Medium	Abandoned rural landscape dominated by distinct over--ageing of the population and a particularly acute decline in farming, mainly due to poor transport infrastructure in these areas. These areas are threatened by depopulation.	Low population retention in the long-term due to low profitability, depopulation and land abandonment
Medium	High	High	Multifunctional cultural landscape	Strong ability to retain long-term population
Medium	High	Medium	Valuable natural and cultural landscape; landscape maintained through agricultural subsidies and tourism	Ability to retain population through subsidies and tourism income
High	Low	High	Intensive agricultural (or industrial) landscape	Low population retention in the long-term due to consumption of environmental goods

3.3.1.4 Scenarios for Bela krajina

According to the results obtained in subchapter 3.3.1.2, we established a rating for all three municipalities in regard to their economic, social and environmental values (Table 22). Low means that more than half of the indicators were rated below the average. Medium means that half of the indicators were negatively rated and the other half positively rated. High means that more than half of the indicators were positively rated.

Table 22: Placing the three municipalities in the model scenarios.

	Črnomelj	Metlika	Semič
Economic value	Low	Medium-high	High
Environmental value	High	Low	High
Social value	Low	Medium	Medium
Landscape type	Natural landscape	Intensive agricultural landscape	Valuable natural and cultural landscape

According to the scenarios proposed in the model matrix of landscape types reflecting their population retention capacity (Table 21), Črnomelj is considered closest to a natural landscape (Column 2 in Table 22). We rearranged the classification of the Črnomelj Municipality as we believe that according to the sustainable development indicators, Črnomelj can be characterised as an abandoned rural landscape dominated by distinct over-aging of the population, poor transport infrastructure, and a particularly acute decline in farming. This municipality is threatened by depopulation, and therefore presents low population retention in the long-term due to low profitability, depopulation and land abandonment. According to the model matrix, Metlika is characterised as an intensive agriculture landscape with low population retention in the long-term due to the consumption of resources (Column 3 in Table 22). With regard to the sustainable development indicators and model matrix, Semič is defined as a valuable natural and cultural landscape (Column 4 in Table 22), i.e. a landscape maintained through agricultural subsidies and tourism with the ability to retain population through subsidies and tourism income.

The scenarios attributed to the three municipalities from the previous step (Table 22) were the basis for future scenarios for Bela krajina. These are plausible future scenarios and include:

1. The first scenario is based on the interpretation of the current situation of the Črnomelj Municipality and assumes that the current situation will continue in the future, so Bela krajina's landscapes will become completely overgrown, as a result of poor demographic structure (depopulation, population age). Abandonment of agricultural land will continue and forests will expand regardless of the potential for agriculture. This scenario is likely to result in the loss of the cultural landscape.
2. The second scenario is based on the situation of the Metlika Municipality, which predicts that industry will grow on the account of nature and that built-up areas and infrastructure will expand. This will lead to an increase in job opportunities, out-migration will decrease and the karst systems will be affected more. Agricultural activities will be more intensive, and an increase in the number of agricultural holdings and a decrease in the number of farms will take place. This scenario leads to unsustainable development of the study region.
3. The third scenario assumes that agricultural land will be more or less maintained due to financial incentives, especially through the promotion of organic farming. The overgrowing process will stabilise. The number of small enterprises will increase, as will the creation of new job opportunities.

Tourism will develop. Population growth will slightly increase. This scenario is based on the interpretation of the Semič Municipality.

The previously mentioned scenarios aim to inform and encourage decision makers to look beyond the current state of the landscape and envision more sustainable possibilities for future landscapes.

3.3.2 Structured interviews

The answers to all the questions from the interviews done by the five stakeholder groups (farmers, resident non-farmers, professionals of nature protection, tourism professionals, representatives of local governments) were analysed individually and are presented in subchapter 3.3.2.1. In general, participants tended to talk about the whole of Bela krajina and its characteristics, instead of just their local landscapes.

It is important to note that even though we conducted structured interviews with a total of 32 respondents, some of the questions were the same for all the interviewees, whilst other questions differed among them (see Table 8). Three different versions of the questionnaire were prepared according to the target stakeholder – one type was prepared for farmers and resident non-farmers; another type was prepared for tourism professionals and professionals of nature protection; and a third type was designed for representatives of local governments.

3.3.2.1 Analysis of the answers

1. What does the landscape provide you with?

Respondents mentioned between one and four different aspects of what the landscape provides for them, resulting in a total of 14 different items. The most salient item was 'Food' (17.9%) followed by 'Unspoiled nature/nature' (15.4%) (Table 23, Figure 39).

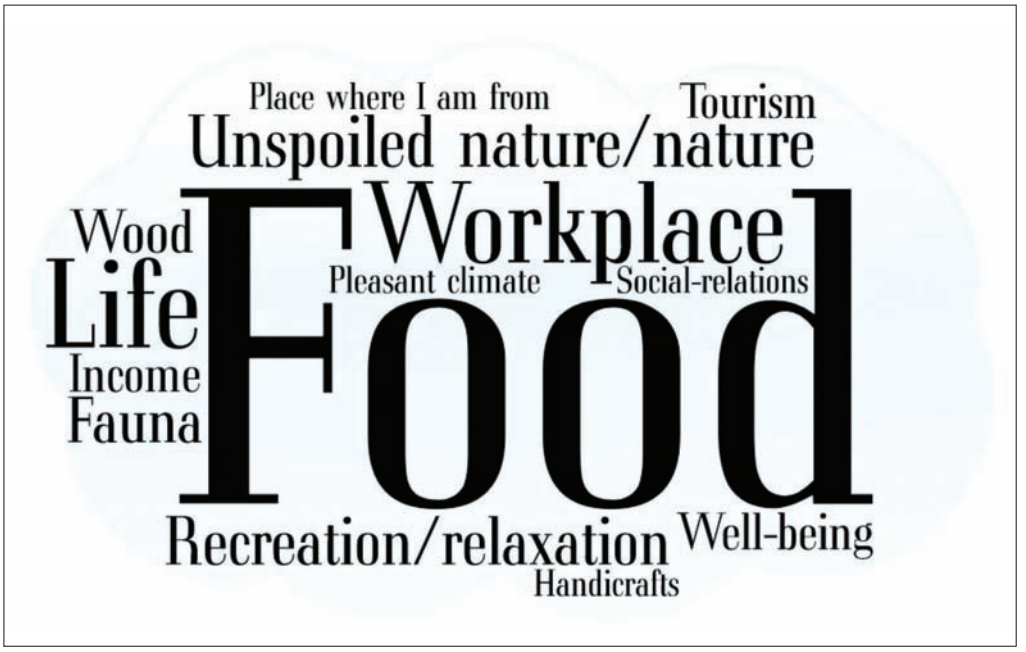


Figure 39: Prominence of words that were most frequently mentioned regarding benefits provided by the landscape.

Table 23: Items mentioned by the respondents regarding what the landscape provides them with.

Item	Response percentage (%)
Food*	17.9
Unspoiled nature/nature	15.4
Recreation/relaxation	12.8
Workplace	10.2
Life	7.7
Well-being	7.7
Place where I am from	5.1
Wood	5.1
Tourism	5.1
Income	2.6
Pleasant climate	2.6
Fauna	2.6
Handicrafts	2.6
Social-relations	2.6

*included wine (one answer)

Items such as 'Workplace' and 'Place where I am from' have a much higher importance for farmers than for resident non-farmers, similar to results shown by Bieling et al. (2014). These results show that the relationship between farmers and the landscape is often based on material factors, as Bieling et al. (2014) also discussed. Benefits such as 'Recreation/relaxation' and 'Well-being' were mostly mentioned by resident non-farmers. These results show the importance of different aspects of the landscape to different groups of stakeholders. Logically, farmers answered with 'Workplace' as a subsistence function that the landscape provides them. On the other hand, items such as 'Recreation/relaxation' and 'Well-being' are more appreciated by resident non-farmers, showing the importance of cultural landscape services for this group of stakeholders. 'Unspoiled nature/nature', one of the most often mentioned aspects of the landscape, was equally recognised by farmers and resident non-farmers, showing their appreciation of the local landscape, and according to Bieling et al. (2014), representing relationships based on landscape properties.

2. What makes this landscape attractive?

Respondents mentioned between one and 12 different aspects that make the landscapes of Bela krajina attractive (on average 3.8 items per respondent), resulting in a total of 32 different items (Figure 40). Table 24 displays these items across all respondents. The most frequently mentioned item 'Naturalness, nature' was expressed by more than a third of the respondents, followed by 'Kolpa River'. An interesting piece of information extracted from the transcriptions was that respondents talked about the Kolpa River, when asked about the attractiveness of their landscape, even those in areas distant from the river. If we included all the rivers mentioned (Kolpa, Lahinja, Krupa and Dobličica) in the item 'Water sources', the frequency of this item would substantially increase, being the most mentioned item from 65.6% of the respondents. These results show how the respondents value the physical qualities of the landscape, such as water bodies/sources.

Farmers mentioned 10 different items that make the landscape attractive. 42.9% of farmers mentioned the 'Sense of belonging' and 'Diversity, variety' of the landscape as the most attractive items, followed by 28.6% referring to 'Kolpa River', 'Beauty', 'Climate' and 'Forest'. Aspects such as: 'Tranquillity', 'Naturalness,

nature', 'Green' and 'Hills' were mentioned only once. We did not find significant differences among their answers in the different municipalities.

Representatives of local governments referred to 16 items that make the landscape attractive to live or attractive to tourism. Half of the respondents mentioned 'Naturalness, nature', 'Natural resources' and 'Kolpa River', 33.3% referred to 'Water sources', 'Green' and 'Diversity, variety'. The items 'Hills', 'Culture, traditions', 'Dobličica River', 'Lahinja River', 'Recreation, relaxation', 'Special, original', 'Tranquillity', 'Cultivation' and 'Litter raking forests' were only mentioned by one respondent. In this group of stakeholders we also did not identify significant differences among the municipalities.

Tourism stakeholders responded with 17 items related to the attractiveness of the landscape in the region, with 75% of the respondents mentioning 'Culture, traditions' being the most prominent. 50% of the respondents highlighted the 'Naturalness, nature' of Bela krajina as potential attractions for tourism. 37.5% of the respondents mentioned 'Clean', 'Kolpa River', and 'Recreation' as aspects of landscape attractiveness. All the other items were only mentioned by 25% or less of the participants ('Litter raking forests', 'Gastronomy', 'Diversity, variety', 'Green', 'Protected areas', 'Forest, woodland', 'Lahinja River', 'Biodiversity', 'Cultural landscape', 'Natural resources' and 'Ecology').

Nature protection stakeholders mentioned 16 different items that make the landscape of Bela krajina attractive. Mentioned by 75% of the respondents was the item 'Culture, traditions', followed by 'Tranquillity' and 'Karstic features' which were mentioned by 50% of the respondents. The following items were mentioned only once: 'Diversity, variety', 'Special, original', 'Unspoilt', 'Natural resources', 'Views', 'Green', 'Litter raking forests', 'Kolpa River', 'Lahinja River', 'Krupa River', 'Biodiversity', 'Quality of life' and 'Recreation, relaxation'. These results are somewhat surprising, as these respondents are more involved with nature protection, and so one might expect that their answers would be more connected to nature elements, nevertheless, the most mentioned item was 'Culture, traditions'.

Figure 40: Prominence of words that were most frequently mentioned regarding aspects of landscape attractiveness.

Resident non-farmers of Bela krajina indicated 11 items that make their landscape attractive to live in. The items 'Clean', 'Naturalness, nature' and 'Recreation, relaxation' were mentioned by 50% of the participants, followed by 'Kolpa River', 'Forest, woodland' and 'Water sources' which were mentioned by 33.3% of the respondents. The remaining items were only mentioned by one respondent ('Unspoilt', 'Quality of life', 'Provision of food', 'Green' and 'Diversity, variety'). A different answer was given by one resident non-farmer who mentioned that the landscape does not limit his activities, as he is a representative of a company located in the region.

Table 24: Items mentioned by the respondents while talking about aspects that make the landscapes of Bela krajina attractive.

Item	Response percentage (%)
Naturalness, nature	9.75
Kolpa River	8.94
Clean	7.32
Diversity, variety	7.32
Culture, traditions	6.50
Recreation, relaxation	6.50
Green	5.69
Forest, woodland	4.07
Natural resources	3.25
Litter raking forests	3.25
Special, original	3.25
Tranquillity	3.25
Water sources	3.25
Lahinja River	2.44
Sense of belonging	2.44
Unspoilt	2.44
Karstic features	1.63
Biodiversity	1.63
Quality of life	1.63
Protected areas	1.63
Cultural landscape	1.63
Gastronomy	1.63
Hills	1.63
Climate	1.63
Beauty	1.63
Krupa River	0.81
Views	0.81
Provision of food	0.81
Cultivation	0.81
Dobličica River	0.81
Ecology	0.81
Does not limit activities	0.81

3. Does the landscape contribute to your well-being? How?

12 out of 13 respondents affirmed that their landscape contributes positively to their well-being. These respondents indicated 20 aspects (Figure 41) of the landscape that contribute to their well-being, such as: 'Beauty', 'Naturalness, nature', 'Forest', 'Kolpa River', 'Hills', 'Recreation, relaxation', 'Good air', 'Good water', 'Vineyards, wine', 'Home', 'Pleasant landscape', 'Cultivated landscape', 'Joy', 'Green', 'Peace', 'Undulating landscape', 'Positive landscape', 'Health', 'Happiness' and 'Good for the soul'.

As in the study by Bieling et al. (2014), we can say that the referred to items are related to forms of the landscape and relationships. According to Bieling et al. (2014), aspects such as 'Peace', 'Good for the soul', 'Home', 'Happiness', 'Joy', 'Health', and 'Recreation, relaxation' are predominantly intangible relationships. We also consider 'Positive landscape' and 'Pleasant landscape' as intangible relationships. Aspects such as 'Good air', 'Good water', 'Green', 'Naturalness, nature' are relationships based on the landscape properties. 'Beauty' as a holistic aspect is considered to be connected to the different relationships between humans and the landscape. Only 1 out of 13 respondents mentioned that the landscape itself does not contribute to his well-being but rather to his lifestyle, however he affirmed that life where he lived is good. On the other hand, this respondent recognised a negative aspect of his landscape, which is the distance to markets.

The relationships between humans and the landscape were mentioned more frequently than the forms of the landscape (Table 25). Within these relationships, the intangible relationships were expressed more often. 'Recreation, relaxation' was mentioned more often (14.71%), followed by 'Naturalness, nature', 'Good air' and 'Peace' each with 11.77% of responses.

Aspects such as 'Beauty', 'Forest', 'Hills', 'Good water', 'Vineyards, wine', 'Home', 'Pleasant landscape', 'Cultivation landscape', 'Joy' and 'Green' were only mentioned by farmers. While items such as 'Peace', 'Undulating landscape', 'Positive landscape', 'Health', 'Good for the soul' and 'Happiness' were only

Figure 41: Prominence of words that were most frequently mentioned regarding the way landscape contributes to human well-being.

Table 25: How the landscape contributes to human well-being.

	Items mentioned	Response percentage (%)
Forms	Forest	2.94
	Kolpa River	2.94
	Hills	2.94
	Vineyards, wine	2.94
	Cultivated landscape	2.94
	Undulating landscape	2.94
Relationships	Recreation, relaxation	14.71
	Naturalness, nature	11.77
	Peace	11.77
	Good air	11.77
	Beauty	5.88
	Home	2.94
	Pleasant landscape	2.94
	Joy	2.94
	Green	2.94
	Good water	2.94
	Positive landscape	2.94
	Health	2.94
	Happiness	2.94
	Good for the soul	2.94

mentioned by resident non-farmers. 'Naturalness, nature', 'Good air' and 'Recreation, relaxation' were equally mentioned by farmers and resident non-farmers. The majority of the landscape forms mentioned were noted by farmers. Resident non-farmers seem to give higher importance to intangible relationships.

4. What are the characteristics of this landscape that distinguish this place from other landscapes?

With this question we expected that the respondents would mention items such as nature (e.g., birch trees, proteus, dolines), ethnic (e.g., Uskoks), culturological (e.g., traditions of working in dolines, dialects) and historical contexts.

Respondents mentioned from 2 to 11 different characteristics of their landscape that make it distinct from other landscapes (on average 4.8 items per respondent), from a total of 33 different items (Figure 42, Table 26).

One might think that when respondents mentioned characteristics of their landscape such as 'Remote', 'Absence of large factories/industry', 'Absence of mass tourism' and 'Not well developed' they were meant as negative aspects, however these were actually expressed as positive characteristics of their landscape. The majority of the respondents answered that the region gains from low development, that it is an advantage for the region to be less developed by protecting natural areas from being destroyed for development.

Respondents also refer to human characteristics while talking about the characteristics of their landscape, such as 'Modesty', 'Hospitality', 'Benevolence' and 'Modern and sustainable mentality', expressing anthropocentric values.

More frequently mentioned distinct characteristics of the landscapes in Bela krajina were 'Karstic terrain', 'Litter raking forests' and 'Absence of large factories/industry'.

Figure 42: Prominence of words that were most frequently mentioned regarding characteristics of the landscape that makes it distinct from other landscapes.

Table 26: Characteristics of the landscape that distinguish it from other places.

Characteristics of the landscape	Response percentage (%)
Karstic terrain	6.9
Litter raking forests	6.9
Absence of large factories/industry	6.9
Hills	5.2
Remote	5.2
Enclosed by natural barriers	5.2
Hospitality	5.2
Preserved nature, biotopes	5.2
Modesty	3.5
Kolpa River	3.5
Clean nature	3.5
Not well developed	3.5
Dolines, cultural dolines	3.5
Wine-growing and wine tasting	3.5
Climate	1.7
Livestock, sheep	1.7
Poor road infrastructure	1.7
Benevolence	1.7

Characteristics of the landscape	Response percentage (%)
Modern and sustainable mentality	1.7
Beech forests	1.7
Uneven surface	1.7
Not excessively settled	1.7
Public access to nature	1.7
Endemic black olm	1.7
Preserved traditions	1.7
Good infrastructure	1.7
Safe for tourism	1.7
Good gastronomy	1.7
Cultural events	1.7
Diversity	1.7
Absence of mass tourism	1.7
Cultural landscape	1.7
Certified tourism	1.7

'Karstic terrain', 'Hills' and 'Litter raking forests' were the most often mentioned characteristics among nature protection stakeholders. Tourism stakeholders commonly mentioned that 'Absence of large factories/industry' is one characteristic of the region that makes it distinct from other places.

Table 27: Characteristics of the landscape mentioned by nature protection stakeholders and tourism stakeholders and the relative percentage difference between both groups of stakeholders.

Characteristics of the landscape	Percentage mentioned by professionals of nature protection	Percentage mentioned by tourism professionals
Climate	100.0	–
Preserved nature, biotopes	50.0	50.0
Karstic terrain	75.0	25.0
Hills	100.0	–
Dolines, cultural dolines	100.0	–
Litter raking forests	75.0	25.0
Livestock, sheep	100.0	–
Remote	66.7	33.3
Enclosed by natural barriers	66.7	33.3
Poor road infrastructure	100.0	–
Modesty	50.0	50.0
Hospitality	33.3	66.7
Benevolence	100.0	–
Modern and sustainable mentality	100.0	–
Kolpa River	50.0	50.0
Beech forests	100.0	–
Uneven surface	100.0	–
Clean nature	–	100.0

Characteristics of the landscape	Percentage mentioned by professionals of nature protection	Percentage mentioned by tourism professionals
Not excessively settled	–	100.0
Absence of large factories/industry	25.0	75.0
Public access to nature	–	100.0
Cultural landscape	–	100.0
Endemic black olm	–	100.0
Preserved traditions	–	100.0
Good infrastructure	–	100.0
Safe for tourism	–	100.0
Good gastronomy	–	100.0
Cultural events	–	100.0
Wine-growing and wine tasting	–	100.0
Diversity	–	100.0
Absence of mass tourism	–	100.0
Not well developed	50.0	50.0
Certified tourism	–	100.0

As can be seen in Table 27, some aspects of the landscape are only mentioned by one group of stakeholders. This could show the importance of different features of the landscape for different stakeholders. Nature protection stakeholders mentioned more forms of the landscape (e.g., karstic terrain, hills, etc.), while tourism stakeholders seem to have a more holistic view of the landscape and its characteristics.

5. Has the landscape changed from the past until now? Has it changed for better or worse, how and why?

90.6% of the respondents responded that the landscape had changed from the past until the present, whilst the remaining respondents said that the landscape had not suffered changes. From those respondents who affirmed that the landscape had changed, their opinion varies considerably regarding the types of change: if the change was for the better or for the worse (Table 28).

The percentage of respondents who mentioned that the landscape had changed for the worse (34.5%) is not significantly different from the percentage of respondents who mentioned that landscape had changed for the better (27.6%) (Table 28, Figure 43).

The answers given by the respondents regarding the ways the landscape had changed were grouped according to the probable direction of landscape change, and are presented in Table 29. Note that these groups were not created by the respondents but by the author; the answers were grouped in order to analyse and understand them.

All the resident non-farmers, professional of nature protection and tourism professionals mentioned that the landscape had changed from the past, as they remembered it. 85.7% of the farmers mentioned

Table 28: Percentage of respondents who mentioned the occurrence of landscape changes.

	Response percentage (%)
Landscape changed for the better	27.6
Landscape changed for the worse	34.5
Some things in the landscape changed for the better, others changed for the worse	20.7
I do not know if the landscape changed for the better or the worse	17.2

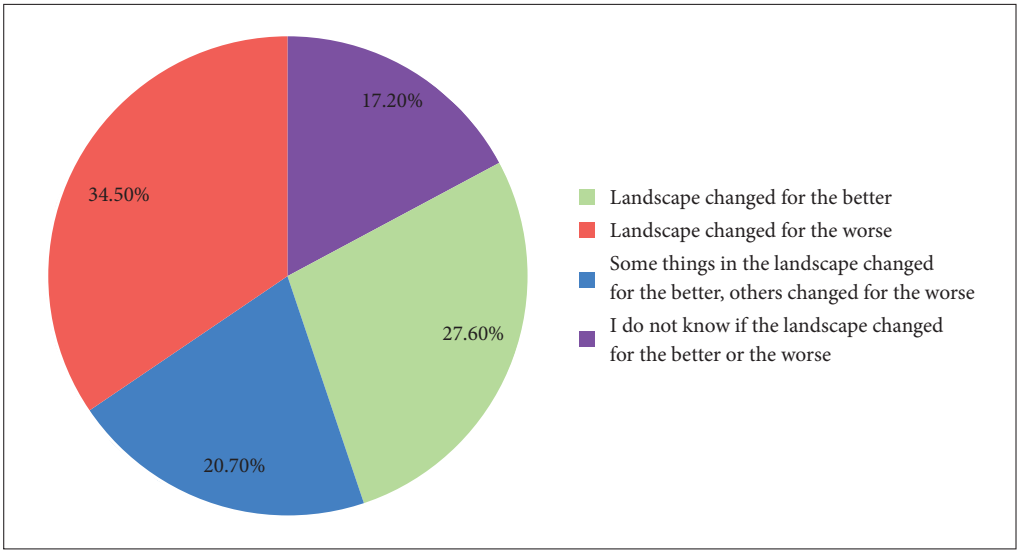


Figure 43: Graphical representation of the answers regarding landscape changes.

that the landscape had changed as they remembered, whilst 14.3% thought otherwise. Representatives of local governments were divided, 66.7% mentioned that the landscape had changed, whilst the remaining 33.3% affirmed that the landscape had not changed.

Changes associated with the abandonment of agricultural land and overgrowth were considered negative (Table 29) by the majority of the respondents, and a similar result was also obtained by Gantar and Golobič (2015).

Regarding whether landscape change had been for the better or for the worse, the opinion of local stakeholders is divided (Table 30).

Table 29: Directions of landscape change according to respondents, grouped by subject matter.

Change in society and / or economy	Abandonment of traditional practices	Modernisation of agriculture	Industry development
• Reduced job opportunities • Worsened relationship between local communities and municipalities • Less connection among locals • Worsened economy • Increase in the number of tourists	• Fewer people engaged in agriculture • Less agricultural production • Increase in forested areas • Increase in overgrown areas • Increase in naturalness and biodiversity • Less mills • Increase of the water level	• Land improvement and hydro meliorations • Modern agriculture • Better vineyards / better wine • Larger land plots • Better machinery • Different ways of farming • Increase in farm land • Less crop diversity	• Higher development • Increase in infrastructure • Increase in built-up areas • Cleaner industry • More industry • Increase in technology • Decrease in green areas • Worse quality of environment

Table 30: Landscape changes according to stakeholder group, regarding type of change.

	Farmers	Resident non-farmers	Professionals of nature protection	Tourism professionals	Representatives of local governments
Landscape changed for the better.	33.3%	14.3%	25.0%	37.5%	25.0%
Landscape changed for the worse.	66.7%	14.3%	50.0%	37.5%	/
Some things in the landscape changed for the better, others changed for the worse.	/	42.8%	/	12.5%	50.0%
I do not know if the landscape changed for the better or the worse.	/	28.6%	25.0%	12.5%	25.0%

6. What are the main factors that influence landscape change?

The respondents mentioned 21 different factors that they believe influence landscape changes in Bela krajina (Table 31).

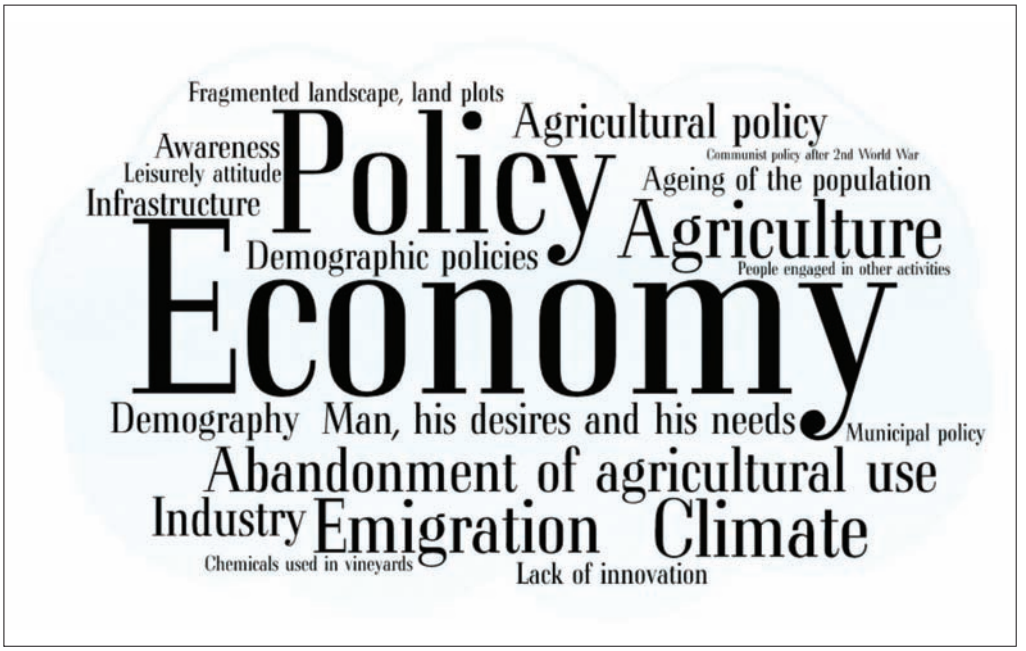


Figure 44: Prominence of words that were most frequently mentioned regarding the factors that influence landscape change.

Table 31: Factors that influence landscape change.

	Response percentage (%)
Economy	12.5%
Policy	10.8%
Abandonment of agricultural use	7.1%
Agriculture	7.1%
Emigration	7.1%
Human desires and needs	7.1%
Agricultural policy	5.3%
Climate	5.3%
Industry	5.3%
Ageing of the population	3.6%
Demography	3.6%
Demographic policies	3.6%
Fragmented landscape, land plots	3.6%
Infrastructure	3.6%
People engaged in other activities	3.6%
Chemicals used in vineyards	1.8%
Communist policy after 2nd World War	1.8%
Lack of innovation	1.8%
Lazy attitude	1.8%
Municipal policy	1.8%
Awareness	1.8%

The factor that influences landscape change with the highest response percentage was 'Economy' with 12.5%, followed by 'Policy' with 10.7% (Figure 44, Table 31). However, as we can see in Table 31, other factors related to 'Policy' were mentioned, such as, 'Agricultural policy', 'Demographic policies', 'Municipal policy' and 'Communist policy after 2nd World War'. If we include these factors in the item 'Policy' then the response percentage is 23.3% and thus this would be the most mentioned item. Therefore, the responses were grouped according to their meanings, as different mentioned factors can actually mean similar things (Table 32), so the number of factors that influence landscape change was reduced to 14 (Figure 45).

Table 32: Factors that influence landscape change grouped according to similar meanings.

Mentioned factors	Response percentage (%)
Policies	23.3%
Demography	14.3%
Economy	12.5%
Abandonment of agricultural use	7.1%
Agriculture	7.1%
Human desires and needs	7.1%
Climate	5.3%
Industry	5.3%

Mentioned factors	Response percentage (%)
Fragmented landscape, land plots	3.6%
Infrastructure	3.6%
Lazy attitude, Lack of innovation	3.6%
People engaged in other activities	3.6%
Chemicals used in vineyards	1.8%
Awareness	1.8%

According to Table 32, the factor that influences landscape change with the highest response was 'Policies' (23.3%), followed by 'Demography' (14.3%) and 'Economy' (12.5%).

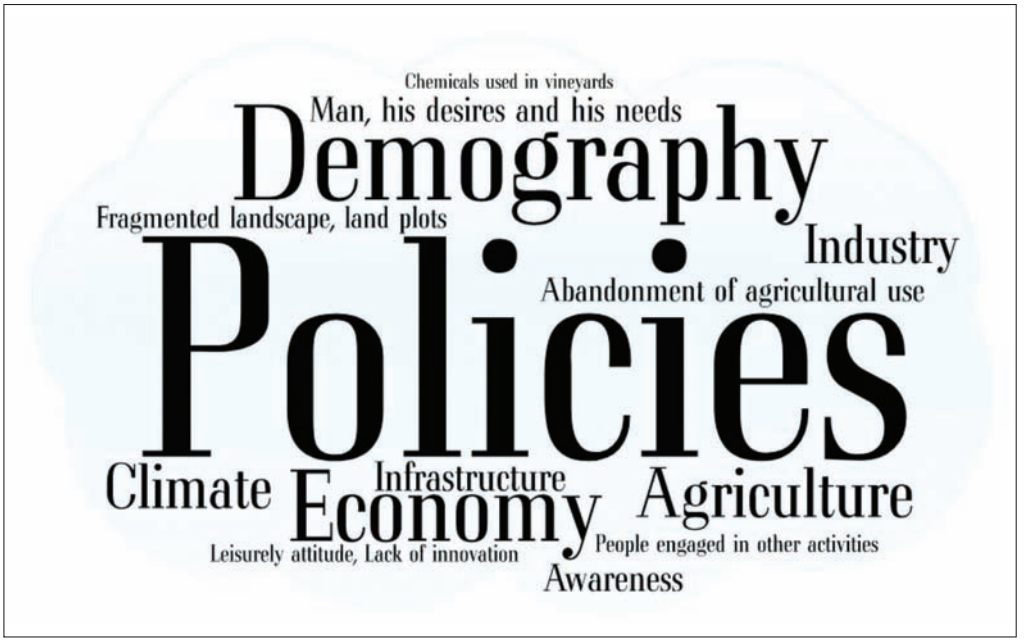


Figure 45: Prominence of words that were most frequently mentioned regarding factors that influence landscape change, grouped according to similar meanings.

Table 33: Factors that influence landscape change according to the group of stakeholders that mentioned them.

Factors that influence landscape change	Farmers	Resident non-farmers	Professionals of nature protection	Tourism professionals	Representatives of local governments
Abandonment of agricultural use	25.0%	/	50.0%	25.0%	/
Industry	/	33.3%	33.3%	33.3%	/

Factors that influence landscape change	Farmers	Resident non-farmers	Professionals of nature protection	Tourism professionals	Representatives of local governments
Lazy attitude, Lack of innovation	/	/	100.0%	/	/
Policies	30.8%	15.4%	7.6%	30.8%	15.4%
Demography	25.0%	12.5%	/	25.0%	37.5%
Fragmented landscape, land plots	50.0%	/	/	/	50.0%
Infrastructure	50.0%	/	/	/	50.0%
People engaged in other activities	50.0%	50.0%	/	/	/
Human desires and needs	25.0%	/	25.0%	25.0%	25.0%
Climate	33.3%	/	33.3%	33.3%	/
Agriculture	/	25.0%	25.0%	/	50.0%
Economy	14.2%	28.6%	/	28.6%	28.6%
Chemicals used in vineyards	/	100.0%	/	/	/
Awareness	/	/	/	100.0%	/

7. What role do you play in landscape management?

27 out of 32 respondents claimed they play a role in landscape management. 5 out of 32 respondents mentioned that they do not play any role in landscape management, all of them resident non-farmers. Nevertheless, they revealed some ways in which they see themselves indirectly involved in landscape management.

A total of 18 different identified roles or ways in managing the landscape were mentioned by the respondents (Table 34). The most often mentioned role in managing the landscape was 'Cultivating the land, mowing grass'.

Managers of protected areas (Kolpa Landscape Park and Lahinja Landscape Park) affirmed that the role they play in landscape management is management of the landscape parks. From the analysis of the answers given, we observed that the creation of management plans for both landscape parks in Bela krajina has been done, however, neither of these have been implemented. The management plan for the Kolpa Landscape Park is still waiting to be approved by the government. The other has not been implemented because the manager of the Lahinja Landscape Park does not feel the need to implement it; actually, according to this source of information, management of this park is not being carried out at all at the present time (MI 2016). The manager of the Kolpa Landscape Park mentioned that the problem they face in managing the park is that they do not manage their own land but mainly private land. Nevertheless, they try to regulate some regimes to maintain favourable status for both species and habitats, whilst not dismissing cultural traditions (BG 2016). The manager of the Lahinja Landscape Park affirmed that together with the Institute of the Republic of Slovenia for Nature Conservation, they have prepared guidelines for the park, especially guidelines for tourism (LB 2016).

Other stakeholders from nature protection in the region mentioned that their role can be seen on one side as maintaining the natural values of the region, and on the other side as trying to actively protect the environment by strongly opposing some activities that negatively impact the environment, such as the Bio-gas plant in Črnomelj.

Tourism professionals operating within the borders of the Lahinja Landscape Park feel they have an important role in the management of the landscape, whether by encouraging locals to maintain their activities in the landscape, such as by cutting grasslands in order to prevent overgrowth and to maintain the appearance of their landscape (also making it more attractive to tourists). They have also shown concern as the manager of the Lahinja Landscape Park is not active in carrying out his role in managing this protected area. They also mentioned that they lack support from the government (VV 2016).

Tourism stakeholders operating in the Kolpa Landscape Park affirmed that they see their role in managing the landscape in the creation of infrastructure for tourism, as tourism also affects landscape management. Tourism stakeholders from the Metlika Municipality feel that they have an impact on landscape development and management, even if not directly; they actively collaborate in initiatives that influence the management of the landscapes, such as being part of the Tourist Association of Slovenia which encourages, rewards and assesses the orderliness of the landscape, and in this way maintains the condition of the countryside and preservation of the natural and cultural heritage.

All farmers mentioned that they manage the landscape in a direct way, by cultivating the land. They all affirmed that the landscape would be abandoned without them and their activities.

»*Farming is a form of struggle against overgrowth*« (JK, farmer 2016).

The majority of farmers claimed that they maintain the appearance of their particular landscape, because they think it is beautiful. Similar statements were given by farmers from rural landscapes in alpine areas of Slovenia (Gantar and Golobič 2015).

Representatives of local governments mentioned that local governments have a special role in managing the landscape. They try to ensure suitable conditions for the normal development of tourism,

Table 34: Roles of local stakeholders in landscape management.

Role in landscape management	Response percentage (%)
Cultivating the land, mowing grass	50.0
Collaborating in initiatives that involve the landscape	16.7
Creating of management plans and guidelines for protected areas	16.7
Bee-keeping	16.7
Building infrastructure and facilities that maintain a clean environment	11.1
Employing people	11.1
Giving financial support to maintain the cultural landscape	11.1
Managing protected areas	11.1
Raising public awareness	11.1
Building infrastructure for tourism	5.6
Maintaining the natural and cultural values of the region	5.6
Elaborating spatial planning documents and policies that regulate the use of the land	5.6
Encouraging locals to maintain the cultural landscape	5.6
Keeping the environment clean	5.6
Regulating land improvements and land consolidation	5.6
Restorating water sources	5.6
Tackling environmental issues	5.6
Taking decisions or making recommendations on the changes of rural areas	5.6

the economy, and everyday life through spatial planning documents, policies, land improvements, and with compensation and financial subsidies to support activities that maintain the cultivated landscape.

The majority of the resident non-farmers (71.4%) said that they are not involved in landscape management, however some of them mentioned their indirect ways of managing the landscape through employment in the region, or by allowing their neighbours to cultivate their land plots that would otherwise not be used. The remaining resident non-farmers, representing 28.6% of the responses, affirmed that they play a role in managing the landscape through cultivating their land plots, being engaged in associations, and being actively involved in projects that bring benefits to people who live in the region (e.g., day care for children, allowing children to study in local schools while their parents work away from their village) and in this way maintain the local population of the villages.

8. What do you consider to be a valuable landscape?

The majority of the respondents mentioned the values of their landscape rather than what they value in a landscape. Others said that Bela krajina is a good example of a valuable landscape. 26 respondents mentioned 31 different aspects of a valuable landscape (Table 35). The most often mentioned item was 'Provides food' (12.6%), followed by 'Cultivated landscape' (10.1%) (Figure 46).

Figure 46: Prominence of words that were most frequently mentioned regarding values of the landscape.

To analyse the answers to this question according to the stakeholder group, we took into consideration the 5 most frequently mentioned items (Table 36).

As a 'Support for life', the landscape is valuable for all stakeholders. All the 5 items (Column 1 in Table 36) mentioned as aspects of a valuable landscape are valued by professionals of nature protection, although the most valuable for them is the 'Provision of water'. The 'Provision of recreation/relaxation' is mostly mentioned by resident non-farmers and tourism stakeholders, while no farmers mentioned it. Besides this aspect, the resident non-farmers mostly value the 'Provision of food' in a landscape. All stakeholders equally mentioned that a valuable landscape is a 'Cultivated landscape'.

Table 35: Values of the landscape as seen by local stakeholders.

A valuable landscape:	Response percentage (%)
Provides food	12.6
Cultivated landscape	10.1
Supports life	8.8
Provides recreation, relaxation	6.2
Provides water	5.0
Diverse landscape	3.8
Has forests	3.8
Accessible for people (including tourists)	3.8
Clean nature	3.8
Preserved nature	3.8
Traditional landscape, traditions	3.8
Beautiful landscape	3.8
Offers tranquillity	2.5
Livestock, sheep	2.5
Provides nature and natural attractions	2.5
Fertile land	2.5
Offers quality of life	2.5
Provides tourism	1.3
Has litter raking forests	1.3
Benefits people	1.3
Place of birth	1.3
Cultural landscape	1.3
Hospitable	1.3
Adapted to development	1.3
Offers cultural events	1.3
Has appropriate infrastructure	1.3
Offers clean air	1.3

Table 36: The most frequently mentioned items regarding the value of the landscape and the relative importance of each to the different groups of stakeholders.

Aspects of a valuable landscape	Farmers	Resident non-farmers	Professionals of nature protection	Tourism professionals
Supports life	28.6%	28.6%	28.6%	14.2%
Provides water	25.0%	25.0%	50.0%	/
Provides recreation/relaxation	/	40.0%	20.0%	40.0%
Provides food	30.0%	40.0%	10.0%	20.0%
Cultivated landscape	25.0%	25.0%	25.0%	25.0%

9. Do you think that agricultural activities affect the appearance of this landscape?

All 19 respondents in this case, without exception, stated that agriculture affects the appearance of their landscape. However, they showed preferences for a mosaic landscape rather than a mono-cultural landscape resulting from intensive agriculture. Here they also mentioned the management of litter raking forests, as a traditional way of farming and as an example of agricultural impact on the landscape.

»It is just part of the landscape here, the agriculture, and it has to be, otherwise it would not be this landscape« (JG, marketeer 2016).

There was no different opinion to this question among different stakeholders.

10. Do you recognise the overgrowth of the agricultural landscape?

89.5% of the respondents recognised that the agricultural landscape of their municipality is overgrown (Table 37). However, of these approximately 30.0% affirmed that currently this process has either stopped or the overgrown areas have started to be cleared again. This is mostly due to subsidies provided by the government, but some affirm that subsidies will not solve the issue of overgrowth.

The main reasons mentioned for the increase in overgrown areas are: 1) ageing population, 2) emigration of the younger generation out of the region, and 3) the younger generation's lack of interest in cultivating the land. It was also mentioned that the links between farmers, their products and the markets are missing. Agricultural cooperatives that served in the past as the link between farmers and the market are now non-existent. In the past these cooperatives guaranteed purchases of products, but there were also other negative issues and therefore there is still some apprehension and mistrust among farmers regarding this.

10.5% of the respondents affirmed that the agricultural areas are not overgrown.

Table 37: Differences in responses from the three participant groups of stakeholders: farmers, resident non-farmers and local government representatives.

	Farmers	Resident non-farmers	Representatives of local governments
Overgrowth is visible	21.05%	21.05%	21.05%
Overgrowth is visible but has been reduced	10.53%	10.53%	5.26%
There is no overgrowing occurring	5.26%	/	5.26%

Bee-keepers (2 respondents, among farmers) claimed that overgrowing of the agricultural landscape is better for bees, although they are also aware that it is not positive for the region, as well as being unsightly. Farmers affirmed that subsidies help to combat the overgrowing of agricultural land. All stakeholders consistently identified the demographical situation of the region (ageing population, out-migrations) as the main driver of overgrowing of the cultural landscapes of Bela krajina.

11. Do the karst features of the landscape influence your activities?

Almost half of the respondents (46.2%) answered that karst features of the landscape do influence their activities, while the other 53.8% affirmed that karst features of the landscape do not influence their activities.

Of the respondents who affirmed that karst features of the landscape influence their activities, one third claimed that karst features negatively influence their activities, one third claimed that karst features are positive in this sense, and one third affirmed that karstic features have benefits as well as drawbacks (Table 38, Figure 47).

The influences of karst landscape features on the activities or lives of the respondents mentioned are specified in Table 39.

Table 38: How karst features of the landscape influence respondents' activities.

	Response percentage (%)
Negatively	33.3
Positively	33.3
It has benefits and drawbacks	33.3

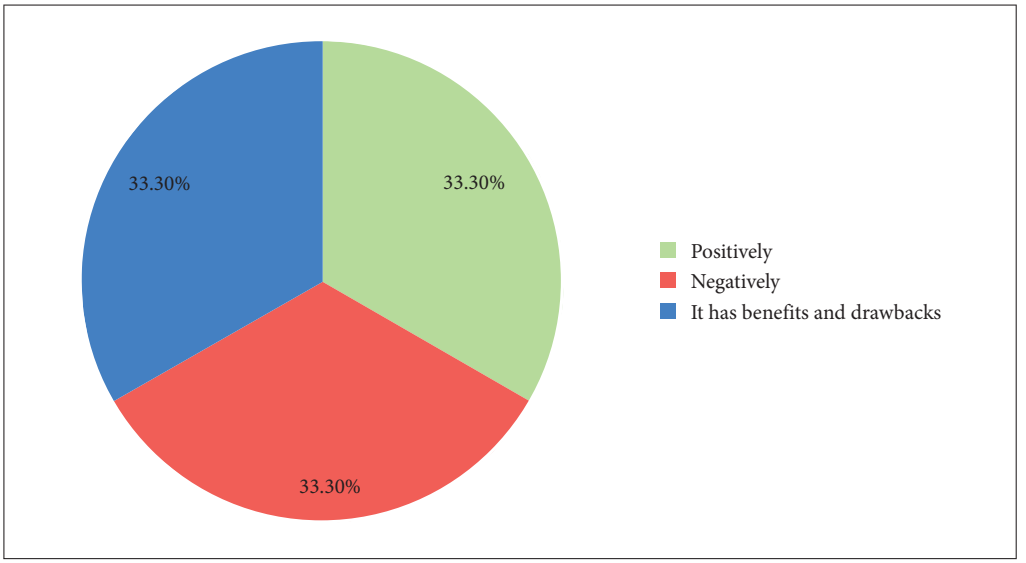


Figure 47: Graphical representation of the answers regarding the influence of landscape features on local activities.

Table 39: Benefits and drawbacks of karst features of the landscape that influence people's activities.

Benefits	Drawbacks
• Enough groundwater • Drinking water • Very fertile soil • Less need for fertilisers • In the past caves were used as shelter • Dolines have the best land and everything grows well there • Speleology • Picking mushrooms	• Harder to work with machinery • Less arable land • Shallow soil • Lack of flat surfaces • Influence the type of farming* • A lot of stones • Steep areas • Smaller land plots • Harder to cultivate • Lack of water in summer months • Expensive to manage • Susceptible to fires in summer months

*Karstic areas that are not possible to farm using machinery have been converted to meadows and pastures.

57.1% of farmers claimed that karst features influence their activities, whilst 42.9% affirmed that karst features of their landscape do not influence their activities. It is important to note that this 42.9% includes bee-keepers and farmers from Griblje, a settlement known for its flatness and arable lands, and thus with higher potential for agriculture. 66.7% of resident non-farmers stated that karst features of their landscape do not influence their activities/their lives, while 33.3% affirmed otherwise. Of those who claimed that karst features influence their activities, all mentioned that they are influenced in a positive way.

12. Do you think that the karst characteristics of this landscape influence local development?

12 (46.2%) out of 26 respondents stated that the karst characteristics of their landscape do not influence development (Figure 48). 11 (42.3%) out of 26 respondents affirmed that the karst characteristics influence local development. Of these, 2 respondents said it influences it in a positive way; 5 mentioned that it is more difficult for agriculture, however they also mentioned positive aspects of the karst landscape and even said that it can be used as a tourism attraction; and the 4 remaining only stated the negative aspects (although one of them said that in the landscape where she lives, karst features are not so evident but probably influence development in other parts of Bela krajina). Finally, 3 (11.5%) respondents out of 26 said they do not have enough knowledge to opine on this topic.

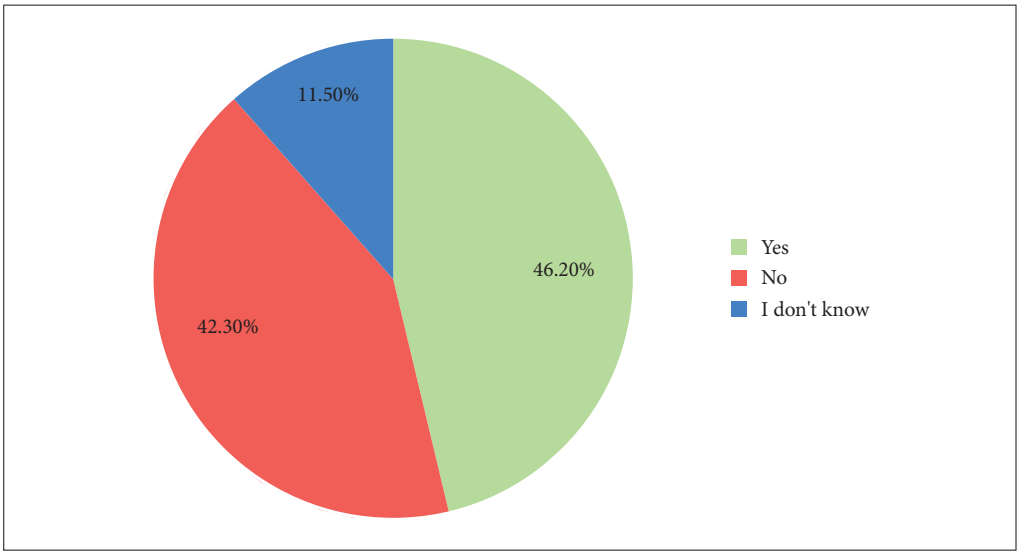


Figure 48: Graphical representation of answers regarding the influence of karst features on local development.

Table 40: Differences in responses from the four participant groups of stakeholders, regarding the influence of karst features on local development.

	Farmers	Resident non-farmers	Professionals of nature protection	Tourism professionals
Yes	11.54%	15.38%	7.69%	7.69%
No	11.54%	7.69%	7.69%	19.23%
I do not know	3.85%	3.85%	/	3.85%

The ways that karst landscape influences local development mentioned were: it hampers agriculture, hampers the building of houses and other infrastructure, and it is vulnerable to pollution.

The respondents talked about the benefits of the karst landscape while discussing its influence on local development, and mentioned the following points: 'the land fragmentation gives the landscape charm', 'the undulating landscape is beautiful', 'we have hot summers and early springs so agricultural products grow fast', 'we have a lot of water', 'life is good here', 'it is attractive for tourism' and 'maybe Bela krajina is so special and local people are so hospitable because of the karst characteristics'.

The majority of the respondents do not see karst features as obstacles to their work or life, or any negative influence on local development, in fact they claimed that they are used to it, and work and live according to these conditions.

»Those who are not capable of coping with the landscape where they live should look for another place« (BR, tourism professional 2016).

Surprisingly, the group of stakeholders who stated most often that karst characteristics of the landscape influence local development were resident non-farmers (Table 40), whereas perhaps one would expect that farmers would mention the problems they encounter in working in karst landscapes. 2 out of 7 resident non-farmers mentioned that karst features positively influence local development. Tourism stakeholders in general see karst characteristics as an attraction for tourism, and therefore such characteristics can also influence in a positive way. With this question we realised that when talking about influences, the majority of respondents perceive influences as obstacles (or as constraints), therefore the respondents who affirmed karst features do not influence development claimed that if it such features do have any influence, they can only be positive.

13. Do you think that nature protection influences your activities?

61.5% of the respondents stated that nature protection does not influence their activities and the remaining 38.5% claimed that it does (Table 41). Of the respondents who claimed nature protection influences their activities, 40% mentioned that it influences in a positive way, while 60% affirmed that it is negatively connected.

Respondents who affirmed that nature protection influences their activities talked about restrictions in land use, restrictions for building new facilities, hindered agricultural activities, and even declared that nature protection in the form of landscape parks or Natura 2000 sites is an artificial creation of the government that just brings privileges to a restricted group of people. Overwhelmingly, 66.7% of the respondents who claimed nature protection negatively influences their activities, also said that they do not feel the influences of nature protection areas or they live outside such protected areas. Therefore, although they were talking about the negative influences that nature protection is supposed to have, in actual fact it is unlikely that they had encountered any such issues / restrictions.

All resident non-farmers who responded that nature protection affected their activities claimed that it affected them in a positive sense. Farmers expressed concerns regarding the restrictions that they face due to the conservation of designated protected areas. Farmers advocate that people who live and work within designated protected areas should have some kind of privileges to compensate for the restrictions they face. The majority of the inhabitants of the region support the protected status of certain areas, such as Lahinja Landscape Park and Kolpa Landscape Park.

Table 41: Differences in responses from the two respondent groups of stakeholders, regarding the influence of nature protection on their activities.

	Farmers	Resident non-farmers
Yes	23.0%	15.4%
No	30.8%	30.8%

14. Do you think that nature protection influences local development?

Only 1 out of 12 respondents affirmed that nature protection can have a negative influence on local development if local inhabitants are not involved in the protection process (Table 42). This respondent argued that when the state or local authorities assign an area to be protected, they usually forget to implement a development program which includes locals.

When the respondents discussed the influences nature protection brings to local development, they mentioned that nature protection is needed in order to keep the water and soil clean, and Bela krajina green.

»As a nature conservationist, I would almost certainly say that (nature protection) positively affects (the local development). […] The restrictions that are written in the regulations or ordinances to ensure nature protection need to be understood. Those who wish to take advantage of nature and harm it through exploitation, will not understand, and they will see (nature protection) as an obstacle, as a barrier. I think that there is evidence that in this area some people have already found ways to profit from the protected areas and to move forwards. I personally do not see regulations for nature protection as obstacles to management and development here, even if half of Bela krajina is considered to be protected or as a Natura 2000 area. This is because the rules are clear. Where the development of industry is possible, there is less nature. Where nature is preserved, there is no place for dirty industry« (MI, professional of nature protection 2016).

»If development destroys nature then there is no development« (AK, tourism professional 2016).

The majority of the respondents affirmed that nature protection promotes local development by attracting tourism to the region. Although the respondents are aware of the benefits of nature protection they also mentioned that there are minor issues connected to it such as: 1) there should be some kind of compensation for local people who live in protected areas to overcome the restrictions they face; 2) Natura 2000 is not well known among local inhabitants, but was created at a political level; 3) a huge amount of Slovenian territory is listed under Natura 2000, if this ecological network were confined to smaller areas with stricter protection and regulations, then Natura 2000 areas could be promoted as special landscapes. Local stakeholders are unwilling to consider the existence of large industries in the region that would harm their landscape. They see the development of the region in small-scale industries and tourism. The region has an enormous potential for tourism that is not being fully explored; although locals do not wish to have mass tourism in the region.

Tourism stakeholders particularly see the protected areas as an opportunity to develop tourism in the region, but always taking into account the protection of nature. One respondent from Semič said that tourism there is not well promoted, and there is great potential but it is not being capitalised on. Tourists who visit attractions in Semič are usually there for a short time and do not bring much profit to the municipality.

Table 42: Differences in responses from the two respondent groups of stakeholders, regarding the influence of nature protection on local development.

	Professionals of nature protection	Tourism professionals
Yes, positively	8.3%	50.0%
Yes, negatively	/	8.3%
No	25.0%	8.3%

15. In your opinion is this landscape developed? Why?

The majority of the respondents, when discussing the development of their landscape, talked about Bela krajina in general. Only two respondents referred to their particular landscape.

16.7% stated that the region is taking steps towards development, eco-farms are blossoming in the region, some young people are returning with new business ideas, and tourism opportunities are quite ambitious (Table 43, Figure 49).

27.8% of the respondents affirmed that the region, as far as the landscape is capable of handling, is developed enough. They mentioned that the region has the capacity to be self-sufficient regarding food, the Kolpa River is cleaner than in the past and there is a trend (although slow) of young people returning to the region.

Slightly more than half of the respondents (55.5%; Table 43, Figure 49) claimed that although the region has a lot of development opportunities, it is still not developed enough, and this can be seen in the statistics that show that the region is stagnating and by the number of people who are still leaving the region. The main reasons mentioned for the stagnation of the region are: 1) lack of industry to employ young people; 2) development has been directed to industry, which has not been successful, and people have not invested in their own products; 3) centralised management, where all the money is taken to the capital, Ljubljana; 4) local inhabitants are too passive and need to be pushed to move forward; 5) misguided policies that financially support otherwise healthy people who could work; and 6) lack of self-initiative and self-employment from inhabitants in finding new opportunities.

There is a general opinion that the region has high development potential, especially through tourism and small scale industry.

Regarding the differences among the stakeholder groups, representatives of local governments, apart from the municipality they are part of, share the same opinion and affirmed that the study region is not developed enough. 50% of tourism stakeholders stated that the region is developed enough, 25%

Table 43: Level of development of the landscape according to local stakeholders.

	Response percentage (%)
Developed enough	27.8
Not developed enough	55.5
Developing	16.7

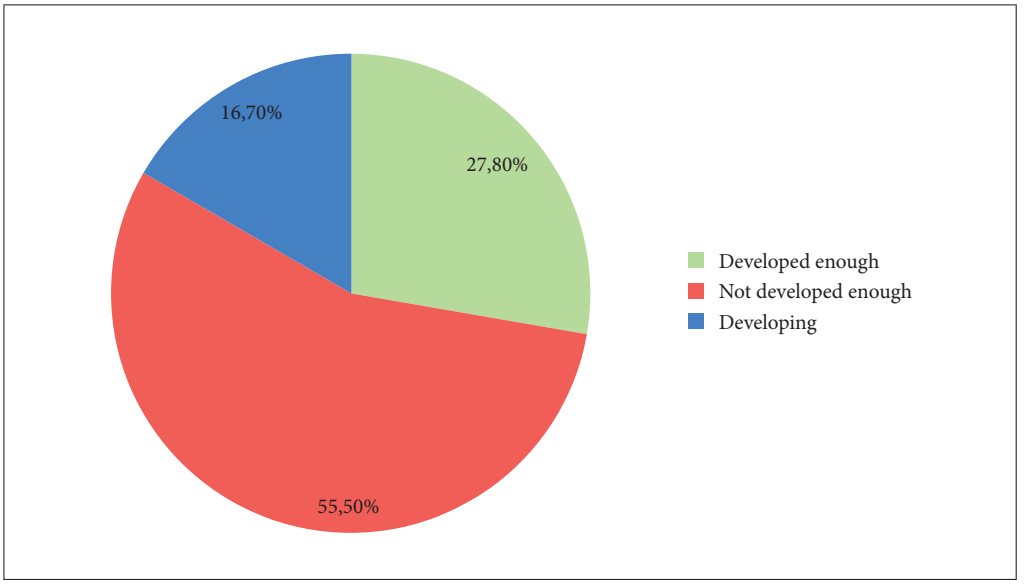


Figure 49: Graphical representation of the answers regarding landscape development.

claimed it is not developed enough, and the remaining 25% affirmed that Bela krajina is developing. Among nature protection stakeholders the opinions about the development are somewhat different, as 50% stated that the region is not as developed as it should be, 25% claimed that Bela krajina is developed enough and 25% that is on the way towards development.

16. What is the goal of the regional development process?

The goals mentioned by the respondents towards regional development were as follows:

- Promotion of agriculture;
- Promotion and development of tourism;
- Provision of infrastructure for villages;
- Development of industry.

We found some differences among answers from representatives of different municipalities. Nevertheless, representatives of the three local governments mentioned that their goal was to promote agricultural activities in the municipality. Representatives from Metlika and Črnomelj emphasised the promotion of tourism, which was not mentioned by the representatives of the Semič Municipality. Semič representatives noted that their goal in the development of industry was to retain local people in the municipality and to stop migration to other regions.

All three municipalities share the same goal of improving the quality of life of the local population.

17. What problems have you encountered in reaching this goal?

A wide range of the problems mentioned by the representatives from local governments include the following:

- Gaps between policies for natural management and what is practised on the ground (e.g., certain crops cannot be cultivated through eco-farming as the end product is not a desirable one; providing incentives to use certain techniques or cultures that are not suitable for certain environments, resulting in degradation);
- Lack of road infrastructure that influences the development of the economy and tourism;
- Financial issues;
- Difficulties in changing the status of agricultural land to development land, which is especially important in the case of overgrown agricultural land plots that are not being used for agricultural purposes and where the construction of buildings is also not permitted;
- Each year the municipality gets less funding from the national government;
- Problems in purchasing land (to expand industrial zones) as landowners live abroad.

As each municipality has different development goals it is difficult to find common issues they encounter in reaching these goals. However, representatives from the Semič and Črnomelj municipalities shared concerns regarding the reduction of funds that are being allocated to the municipalities, and that the landscape (especially agricultural areas) is usually not on the priority list of the local governments when finances are being allocated.

18. Do you think that it is important to involve local stakeholders in decision-making processes on landscape management?

The answers to this question were unanimous, with no differences among municipalities. All the representatives of local governments affirmed that it is important to involve local stakeholders in the decision-making processes concerning landscape management. They also remarked that without the local population and NGOs it would be difficult to plan, because the decision-making process should be a bottom-up process, arising from the needs of the local population. Therefore, local governments, with their professional knowledge, should try to get a consensus with local communities to satisfy their needs and find solutions together.

»*We, as representatives of the municipality, are here to serve people*« (BJ, representative of local government 2016).

19. Are local stakeholders involved in the decision-making processes on landscape practices or management? How?

The representatives of local governments generally affirmed that local stakeholders are involved in the decision-making processes on landscape practices or management, and are represented in decision-making bodies such as: local community councils, diverse organisations and local political parties. Nevertheless, representatives of local governments expressed concerns regarding the participation of local populations in the decision-making processes on landscape practices or management. They mentioned that more efforts could be made in order to involve the local population, and there is probably not enough communication between local governments and local populations, or there is not the right communication, so local governments should have people in the field who are in contact with local populations. However, there is a lack of staff in local governments that could carry out this function. It was also mentioned that local communities tend to get involved more if they understand what is going on, or if they see the proposals and sketches of the plans.

We found differences in responses among the municipalities. Representatives from the Metlika Municipality affirmed that there is a trend of apathy among the local public, local communities are becoming less and less active, and they feel the need to financially support activities in local communities in order to attract their interest and participation.

Representatives from the Črnomelj Municipality affirm that local communities are not active enough, they are only active when they see some potential benefit, or when they have vested interests.

On the other hand, representatives from the Semič Municipality stated that the local population is quite active and they participate in decision-making processes, and the municipality always has an open-door policy for the local population and do not have strict consultation times for the public.

20. Do you see the increase in self-sufficiency in food as an employment opportunity for rural development?

85% of the respondents affirmed that the increase in self-sufficiency in food could be a solution to unemployment rates, especially in rural areas. 15% of the respondents do not see the increase in self-sufficiency in food as an employment opportunity for rural development (Figure 50).

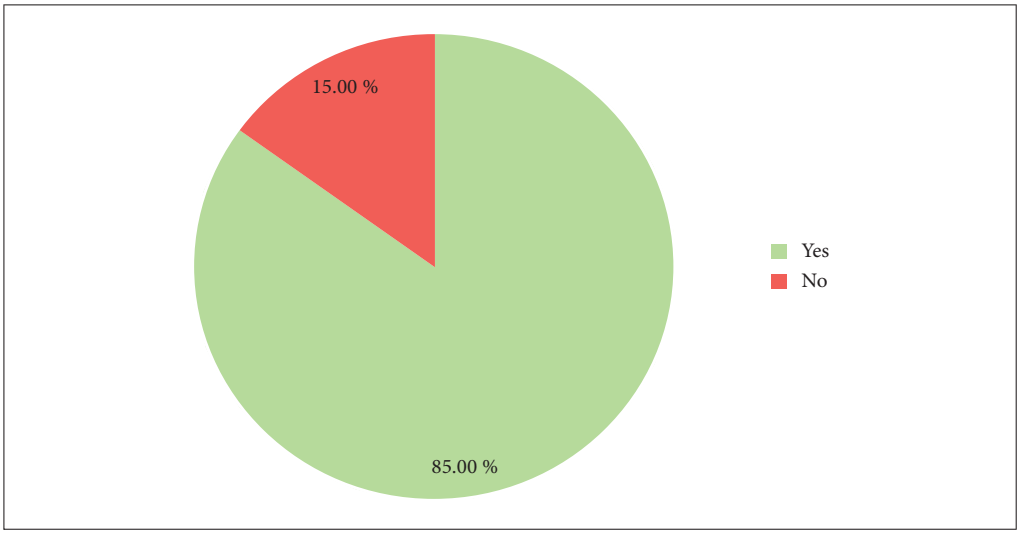


Figure 50: Graphical representation of the answers regarding the increase in self-sufficiency in food as an employment opportunity for rural development.

The main reasons mentioned by the respondents who do not see self-sufficiency in food as an employment opportunity are: 1) self-sufficiency in food is not an employment solution because we do not have customers to sell our products to here; 2) we do not have enough land with suitable conditions to achieve that here; and 3) this is an illusion, the consumer should be educated first in order for the whole circle to work properly, however we cannot tell people to buy something four times more expensive if they can buy the same product for much less in a supermarket.

The respondents who see the increase in self-sufficiency in food as a job opportunity in rural areas talked about the capability of their municipality and region to be self-sufficient. Around 60% of them stated that Bela krajina has a high potential to be self-sufficient in food, as it has enough surface area and a good climate to produce everything that local people need. This can be seen in statements from the participants, such as:

»*We can be self-sufficient with food just here. We can produce everything we want in Bela krajina…*« (VV, tourism professional 2016).

»*I think Bela krajina could be self-sufficient, according to its size and to its climate, in order to produce everything we need*« (GA, representative of local government 2016).

Less than 18% do not believe the region can be self-sufficient in food and the remaining respondents did not mention such self-sufficiency.

Even though the majority of the respondents believe that self-sufficiency in food could be a solution to the high unemployment rate in the region, they also mentioned some aspects that could be obstacles to putting this into practice. The mentioned aspects are: 1) the higher prices of the local products, resulting from the difficult farming conditions of the region; 2) the sharing of products among different people would be difficult in Bela krajina as the locals do not want to show that they lack something; 3) people's mentality has to be changed; and, 4) misguided agricultural policies that should support the local products so that the final price could be affordable to everyone, but fail to do so.

Although no differences can be seen among the different stakeholders, the distribution of the answers among the different stakeholders can be seen in Table 44.

Table 44: Differences in responses from the three respondent groups of stakeholders regarding food self-sufficiency.

	Farmers	Resident non-farmers	Representatives of local governments
Yes	30%	30%	25%
No	5%	5%	5%

21. How do you see this landscape in 2030?

It was interesting to note that the answers to this question showed the preferences and interests of different stakeholders in the landscape, and also showed their concerns and their fears of change. Nevertheless, the main visions for their future landscape are:

- The landscape will change as there will be more road infrastructure; although some stakeholders support the development of infrastructure, others say that it will be bad for the landscape;
- People should continue to work hard to maintain the landscape;
- The landscape should remain as it is now;
- According to trends, the landscape will be more overgrown;
- If there is no industry, there will be no job opportunities and young people will move away.

The obtained answers reflect the fear that local stakeholders have of losing their current landscape, they also showed their concerns in losing young people.

»*Young people are the heart of this valley*« (SŽ, professional of nature protection 2016).

The future of the landscape according to tourism stakeholders should be the maintenance of a green, clean and preserved landscape, and people should keep working hard on this. Tourism stakeholders showed concerns regarding the development of new infrastructure in the region.

Nature protection stakeholders expressed their desire for no change, and mentioned the potential of the region for tourism development.

Representatives of local governments believe that the landscape will not change much, overgrowth will be stopped and the amount of cultivated land will increase; some also demonstrated a desire for small scale industry and for progress, while others mentioned that the region will be more self-sufficient, and the local population will eventually realise how important it is for their health and for the maintenance of the landscape.

Farmers shared different visions of their future landscape. Some stated that small land plots would be abandoned and become overgrown, and the larger areas will be cultivated; they hope for the development of industry and creation of job opportunities to retain young people in the region; they want all villages to have small farms with cattle, and some affirmed that they would be satisfied if the landscape remains at least as it is now.

Resident non-farmers shared a more negative vision of the future landscape, the majority stated that the landscape will be even more overgrown than it is now, however some contended that it might be equally as cultivated as it is now.

3.3.2.2 General responses

In using interviews, the qualitative analysis of the landscape features for land use and sustainable development gave us various insights into the local stakeholders' perspectives of their landscapes.

Farmers affirmed that their local landscape contributes to their well-being. In general, they argued that they play an important role in landscape management, and they feel proud to contribute to the maintenance of the cultural landscapes of Bela krajina. Yet some contend that the landscape in the recent past was more abandoned than it is at present, whilst others said that the landscape is currently becoming overgrown. The differences in the answers might be due to the farmers' locations, as some areas are more overgrown whilst others are cleared and are subject to intervention (e.g., Stari trg). Some farmers expressed their concerns regarding the existence of large commercial areas in the region, selling non-local products, which they cannot compete with (offering lower prices, etc.), and pointing their fingers at national policies. They affirmed that karst landscape features influence the type of farming, mainly due to the stoniness and shallow depth of soils. Thus these influence local development, because the difficult farming conditions are leading to out-migration. On the other hand, they also said that karst landscapes may attract tourism to the region, and in this way karst features have a positive impact on the local development. We found differences in the answers of bee-keepers and other farmers. Bee-keepers said that karst features do not influence local development. This answer is understandable as bee-keepers are not directly affected by the agricultural constraints that karst features might pose. In addition, one farmer from Griblje said that karst features do not influence his activities or local development. This answer is reasonable; as the natural conditions around Griblje are more favourable for agriculture than other parts of the study region. As expected, and as has also been reported by other studies (e.g., Lampič and Mrak 2008; Mrak 2008), the majority of farmers see nature protection as limiting their activities, as there are restrictions but not compensation for people who live and work within the borders of protected areas. Farmers shared a general vision of their landscape in the future, it should remain at least as it is now.

For **resident non-farmers** their green and clean landscape (characteristics described by them) positively affect their well-being, allowing for relaxation. Half of the resident non-farmers answered that they do not play any role in landscape management, while the other half said they play an indirect role

through their attitudes and ideologies. Unanimously, resident non-farmers declared that karst features do not influence their activities. However, their opinion is again divided regarding the influence of karst features on local development. Some stated that such features do not have any influence on development, whilst others said that they do. This difference in opinion can be related to the heterogeneity of this group of stakeholders in regard to their age and professions, however profile data of the respondents was not acquired and thus this relation cannot be assessed. With regard to landscape changes, some resident non-farmers mentioned that changes are related to the improvement of infrastructure, and some to the abandonment of agricultural practices. Resident non-farmers affirmed that nature protection does not influence their activities, and just one respondent claimed that nature protection positively affects his activities, as he owns a restaurant which can benefit from tourism. They are very much in favour of nature protection, as this is needed to preserve the nature of the region and to attract tourists. As with farmers, resident non-farmers would also like to keep their landscape as it is now. However, some are afraid that overgrowth will continue, while others said that if the landscape does change, these changes will be minimal.

In general, **representatives of local governments** commented that Bela krajina is not as developed as it should be, especially when compared to other Slovenian regions. They mentioned that the main aspects of the underdeveloped landscape are the lack of employment, lack of basic infrastructure and lack of industry. These answers show that the representatives from local governments mainly see development through a socio-economic point of view. They feel responsible to improve the current state of the landscape through their activities (e.g., acting against overgrowth of agricultural land by giving financial incentives, sewage disposal, and construction of a waste water treatment plant). The answers regarding the main drivers that lead to landscape changes were probably diverse because the respondents come from different departments within the local governments and thus have different opinions. Apart from one respondent, all the representatives of local governments mentioned the increase in self-sufficiency in food being a possible source of employment opportunities in Bela krajina, and the majority stated that the region has the potential to be self-sufficient. Surprisingly, the only respondent who disagreed with this vision, stating that it was an illusion, is an employee of the department of agriculture. Regarding the importance of involving local stakeholders in the decision-making processes, we found two positions, on one side the representatives of local governments claimed that local stakeholders rarely show interest and rarely participate in decision-making processes, on the other side farmers claimed that their ideas and opinions are not taken into consideration. Thus we noted a lack of communication and mistrust among different local stakeholders. The lack of finances was one of the most often mentioned issues which local governments face in reaching their goals towards sustainable development. A common vision for the future of Bela krajina's landscapes is the maintenance of cultivated lands and appealing to young people to stay in the region.

Professionals of nature protection stated that the landscapes of Bela krajina are valuable because they are rich and diverse. As expected, nature protection stakeholders see nature protection as positively influencing local development. Interestingly, this is because they claim nature protection contributes to development through tourism. This group of stakeholders affirmed that karst features are positive elements of Bela krajina's landscapes. Opinions regarding the development status of Bela krajina are divided in this case. While some contend that the region is developed enough, others contend that it is lagging behind, mainly due to the centralisation of funds which are not reaching less developed regions of the country. Their visions of the future landscape are similar to other stakeholders, they wish for the landscape to be maintained as it is now and for increased tourism in the region.

Tourism professionals affirmed that Bela krajina's landscapes are valuable due to their diversity and nature, and these aspects are the ones that make Bela krajina's landscapes different from other places. As nature protection stakeholders, this group also talked about the importance of nature and nature protection for the development of tourism in the region. In general, they do not see karst features as negatively influencing local development, rather the opposite. However, tourism stakeholders have a more

negative vision of their landscape's future, as they believe it will become even more overgrown, and therefore wish for an increase in local awareness of the region's qualities.

We did not find significant differences among the answers from respondents from different municipalities. Presumably, this is because respondents tended to talk more about Bela krajina as a whole, rather than their own local landscapes, even though this opinion was asked for at the beginning of the interviews. We would like to point out two of Bela krajina's landscape features that were mentioned by local stakeholders. It is well known that water is among the most appreciated landscape elements (Kaltenborn and Bjerke 2002) and this was also confirmed with this study, by the responses to questions such as 'What makes this landscape attractive?' and 'What do you consider to be a valuable landscape?'. Remoteness is also another characteristic of Bela krajina. However, remoteness is perceived by people from Bela krajina as both an asset and a major liability, a view that was also put forward by Keller (2001). Some respondents said that remoteness and isolation are assets, which contribute to the preservation of the unspoilt nature in the region. Other respondents associated remoteness with constraints of service delivery, communications and job opportunities.

3.3.3 Comparison of the results

The approach involved integrating both quantitative and qualitative methods. The qualitative evaluation differs from the quantitative approach in many respects, one of them being the latter's emphasis on numbers. While the quantitative evaluation captured a large amount of information from a number of sources, and sought to objectively use the interrelationships to understand the influence of landscape features on sustainable development, the qualitative evaluation involved local people and included their insights to generate a subjective understanding of how people perceive the karst landscape features and their influences on sustainable development. Table 45 shows the main information we obtained from both methods.

Table 45: Main differences between the results obtained from the quantitative and qualitative evaluations of the landscape features for sustainable development.

	Quantitative evaluation: sustainable development indicators	Qualitative evaluation: structured interviews
Sustainable regional development	• Differences among pilot areas • Do not take into account karst features • Differences among the three pillars of sustainability • Detailed economic, social and environmental data	• No differences among pilot areas • Karst features hamper agriculture • Karst features can promote tourism • Importance of water sources • Importance of unspoilt nature for tourism and well-being

The karst landscape features mentioned in the interviews were added to the Karst specific indicators (see subchapter 4.2) as they obviously represent important aspects for the locals.

4 Discussion and conclusions

Bela krajina is characterised by a weak economy, poor demographic structure and well-preserved nature (Table 20). The study region is one of the most naturally preserved regions of Slovenia and is characterised by karst features, predominantly forested landscape and rich biodiversity. The region has been settled by various ethnic groups that have contributed to its ethnic and cultural diversity (Ribeiro 2017).

According to Plut (1998; 2008), the uneven regional development of Bela krajina is a reflection of the relatively scarce natural resources, karst terrain, remoteness in terms of major roads, underdeveloped infrastructure, belated industrialisation, dispersed settlements and low education levels.

The main goal of this study was to identify and analyse the influence of karst landscape features on land use and sustainable development of Bela krajina. In order to draw attention to the combination of social perspectives with natural conditions for an integrative view of the karst landscapes, we used three approaches:

1. state assessment of the karst landscape,
2. analyses of land use dynamics, and
3. quantitative and qualitative analyses of the sustainable development of Bela krajina.

With the first approach we measured the degree of disturbance as a result of human impacts on the karst landscape in three municipalities (Črnomelj, Metlika and Semič). This was done using an environmental index – the 'Karst Disturbance Index', defined by van Beynen and Townsend (2005) and tested in various countries (e.g., Calò and Parise 2006; North 2007). In this study we made minor modifications to the indicators used, according to their relevance to the study region. A novelty of this method is that it allows for the assessment of the karst disturbance, as a result of human activities, of different regions with the application of only one index, which includes various indicators specific to karst areas. As the Karst Disturbance Index had not been tested in Slovenia before, comparison of results obtained from this index among karst regions is not possible. However, from reports on human impacts on karst landscapes in Slovenia (e.g., Prelovšek and Zupan Hajna 2011) we can say that in comparing Bela krajina with the Kras region (Perko 1998), which is also part of the Dinaric Karst, the degree of human disturbance in Bela krajina is lower than in Kras. This does not mean that human disturbance in the study region can be neglected. On the contrary, human disturbance should be used to inform and to raise awareness among locals about the vulnerability of karst landscapes, with implications not just for the environment and human health, but also with implications for the sustainable development of Bela krajina. The results obtained from this approach, i.e. the low disturbance of the study region, could be an indicator of low industrial development in the region.

With the second approach we analysed the spatial processes and patterns across temporal and spatial scales to reveal landscape changes in Bela krajina. The analyses were undertaken in two case studies (Adlešiči and Bojanci) which were selected for an in-depth study of landscape changes over the last 200 years based on historical sources (datasets). The choice of these case studies was guided by the distinctive patterns of each area's landscapes contrasting with each other in land use and appearance. These case studies show ecologically and historically distinctive cultural landscapes. Although these sites have different management regimes, they are both affected by the difficult terrain (due to karst features) and isolation. Thus, in this study we conclude that major land use changes have occurred in Bela krajina during the past 200 years (Figure 51). The total area of fields decreased by 25.9% in Adlešiči and 9.0% in Bojanci, whilst the total area of forests increased by 32.8% in Adlešiči and 56.7% in Bojanci. Conversion of farmland to forest reduces the amount of land available for food, which is an important aspect regarding the sustainable development for Bela krajina. From an environmental point of view, afforestation can be seen as a positive land use change, however in the study region it contributes to the loss of landscape diversity, loss of biodiversity and to the loss of the cultural landscape. On the other side, the proportion of forests in the study region is already high and it is not efficiently used for timber production and/or wood biomass. In both case studies the proportion of gardens increased between 1824 and 2012, which could be an indicator of the realignment towards homestead food self-sufficiency. This could also mean that gardens have been mapped according to different criteria (e.g., according to its size or according to its proximity to houses) and therefore the changes in the proportion of gardens might be misleading. The natural conditions for agriculture were identified as being more favourable in Bojanci than in Adlešiči, however land abandonment in the studied period was more pronounced in Bojanci, suggesting that the natural characteristics of the karst landscape is not the major driver of landscape changes in these case studies.

With the third approach we carried out quantitative (using sustainable development indicators) and qualitative (using structured interviews) analyses of the landscape features for the sustainable development of Bela krajina. We measured the local sustainable development of each of the three municipalities by comparing them with the average for the study region, along with the Slovenian average. From this quantitative analysis, and taking into account the three pillars of sustainable development, we concluded that the most developed municipality in Bela krajina is Semič, and the least developed is Črnomelj. The main differences between the three municipalities seem to be related to their structure. Semič appears to be the most developed municipality of Bela krajina, as a result of it being a small municipality, dominated by conventional agriculture and geographically close to regional centres. The municipality has a quite important industrial tradition (e.g., Iskra) which was an important driver for its development, and it also economically benefits from wine production. Semič Municipality is also characterised by: dispersed settlements, construction challenges for infrastructure and mobility, low population density

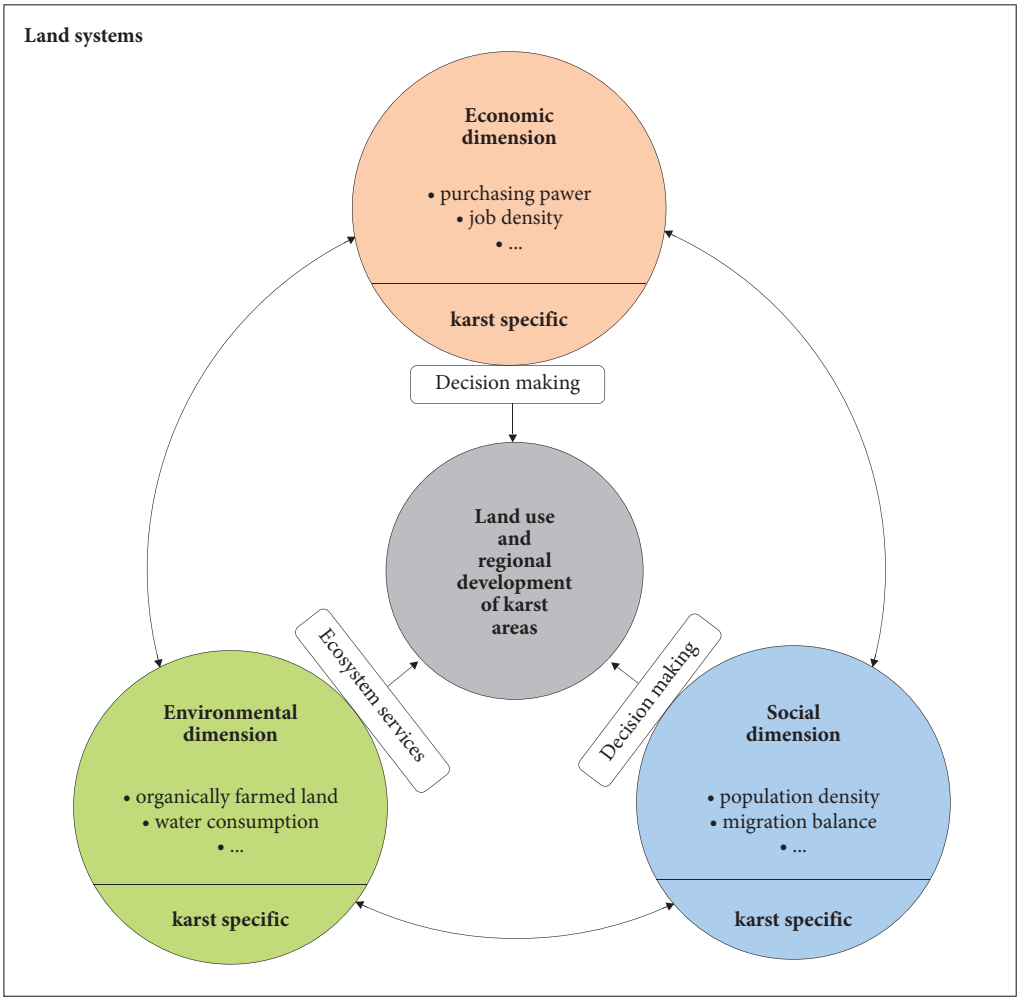


Figure 51: Schematic representation of the major land use changes occurring in Bela krajina during the past 200 years.

and remote villages with few inhabitants. There is also almost non-existent public transport (Adamič et al. 2012). According to the Development Strategy for Semič Municipality, the transport infrastructure still does not meet the needs of economic development (Adamič et al. 2012). Meanwhile, Črnomelj appears to be the least developed municipality, as a result of the large distances to regional centres, worse accessibility, it being a larger municipality, major differences within the municipality and low population density.

The results are somewhat surprising as the Črnomelj and Metlika municipalities are considered to be 'centres of inter-municipal importance' and Semič as a 'centre of local importance' (Nared et al. 2017), therefore greater development would be expected from these two municipalities. However, it is important to note that these results are based on a set of sustainable development indicators which might be insufficient to show the current situation of each municipality. Another important aspect to be noted is that our analysis was compared only within Bela krajina.

Comparing Bela krajina to the Slovenian average, we considered the study region to be underdeveloped, especially regarding its social and economic aspects. Bela krajina is affected by a negative net migration balance. The out-migration of younger generations exacerbates the rural demographic structure of the region. Due to migration, a deficit in the younger population arises, which is directly connected to the decrease in birth rates in the region. This demographic situation is leading to the stagnation of the population, as well as to the depopulation of the region, and to the aging demographic structure. Generational renewal is thus extremely important in order to preserve the vitality of Bela krajina. Therefore, the socio-economic structure of the population presents a worrying limiting factor for the sustainable development of Bela krajina. Nevertheless, according to environmental indicators, the study region is placed above the Slovenian average as a result of the high proportion of organically farmed land, the high proportion of forested areas, the high proportion of protected areas and low levels of generated waste.

According to the model scenarios attributed to the municipalities, the future of Bela krajina's landscape can be illustrated by three possible future scenarios (see subchapter 3.3.1.4):

- Scenario 1: The first scenario is based on the interpretation of the current situation of the Črnomelj Municipality and assumes that the current situation will continue in the future, and so Bela krajina's landscapes will become completely overgrown, as a result of the poor demographic structure (depopulation, population age). Abandonment of agricultural land will continue and forests will expand, regardless of the potential for agriculture. Even though this scenario could be seen as a nature conservation scenario, the loss of human intervention will decrease the diversity of the landscape which will result in the loss of a cultural landscape. A similar scenario was presented by Kaligarič and Ivajnšič (2014), which predicted the almost complete reforestation of the Kras region by 2100.
- Scenario 2: The second scenario is based on the situation of the Metlika Municipality which predicts more industrial farming. Agricultural activities will be more intensive, an increase in agricultural holdings and a decrease in the number of farms will take place in the areas most favourable for agriculture. The productivity per unit area will therefore increase. This type of farming will be orientated towards economic rationality. Industry will grow in spite of nature; built-up areas and infrastructure will expand. This will lead to an increase in job opportunities and a decrease in out-migration. This scenario reflects unsustainable development. Price et al. (2015) predicted a comparable scenario for Switzerland, which was named as a 'high growth, pressure scenario'. This scenario predicted for Switzerland involves economic and social growth with low environmental concerns (Price et al. 2015).
- Scenario 3: In the third scenario we assume that agricultural land will be more or less maintained due to financial incentives, especially through the promotion of organic farming. Organic farming will become a more profitable way to farm. The financial incentive system is progressive, meaning that the more farmers contribute to local nature conservation plans, the more subsidies they receive (Tress and Tress 2003). The overgrowing process will stabilise. The number of small enterprises will rise and with this the creation of new job opportunities; the enterprises will be located in clusters

and there will be more opportunities for businesses and industries. Tourism will develop. Population growth will slightly increase. This scenario is based on the interpretation of the Semič Municipality. According to this scenario the region has the ability to retain population, the cultural landscapes will be maintained and sustainable development is feasible. A similar scenario, named the 'self-sufficiency scenario', was predicted by Price et al. (2015) for Switzerland. The 'scenario' emphasises self-sufficiency and development at the regional level as well as higher ecological awareness (Price et al. 2015).

These three scenarios are the result of the quantitative evaluation of the landscape features of the three municipalities and represent their future scenarios, thus they encompass the expected futures of the Bela krajina's landscapes. It is important to note that these scenarios focus on 'What will happen' and not on 'What will happen if…'. Scenario 1 predicts the consequences for the abandoned rural landscape in Črnomelj, scenario 2 is a prediction based on the intensive agriculture landscape that is currently taking place in Metlika, and scenario 3 reflects the valuable natural and cultural landscape of Semič, that is maintained through subsidies. Of these scenarios, the only pathway to the sustainable development of Bela krajina is scenario 3.

Even though we would have liked to include the interests of locals in the design of these scenarios, analysis of question number 21 (see subchapter 3.3.2) revealed some of the interests of the respondents as well as their opinion based on the current state of the landscape. Thus we deduced that the question was not objective enough and it could not be included in the creation of scenarios.

The qualitative analysis of the landscape features for the sustainable development of Bela krajina included 32 interviews with local stakeholders: farmers, resident non-farmers, professionals of nature protection, tourism professionals and representatives of local governments. Different perceptions among different stakeholders were noted and described in subchapter 3.3.2, however all of them shared similar opinions about the naturalness of Bela krajina's landscapes. As a result of the great biodiversity and landscape diversity, a large area of Bela krajina's territory is under environmental protection. To understand the importance of protected areas for local inhabitants as well as their contributions to local/regional development, we added two questions related to these protected areas to the interviews. One question regarded the impact of protected areas on the activities of local inhabitants. The other question regarded the impact of protected areas on local development. Among the positive impacts of the protected areas in Bela krajina, the respondents mentioned: the protection of nature, the protection of cultivated landscape (cultural landscape), attraction of tourism and development potential. Similar results were obtained in the past (Mrak 2008) through surveys that took place within the territory of the Lahinja Landscape Park. Among the negative impacts of protected areas on the activities of locals, some respondents mentioned the limitations for agriculture, which was also mentioned by the inhabitants of the Lahinja Landscape Park (Mrak 2008).

As mentioned in subchapter 2.1, sustainable development studies usually neglect the natural characteristics of the areas being studied. We argue that the characteristics of specific areas, such as karst regions, should be included in the measurement of development, in order to achieve sustainable development. Thus, at the end of the study we proposed a set of indicators to be taken into consideration in the measurement and monitoring of sustainable development of karst regions, which were named 'Karst specific indicators'. The majority of the indicators included in the proposed set of indicators are related to natural-geographic aspects of karst landscapes, as it was proved (in the results from interviews) that karst features negatively influence the farming in the region and positively influence development through the attraction of tourism.

To conclude, the region has areas of high value for development that are not very important for conservation (e.g., the TRIS Kanižarica business zone), as well as areas of high conservation value that have low development interest (e.g., karst caves, karst springs). In the study region there are also areas that meet both criteria, i.e. of high conservation value and high development appeal (e.g., the Lahinja and Kolpa Landscape Parks).

4.1 Comments and limitations

The application of the approaches used brought both advantages and disadvantages.

We faced several challenges while using the 'stability mapping' method (subchapter 3.2). Some trajectories of change resulted from the stability mapping showing that some built-up areas appeared and disappeared in adjacent time periods. We are aware that new areas may have been built and old buildings may have been destroyed, however in these examples the dynamics of built-up areas among different time periods suggest mapping errors, and not the expansion or retreat of this land use type. As can be seen in the graphical results represented in Figures 32 and 33, the built-area areas increased in 1987 and decreased in 2012 in a similar area mapped in the previous century. With these two arguments we prove that built-up areas in the Agrokarta, the map representing the layer for 1987, were imprecisely mapped. Working with only four time periods (four map layers) made it difficult to carry out the interpretation of some land use changes. As the overgrown areas were not mapped in 1877 (or simply did not exist), some trajectories of change were considered in our analyses to have 'No clear trend' as they endured two or three land use changes. However, if the areas in 1877 mapped as meadows were actually overgrown areas, these trajectories of change would be considered as cases of natural succession due to land abandonment. As a consequence of this, the aforementioned cases would be defined as 'Stepped' or 'Quasi-stable' classes of change, and not defined as having 'No clear trend'. Thus, we contend that the stability mapping method used presents a useful approach to analysing land use changes and gives a good overall graphical result, although the results should be treated with caution. As suggested by Ribeiro, Ellis Burnet and Torkar (2013) the number of input datasets (time periods) can be a limiting factor, and analysis done with less than 6 datasets, as in the case of the present study, hampers the detection of all processes of change. Consequently, the results can be subject to subjective interpretation.

Table 46: Summary of the strengths and weaknesses of the approaches utilised in the study.

Approach	Karst Disturbance Index	Stability mapping	Measurement of sustainable regional development	
			Sustainable development indicators	Structured interviews
Strengths	• Straightforward approach • Specific to karst landscapes • Allows for comparison among different karst landscapes	• Useful approach to analyse land use changes • Gives a good overall graphical result	• Gives an overview of the development state • Allows for comparison between different areas if the same indicators are applied	• Allows for the examination of a respondent's perceptions of landscape values, features and changes
Weaknesses	• Data availability can be a limiting factor	• The number of input datasets (time series) is a limiting factor	• The majority of environmental data is not available at the municipal level (LAU 2) • Lack of common framework, hampering the comparison among different studies	• Time-consuming and costly • Subject to subjectivity (from respondents and interpreters)

Judging only by the analysis of sustainable development indicators, the Semič Municipality appears to be the most developed in Bela krajina. This result is somewhat surprising and it could differ if a different set or number of indicators were to be used. For instance, we perceived some differences between our results and the 'Municipality Development Coefficient' (which uses different indicators, Figure 38). This proves that measuring the sustainable development of an area through the application of a set of indicators might be subjective and sometimes misleading. The main benefits and drawbacks of all the approaches used within this research are summarised in Table 46.

4.2 Karst and sustainability

Considering the vulnerability of karst regions to human impacts, these areas pose an additional issue to sustainable development. As claimed by Brinkmann and Garren (2011), karst systems impact the effectiveness of sustainability efforts.

In order to measure and monitor the sustainable development of karst regions, we believe that an additional set of indicators is required (together with the previously applied set of sustainable development indicators in subchapter 3.3.1), which emphasise the specificities of karst areas. Therefore, we propose a set of indicators to measure and monitor sustainable development in karst regions (Table 47).

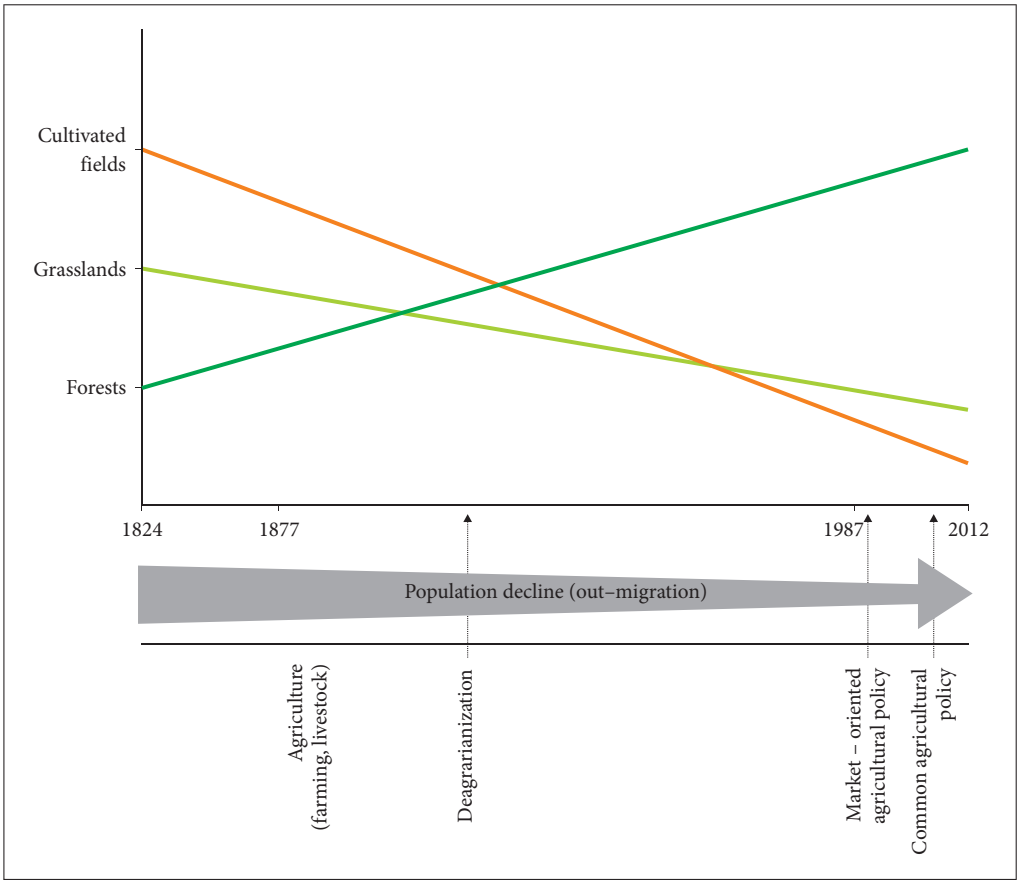


Figure 52: Factors which influence the sustainable development of karst areas.

Table 47: Indicators for measuring and monitoring sustainable development of karst regions (for details see Ribeiro 2017; Ribeiro, Zorn and Čarni 2017).

Domain	Theme	Indicator
Karst specific indicators	Natural features due to karstified terrain	Proportion of karstified surface (% of total area)
		Proportion of stony surface (% of total area)
		Areas affected by karst floods (% of total area)
		Areas affected by drought in summer months (% of total area)
		Density of dolines (number per km^2)
		Microclimate (temperature inversion)
	Typical livestock in karst areas	Number of sheep (number of sheep/ha)
	Protected areas due to karst features	Proportion of Natura 2000 areas due to karst features (% of Natura 2000 areas)
		Density of valuable natural features of national importance due to surface and subterranean karst phenomena
	Water availability in karst areas	Number of karst sources providing drinking water (number/km^2)
		Density of surface karst waters (km/km^2)
	Agricultural potential of karst regions	Land fragmentation
		Proportion of agricultural land on karst surfaces (%)
		Proportion of cultural dolines (% cultural dolines per total number of dolines)
		Proportion of overgrown areas (% of total area)
	Social and cultural background	Ethnic structure*
	Special cultural features due to karst	Number of special landscape features recognised as important cultural heritage
	Karst disturbance (influence of human activities)	Disturbance level of karst areas (assessment resulted from Karst Disturbance Index, subchapter 3.1)

*Specific indicators that are important for Bela krajina, but might not be as important or influential in other karst regions.

4.3 Key methodological achievements

The main objective of this study was to understand the relationships between landscape features, land use and the sustainable development of a karst region. Thus the research reflects the applicability of different methods for the analysis of the relationship between landscape features, land use and sustainable development.

The first approach used was the Karst Disturbance Index, which was applied for the first time in Slovenia. In a country with a large surface area of karst terrain, such integrative assessments are necessary. During the application of the index we altered some of the indicators that are more important for the particular study region.

What is also lacking in the literature is a critical comparison between different landscapes; the analysis of the speed of changes in different landscapes; the reasons for these changes, and finally modelling of the landscape development integrating landscape features. Hence, with this study, we also aimed to enhance the understanding of the evolution of Bela krajina's landscapes and the historical processes that have shaped the region, in order to identify sustainable strategies for future landscape management. This was achieved through the analyses of land use dynamics for two case studies presented in subchapter 3.2.

The study is based upon understanding and measuring sustainable local development (development of three municipalities), taking into account socio-geographical, economic and natural geographical particularities. Several studies have been done in the field of landscape research (e.g., Hladnik 2005; Paudel and Yuan 2012; Swetnam 2007), and regional development (e.g., Černe 2003; Ravbar 2009), however, there is still a lack of interdisciplinary and integrated studies. Studies on regional development usually do not include landscape related variables (Dissart 2007). Thereby a common practice within literature dealing with this topic is to confine amenities to a single dimensional variable (Deller et al. 2001). Therefore, we made efforts to measure the sustainable development of the study region through a balance (somewhat limited by data availability) of social, economic, and environmental aspects. Thus, we attempted to measure sustainable development with multi-dimensional variables in this study.

With everything considered, we wanted to bring forth new information and understanding in the fields of landscape research and sustainable development, and to justify the importance of landscape features at municipality/regional scales. Thus, and following the ideas of Bloemers et al. (2010), from a scientific point of view the main challenges were to integrate natural geographical, socio-geographical, and economic particularities together to carry out in-depth interdisciplinary research. We did this to inform current situations through long-term historical research, including a social perspective on the current environmental demands; to propose new links between research, policy and practice through the concept of landscape as a cultural construction; and, to understand personal and collective practices of local identity using the landscape.

Studies on sustainable development of karst regions, including the development potential of these areas and their environmental degradation, are scarce. The measurement and monitoring of the development potential and management of karst areas is of great importance in Slovenia. Therefore, we proposed a set of sustainable development indicators (subchapter 4.2), to measure and monitor the sustainable development of karst regions, taking into account their specificities and vulnerability. Until now, a set of such indicators has not been proposed.

It is hoped that this work can function as a model and stimulus for further efforts towards sustainable development research of karst regions.

4.4 Recommendations

The results of our study show that karst landscape features influence both the land use and the sustainable development of Bela krajina.

Agriculture in Bela krajina faces challenges. It is not competitive due to the soil and relief conditions, the poor economic and financial power of farms, as well as the unfavourable age and education structure of the local population. As a result, abandonment of farming and reduction of farms is taking place. Even though the economic significance of farming is low and has decreased in the last decades in favour of other activities, it is of vital importance for landscape stability and the sustainable development of Bela krajina. The preservation of extensive agriculture (traditional practices) should be stimulated

in order to fight against the overgrowth of agricultural land. Simultaneously, the preservation of extensive agriculture is very important in order to preserve biodiversity, landscape diversity and cultural landscapes which are crucial to provide ecosystem services (Ribeiro and Šmid Hribar 2019). Another challenge that agriculture in the study region faces is to produce enough food at competitive prices, and to feed the local population with a smaller rural labour force. Nevertheless, agricultural growth, and adopting efficient and sustainable techniques adapted to karst characteristics, is key for the sustainable development of Bela krajina. Due to the karst landscape features in the study region, organic farming is potentially appealing for the region, where land plots are small and conventional agricultural production is very limited. Incentive-based policies to influence land use decisions adapted to karst characteristics should be prepared. In vulnerable areas such as karst landscapes, farmers should be encouraged to use appropriate methods of farming (e.g., organic farming). The expansion of the proportion of organic products and the increase in the demand for local products is emerging as an answer to improve the economic situations of local farmers and thus contribute to local development. The promotion of local markets with locally produced and environmentally friendly products also contributes to the local economy (e.g., creation of small enterprises), the health care of the local population (promotion of healthy local food in schools, kindergartens, nursing homes and canteens of other institutions), and the environmental conditions of the karst landscapes of Bela krajina. Therefore, we suggest the promotion of regional food self-sufficiency as a contributor to sustainable development, which would also contribute to the maintenance of landscape diversity and traditions, and to employment in rural areas of Bela krajina. This would involve the creation of agro-food chains that are absent from the region at the moment. The efficiency of this strategy has been discussed by several studies (e.g., Bah 2013; Noromiarilanto et al. 2016). This strategy would provide reasons for people to stay in the region and reduce out-migration. However, this is only possible with the participation of locals, where local people are encouraged to think about their future and exploit their ideas to stay in the region.

The same can be applied to the involvement of local inhabitants in the protection and management of protected areas, which constitute 46% of Bela krajina's territory. As key stakeholders, local inhabitants have to be educated and involved in the management processes, and must support them, otherwise the protected areas will not benefit the locals. Local inhabitants would thus embrace the protected areas as their own, and protected areas could act as promotion for local development. Previous studies have confirmed this approach (e.g., Lampič and Mrak 2008; Lampič, Mrak and Plut 2011). We contend that the protected areas in Bela krajina should be promoted as specific development areas, as suggested by Plut and Brečko Grubar (2008). According to Lampič, Mrak and Plut (2011), the protection and development of areas rated as category V in the IUCN, such as the Lahinja and Kolpa Landscape Parks, is equally important. Thus the study region possesses good development potential based on the existing protected areas. The Kolpa River is currently the core of local tourism.

Since tourism in Bela krajina is linked to the natural and cultural amenities of the region, the well-preserved natural and cultural heritage has the potential to promote the development of tourism. Many traditional events still take place: *Jurjevanje*, *Vinska vigred* and *Semiška ohcet*. This shows potential development based on endogenous resources, emphasising the resources present in the region. Therefore, the promotion of unique features of the landscape (e.g., strong ethnic and cultural identity, considerable areas under protection, the endemic black olm) as tourist attractions, as promoters of development, and the conservation of the traditional landscape and traditions (e.g., *Uskok* traditions), is relevant for the study region. We encourage the promotion of the black olm as a unique karst symbol of Bela krajina, being a distinctive symbol to promote sustainable tourism in the region. The attraction of the natural environment and tourism can be a significant part of Bela krajina's economy. Companies built around the utilisation of the region's amenities (e.g., tourist offers involving local agricultural products and accommodation) can lead to development of the region and provide new jobs. However additional infrastructure is still necessary, such as different kinds of accommodation, trails and roads, as well as transportation and other facilities. In spite of this, and even though many of the respondents stated

that the region has a high tourism potential, sustainable development of the region cannot be based only built around tourism or natural amenities, as most tourism is seasonal and factors such as poor seasonal weather can have an impact on the local economy. Tourism development should be of high quality and variety, showing the distinctive characteristics of Bela krajina's landscape. It is therefore necessary to develop a strategic tourism plan that involves the three municipalities, based on products resulting from their rich cultural and natural heritage, and the many opportunities for active recreation.

The creation and development of small enterprises is thus of extreme importance for the development of the study region, which according to its vulnerability (e.g., ecological vulnerability of water sources can be considered as a limiting factor for the development of industry) does not allow for the development of industry at a larger scale.

Even though one aspect that influences the regional development of Bela krajina is its poor accessibility and limited connections to larger urban centres and neighbouring regions (e.g., Novo mesto), some local stakeholders stated that the remoteness of Bela krajina contributes to the preservation of the unspoiled nature of the study region. This weak connection to larger urban centres also affects the socio-economic structure of the region (hindering service delivery, communications and job opportunities). Thus the development of transport infrastructure, such as the proposed corridor of the 'Third Development Axis', connecting Bela krajina with other Slovene regions and the Croatian highway, would increase the accessibility to the region and strengthen the regional economy. However, the strategic location of the study region, along the Croatian border, could be used to promote trans-boundary cooperation with the neighbouring Croatian municipalities, taking advantage of easier trade with the neighbouring country. It is relevant to mention the importance of development projects, such as the Pokolpje Business Opportunity (Pokolpje poslovna priložnost 2017), to promote business opportunities and benefits for investment and employment in the study region.

Thus the development of Bela krajina must be based on strengthening the multifunctional role of the landscape, based on the principles of sustainable development and management of renewable natural resources, preservation of the cultural landscape, protecting the environment, and biodiversity. It has also been shown that afforestation is taking place in the study region, and that the region is characterised by these extensive forested landscapes (see subchapter 3.2). Thus we suggest that these forested landscapes, and the associated richness of biomass, should be promoted as factors with great economic potential. The various renewable energy sources present in the study region also offer potential development, particularly wood biomass, solar energy, hydropower and geothermal energy, that are currently not being sufficiently exploited. Measures to address the economic and social enhancement of the study region must be taken to establish new ways to increase employment; otherwise the region will continue to suffer from out-migration and population decline. In addition, considering the vulnerability of karst regions to human impacts, these areas pose a further problem to sustainable development. Taking into account the fact that almost half of Slovenia is covered by karst, the proposed set of 'Karst specific indicators' has the potential to bring a more integrative assessment of the sustainable development of karst regions.

When considering all the aforementioned recommendations, karst landscape features should not only be seen as limiting factors, but also for their own development potential.

4.5 Suggested areas for future study

It is hoped that this study can provide planners with elements to sustainably manage the landscape and promote sustainable development in Bela krajina and other karst areas. However, we are aware that a lot more could be done, and thus in the following paragraphs we have proposed some suggestions for areas of further study. We hope that these open questions can open paths to new research.

The application of the Karst Disturbance Index (subchapter 3.1) to other Slovenian karst regions would be necessary to make an overall assessment of the disturbance degree of karst areas in the country.

The inclusion of additional datasets, especially those dating between 1877 and 1987, to the analyses of land use changes would improve understanding of the landscape changes in the study region, as well as provide better interpretation of the trajectories of change acquired from the stability mapping approach (subchapter 3.2).

In addition to the interviews presented in subchapter 3.3.2, supplementary interviews should be done with former residents of Bela krajina who no longer live in the region, in order to understand their reasons for leaving the region. Supplementary interviews should also be done with tourists to understand the reasons that make the region attractive to them.

Since the proposed scenarios did not follow widely applied scenario techniques (e.g., Tress and Tress 2003; Gantar and Golobič 2015), we propose a participatory scenario for further studies that would address the question of how different demands on Bela krajina's landscapes can be identified by different stakeholders. This could enhance the role of stakeholders in planning future landscapes.

Although we analysed the influence of landscape features on land use and sustainable development in this study, it would be interesting to study the opposite relationship, i.e. how land use and sustainable development influence the landscape features. And furthermore, what are the impacts of land use changes on the economy, population and environment?

The results of the present study have some implications for the future monitoring and management of karst landscapes. We believe that the information obtained may be useful to several stakeholders. The results of this study can be relevant at a national level, but they are particularly useful for the sustainable development of karst regions.

5 References and Sources

5.1 References

Aarhus Convention: An Implementation Guide. UNECE, Switzerland, 1994.

Adamič, M., Plut, D., Kambič, A., Kambič, M., Štukelj, P. 2012: Strategija razvoja občine Semič do leta 2020 [Development Strategy of Semič Municipality until 2020]. Semič.

Agenda 2000 – For a Stronger and Wider Europe. Supplement 5/97 to the Bulletin of the European Union. European Commission, Luxembourg, 1997.

Agrokarta [Agricultural map], 1987. Upravna enota Črnomelj. Črnomelj.

Aljančič, G., Năpăruș-Aljančič, M., Stanković, D., Pavićević, M., Gorički, Š., Kuntner, M., Merzlyakov, L. 2014: A survey of the distribution of Proteus anguinus by environmental DNA sampling. CEPF final project completion report. Society for Cave Biology. Ljubljana. DOI: https://doi.org/ 10.13140/RG.2.1.2818.200610

Atlas okolja [Atlas of the environment], 2016. ARSO. INTERNET: http://gis.arso.gov.si/atlasokolja/profile.aspx?id=Atlas_Okolja_AXL@Arso (12. 5. 2016).

Bah, A. A. 2013: Strategies for Promoting Rice Self-sufficiency in Sierra Leone. Journal of Northeast Agricultural University 20-4. DOI: https://doi.org/10.1016/S1006-8104(14)60051-9

Beilin, R., Lindborg, R., Queiroz, C. 2011: Biodiversity and Land Abandonment: Connecting Agriculture, Place and Nature in the Landscape. Landscapes, identities and development. Farnham.

Bender, O., Boehmer, H. J., Jens, D., Schumacher, K. P. 2005: Using GIS to analyse long-term cultural landscape change in Southern Germany. Landscape and Urban Planning 70-1,2. DOI: https://doi.org/10.1016/j.landurbplan.2003.10.008

Bieling, C., Plieninger, T., Pirker, H., Vogl, C. R. 2014: Linkages between landscapes and human well-being: an empirical exploration with short interviews. Ecological Economics 105. DOI: https://doi.org/10.1016/j.ecolecon.2014.05.013

Bloemers, T., Daniels, S., Fairclough, G., Pedroli, B., Stiles R. 2010: Landscape in a Changing World: Bridging Divides, Integrating Disciplines, Serving Society. Science Policy Briefing 41.

Bole, D. 2008: Ekonomska preobrazba slovenskih mest [Economic Transition in Slovene Cities]. Ljubljana.
Bowen, M. E., McAlpine, C. A., House, A. P. N., Smith, G. C. 2007: Regrowth forests on abandoned agricultural land: A review of their habitat values for recovering forest fauna. Biological Conservation 140-3,4. DOI: https://doi.org/10.1016/j.biocon.2007.08.012
Brinkmann, R., Garren, S. J. 2011: Karst and Sustainability. Karst Management. Dordrecht.
Bukovac, J., Poljak, M., Šušnjar, M., Čakalo, M. 1984: Tumač za list Črnomelj: L 33-91: Socijalistička federativna republika Jugoslavija, osnovna geološka karta, 1:100 000. Beograd.
Calò, F., Parise, M. 2006: Evaluating the Human Disturbance to Karst Environments in Southern Italy. Acta Carsologica 35-2. DOI: https://doi.org/10.3986/ac.v35i2-3.227
Caring for the earth: A strategy for sustainable living. IUCN-UNEP-WWF, Gland, 1991. INTERNET: http://www.sustainablemeasures.com/sustainability (21. 10. 2016).
Carpenter, R. A. 1995: Limitations in Measuring Ecosystem Sustainability. A Sustainable World: Defining and measuring sustainable development. Sacramento and Claremont.
Ciglič, R., Hrvatin, M., Komac, B., Perko, D. 2012: Karst as a criterion for defining areas less suitable for agriculture. Acta geographica Slovenica 52-1. DOI: https://doi.org/10.3986/AGS52103
Clement, K., Hansen, M., Bradley, K. 2003: Sustainable Regional Development: Learning from Nordic Experience. Report. Stockholm.
Cooper, A. H., Brown T. J., Price S. J., Ford J. R., Waters, C. N. 2018: Humans are the most significant global geomorphological driving force of the 21st century. The Anthropocene Review 5-3. DOI: https://doi.org/10.1177/2053019618800234
Cousins, S. A. O. 2001: Analysis of land-cover transitions based on 17th and 18th century cadastral maps and aerial photographs. Landscape Ecology 16-1. DOI: https://doi.org/10.1023/A:1008108704358
Culver, D. C., Christman, M. C., Sket, B., Trontelj, P. 2004: Sampling adequacy in an extreme environment: species richness patterns in Slovenian caves. Biodiversity and Conservation 13-6. DOI: https://doi.org/10.1023/B:BIOC.0000018153.49280.89
Culver, D. C., Sket, B. 2000: Hotspots of subterranean biodiversity in caves and wells. Journal of Cave and Karst Studies 62-1.
Cunder, T. 2001: Območja z omejenimi dejavniki za kmetijstvo in reforma kmetijske politike v Sloveniji [Restricted areas for agriculture and agricultural policy reform in Slovenia]. Ljubljana.
Černe, A. 2003: Regional development perspectives of Slovenia. Dela 19.
Černe, A., Kušar, S. 2010: The system of indicators for regional development, structure and potentials. Ljubljana.
De Groot, R. S. 2006: Function-analysis and valuation as a tool to assess land use conflicts in planning for sustainable, multi-functional landscapes. Landscape and Urban Planning 75-3,4. DOI: https://doi.org/10.1016/j.landurbplan.2005.02.016
Deelstra, T. 1995: The European Sustainability Index Project. A Sustainable World: Defining and measuring sustainable development. Sacramento and Claremont.
Deller, S. C., Tsai, T.-H., Marcouiller, D. W., English, D. B. K. 2001: The role of amenities and quality of life in rural economic growth. American Journal of Agricultural Economics 83-2.
Dissart, J.-C. 2007: Landscapes and regional development: What are the Links? Cahiers d'économie et sociologie rurales 84-85.
Dobernik, M. 2002: Reproduciranje franciscejskega katastra [Reproduction of the Franciscean Cadastre]. Arhivi 25-2.
DOF – Ortofoto [Digital orthophoto]. Geodetska uprava Republike Slovenije, Ljubljana, 2009.
Društva, politične stranke in ustanove [Associations, political parties and institutions]. Ministrstvo Republike Slovenije za notranje zadeve, Ljubljana, 2017. INTERNET: http://mrrsp.gov.si (27. 1. 2017).
Dular, A. 1985: Etnološka topografija slovenskega etničnega ozemlja – 20. Stoletje: Občina Črnomelj [Ethnological topography of the Slovene ethnic territory – 20th Century: Črnomelj Municipality]. Ljubljana.

Eagles, P. F. J., McCool, S. F., Haynes, C. D. 2002: Sustainable Tourism in Protected Areas: Guidelines for Planning and Management. Gland and Cambridge.
Earth Summit. Report of the United Nations Conference on Environment and Development. UNCED, Rio de Janeiro, 1992.
eDaljinar. Ministrstvo Republike Slovenije za infrastrukturo, Ljubljana, 2016.
Ellis, E. 2010: Land-use and land-cover change. Encyclopedia of Earth. INTERNET: http://www.eoearth.org/article/Land-use_and_land-cover_change (5. 8. 2017).
Environmental indicators: Typology and overview. EEA, Copenhagen, 1999.
Erhartič, B., Zorn, M. 2012: Geodiversity and geomorphosite research in Slovenia. Geografski vestnik 84-1.
EU budget in my country–Slovenia. European Commission, 2014. INTERNET: http://ec.europa.eu/budget/mycountry/SI/index_en.cfm (3. 9. 2016).
Europe 2020: A strategy for smart, sustainable and inclusive growth. European Commission, Brussels, 2010.
European Landscape Convention. Council of Europe, 2000. INTERNET: http://www.pcl-eu.de/project/convention/intro.php?PHPSESSID=4d2ef5d6833223d11cf81320b70026ac (21. 11. 2012).
Eurostat Archive 2020. INTERNET: https://ec.europa.eu/eurostat/statistics-explained/index.php/Archive:Sustainable_development_indicators_introduced (6. 7. 2020).
Evidenca hišnih številk [Register of house numbers]. Geodetska Uprava Republike Slovenije, Ljubljana, 2015.
Evidenca dejanske rabe kmetijskih in gozdnih zemljišč [Land use database]. Ministrstvo Republike Slovenije za kmetijstvo, gozdarstvo in prehrano, Ljubljana, 2015. INTERNET: https://rkg.gov.si/vstop/ (25. 4. 2016).
Factsheet on 2014-2020 Rural Development Programme for Slovenia. European Commission, 2015. INTERNET: https://ec.europa.eu/agriculture/sites/agriculture/files/rural-development-2014-2020/country-files/si/factsheet_en.pdf (3. 9. 2016).
Filepné Kovács, K., Valánszki, I., Sallay, Á., Jombach, S., Mikházi, Z., Kollányi, L. 2015: Landscape function analysis as a base of landscape visions. Acta Universitatis Sapientiae Agriculture and Environment 7.
Ford, D., Williams, P. 2007: Karst Hydrogeology and Geomorphology. Chichester. DOI: https://doi.org/10.1002/9781118684986
Forman, R. T. T. 1995: Land Mosaics: The Ecology of Landscapes and Regions. New York.
Franciscejski kataster za Kranjsko [Franciscean Land Cadaster], k.o. Adlešiči, Bojanci, 1823–1869. Arhiv Republike Slovenije. Ljubljana.
Gabrovec, M., Bičík, I., Komac, B. 2019: Land registers as a source of studying long-term land-use changes. Acta geographica Slovenica 59- 2. DOI: https://doi.org/10.3986/AGS.7349
Gabrovec, M., Komac, B., Kozina, J., Polajnar Horvat, K., Nared, J., Smrekar, A., Topole, M., Urbanc, M. 2017: Triglav National Park, Slovenia, and its contribution to regional development. Eco.mont 9. DOI: https://doi.org/10.1553/eco.mont-9-sis57
Gabrovšek, F., Knez, M., Kogovšek, J., Mihevc, A., Mulec, J., Perne, M., Pipan, T., Prelovšek, M., Slabe, T., Šebela, S., Ravbar, N. 2011: Development challenges in karst regions: sustainable land use planning in the karst of Slovenia. Carbonates Evaporites 26-4. DOI: https://doi.org/10.1007/s13146-011-0072-3
Gams, I. 2003: Kras v Sloveniji v prostoru in času [Karst in Slovenia in space and time]. Ljubljana.
Gams, I., Lovrenčak, F., Ingolič, B. 1971: Krajna vas: a study of the natural conditions and of agrarian land utilization on the Karst. Geografski zbornik 12.
Gantar, D., Golobič, M. 2015: Landscape scenarios: a study of influences on attitudes and actions in a rural landscape. Futures 69. DOI: https://doi.org/10.1016/j.futures.2015.02.002
Geniaux, G., Bellon, S., Deverre, C., Powell, B. 2009: Sustainable Development Indicator Frameworks and Initiatives. Report No.49. Wageningen.
Getzner, M., Jungmeier, M. 2002: Conservation policy and the regional economy: the regional economic impact of Natura 2000 conservation sites in Austria. Journal for Nature Conservation 10-1. DOI: https://doi.org/10.1078/1617-1381-00003

Giddings, B., Hopwood, B., O'Brien, G. 2002: Environment, economy and society: fitting them together into sustainable development. Sustainable Development 10-4. DOI: https://doi.org/10.1002/sd.199

Golobič, M., Lestan, K. A. 2016: Potential impacts of EU policies on cultural landscape diversity: example of Slovenian coastal landscapes. Annales 26-2. DOI: https://doi.org/10.19233/ASHS.2016.16

Goulet, D. 1995: Authentic Development: Is it Sustainable? A Sustainable World: Defining and measuring sustainable development. Sacramento and Claremont.

Gramm, D., Pecher, C., Tasser, E., Tappeiner, U. 2008: Methods. Mapping the Alps, Society-Economy-Environment. Heidelberg.

Guiding Principles for Sustainable Spatial Development of the European Continent. CEMAT, Hanover, 2000.

Habič, P. 1969: Hidrografska rajonizacija krasa v Sloveniji [Hydrographic Regionalisation of the Slovene Karst]. Krš Jugoslavije 6.

Habitatni tipi Slovenije 2004: tipologija [Habitat Types of Slovenia 2004: typology]. Agencija Republike Slovenije za okolje, Ljubljana, 2004.

Habitatni tipi Slovenije 2011: tipologija [Habitat Types of Slovenia 2011: typology]. Zavod Republike Slovenije za varstvo narave, Ljubljana, 2011.

Hart, M. 1999: Guide to sustainable community indicators. North Andover.

Hladnik, D. 2005: Spatial structure of disturbed landscapes in Slovenia. Ecological Engineering 24-1,2. DOI: https://doi.org/10.1016/j.ecoleng.2004.12.004

Hobbs, R. J., Cramer, V. 2007: Why Old Fields? Socioeconomic and Ecological Causes and Consequences of Land Abandonment. Old Fields: Dynamics and Restoration of Abandoned Farmland. Washington.

Hudoklin, A. 2011: Are we guaranteeing the favourable status of the Proteus anguinus in the Natura 2000 network in Slovenia? Pressures and Protection of the Underground Karst-Cases from Slovenia and Croatia. Postojna.

Implications of economic policy for food security: a training manual. FAO, 1999. INTERNET: http://www.fao.org/docrep/004/x3936e/x3936e03.htm (8. 4. 2017).

Indicators of Sustainable Development: Guidelines and Methodologies. United Nations, New York, 2007.

Jamarski klub Novo mesto – Program jamarske šole [Cave School Program]. Novo mesto, 2016. INTERNET: http://www.jknm.si/si/izobrazevanje/program/ (12. 4. 2016).

Kačičnik Gabrič, A. 2000: Kataster na Slovenskem [Cadastre in Slovenia]. Zgodovina v šoli 9-1.

Kačičnik Jančar, M. 2011: Navodila za kartiranje negozdnih habitatnih tipov [Instructions for mapping non-forest habitat types]. Ljubljana.

Kaligarič, M., Ivajnšič, D. 2014: Vanishing landscape of the »classic« Karst: changed landscape identity and projections for the future. Landscape and Urban Planning 132. DOI: https://doi.org/10.1016/j.landurbplan.2014.09.004

Kaltenborn, B. P., Bjerke, T. 2002: Associations between environmental value orientations and landscape preferences. Landscape and Urban Planning 59-1. DOI: https://doi.org/10.1016/S0169-2046(01)00243-2

Kataster jam [Cave Registry], 2016. Jamarska zveza Slovenije. Ljubljana.

Kazalniki blaginje v Sloveniji 2015 [Indicators of well-being in Slovenia]. Statistični urad Republike Slovenije, 2015. INTERNET: http://www.kazalniki-blaginje.gov.si/ (1. 8. 2016).

Kazana, V., Kazaklis, A. 2009: Exploring quality of life concerns in the context of sustainable rural development at the local level: a Greek case study. Regional Environmental Change 9-3. DOI: https://doi.org/10.1007/s10113-008-0056-6

Keller, J. W. 2001: The Importance of Rural Development in the 21st Century – Persistence, Sustainability, and Futures. INTERNET: http://www.regional.org.au/au/countrytowns/keynote/keller_notes.htm#TopOfPage.

Kladnik, D. 1998: Dinarski svet [Dinaric World]. Slovenija – pokrajine in ljudje. Ljubljana.

Kladnik, D., Ravbar, M. 2003: The Importance of the Division of the Countryside in Stimulating Regional Development. Acta Geographica Slovenica 43-1.

Kladnik, D., Senegačnik, J. 1983: Opredelitev naselij s kraškim površjem [Definition of settlements with karst surface]. Ljubljana.

Klemenčič, M. 1989: Družbenogospodarski prehod v Sloveniji [The socioeconomic transition process in Slovenia]. Dela 6.

Knific, K. 2003: Raba tal na krasu – primer iz Bele krajine [Land use in karst – an example from Bela Krajina]. Graduate thesis. Filozofska fakulteta Univerze v Ljubljani. Ljubljana.

Koeficient razvitosti občin 2016 [Municipality Development Coefficient]. Ministrstvo Republike Slovenije za finance, Ljubljana, 2016.

Kogovšek, J. 1995: Podrobno spremljanje kvalitete vode, odtekajoče z avtoceste in njen vpliv na kraško vodo [Detailed monitoring of the quality of water exiting the highway and its impact on karst water]. Annales 5-7.

Kogovšek, J., Petrič, M. 2002: Ogroženost kraškega sveta [Threat to the karst world]. Nesreče in varstvo pred njimi. Ljubljana.

Kozina, J. 2013: Življenjsko okolje prebivalcev v ustvarjalnih poklicih v Sloveniji [Living environment of inhabitants in creative occupations in Slovenia]. Ph.D. thesis. Filozofska fakulteta Univerze v Ljubljani. Ljubljana.

Kozina, J. 2016: Življenjsko okolje ustvarjalnih ljudi v Sloveniji [Living environment of creative people in Slovenia]. Ljubljana.

Križnik, K., Purkat, N. (eds.) 2008: Učni načrt [Syllabus]. Geografija: gimnazija: splošna, klasična, ekonomska gimnazija. Ljubljana. INTERNET: http://www.mss.gov.si/fileadmin/mss.gov.si/pageuploads/podrocje/ss/programi/2008/Gimnazije/UN_GEOGRAFIJA_gimn.pdf.

Lah, A. 1998: Voda-vodovje: poglavitni življenjski vir narave in gospodarstva [Water-waters: the main life-source of nature and economy]. Ljubljana.

Lambin, E. F., Meyfroidt, P. 2011: Global land use change, economic globalization, and the looming land scarcity. PNAS 108-9. DOI: https://doi.org/10.1073/pnas.1100480108

Lampič, B., Bedrač, M., Cunder, T., Klun, M., Mrak, I., Slabe Erker, R. 2016: Trajnostna naravnanost kmetijstva v slovenskih regijah [Sustainable orientation of agriculture in Slovenian regions]. Ljubljana.

Lampič, B., Mrak, I. 2008: Vrednote, vrednosti in razvojni potenciali območij varovanja [Valuables, values and development potentials of protected areas]. Dela 29.

Lampič, B., Mrak, I., Plut, D. 2011: Geographical Identification of Development Potential for the Sustainable Development of Protected Areas in Slovenia. Hrvatski geografski glasnik 73-2. DOI: https://doi.org/10.21861/hgg.2011.73.02.04

Lampič, B., Slabe, A. 2013: Tržna pridelava na ekoloških kmetijah kot dejavnik razvoja na podeželju [Market-orientated production of organic farms as a factor of rural development]. Nove razvojne perspective. Ljubljana.

Landscape Conservation Law: Present Trends and Perspectives in International and Comparative Law. IUCN Commission on Environmental Law, Gland, 2000.

Laszlo, E. 1994: The Choice: Evolution or Extinction? A Thinking Person's Guide to Global Issues. New York.

Lisec, A., Pišek, J., Drobne, S. 2013: Suitability analysis of land use records of agricultural and forest land for detecting land use change on the case of the Pomurska statistical region. Acta Geographica Slovenia 53-1. DOI: https://doi.org/10.3986/AGS53104

Lizana, J., Ortiz, C., Soltero, V. M., Chacartegui, R. 2017: District heating systems based on low-carbon energy technologies in Mediterranean areas. Energy 120. DOI: https://doi.org/10.1016/j.energy.2016.11.096

Luthar, O., Dobrovoljc, H., Fridl, J., Mulec, J., Pavšek, M. (eds.) 2008: Kras, trajnostni razvoj kraške pokrajine [Karst, sustainable development of karst landscapes]. Ljubljana.

MacDonald, D. H., Bark, R., MacRae, A., Kalivas, T., Grandgirard, A., Strathearn, S. 2013: An interview methodology for exploring the values that community leaders assign to multiple-use landscapes. Ecology and Society 18-1. DOI: https://doi.org/10.5751/ES-05191-180129

Mander, Ü., Uuemaa, E. 2010: Landscape assessment for sustainable planning. Ecological indicators 10-1. DOI: https://doi.org/10.1016/j.ecolind.2009.08.003

Marcucci, D. J. 2000: Landscape history as a planning tool. Landscape and Urban Planning 49-1,2. DOI: https://doi.org/10.1016/S0169-2046(00)00054-2

Marušič, J. 1995: Značilni krajinski vzorci Slovenije: po projektu Regionalna razdelitev krajinskih tipov Slovenije [Characteristic landscape patterns of Slovenia: according to the Project of regional distribution of landscape types in Slovenia]. Ljubljana.

Matthews, R., Selman, P. 2006: Landscape as a Focus for Integrating Human and Environmental Processes. Journal of Agricultural Economics 57-2. DOI: https://doi.org/10.1111/j.1477-9552.2006.00047.x

Mayer, M., Müller, M., Woltering, M., Arnegger, J., Job, H. 2010: The economic impact of tourism in six German national parks. Landscape and Urban Planning 97-2. DOI: https://doi.org/10.1016/j.landurbplan.2010.04.013

Meadows, D. 1998: Indicators and Information Systems for Sustainable Development. A Report to the Balaton Group.

Meyfroidt, P., Chowdhury, R. R., de Bremond, A., Ellis, E. C., Erb, K.-H., Filatova, T., Garrett, R. D., Grove, J. M., Heinimann, A., Kuemmerle, T., Kull, C. A., Lambin, E. F., Landon, Y., Y.le P. de, Messerli, P., Müller, D., Nielsen, J. Ø., Peterson, G. D., Rodriguez García, V., Schlüter, M., Turner II, B. L., Verburg, P. H. 2018: Middle-range theories of land system change. Global Environmental Change 53. DOI: https://doi.org/10.1016/j.gloenvcha.2018.08.006

Millennium Ecosystem Assessment: Ecosystems and Human Well-being: Synthesis. Washington, 2005. INTERNET: http://www.millenniumassessment.org/documents/document.356.aspx.pdf (13. 11. 2017).

Mrak, I. 2008: Odnos prebivalcev do Krajinskega Parka Lahinja [Attitudes of residents towards Lahinja Landscape Park]. Bela krajina in Krajinski park Lahinja. Ljubljana.

Munro, D. A. 1995: Sustainability: Rhetoric or Reality? A Sustainable World: Defining and measuring sustainable development. Sacramento and Claremont.

Muršič, R. 2011: Metodologija preučevanja načinov življenja: Temelji raziskovalnega dela v etnologiji ter socialni in kulturni antropologiji [Methodology for studying lifestyles: Foundations of research work in ethnology and social and cultural anthropology]. Ljubljana.

Nared, J., Bole, D., Breg Valjavec, M., Ciglič, R., Goluža, M., Kozina, J., Razpotnik Visković, N., Repolusk, P., Rus, P., Tiran, J., Černič Istenič, M. 2017. Central Settlemens in Slovenia in 2016. Acta Geographica Slovenica 57-2. DOI: https://doi.org/10.3986/AGS.4606

Navarro, L. M., Pereira, H. M. 2012: Rewilding Abandoned Landscapes in Europe. Ecosystems 15-6. DOI: https://doi.org/10.1007/s10021-012-9558-7

Naveh, Z. 2001: Ten major premises for a holistic conception of multifunctional landscapes. Landscape and Urban Planning 57-3,4. DOI: https://doi.org/10.1016/S0169-2046(01)00209-2

Noromiarilanto, F., Brinkmann, K., Faramalala, M. H., Buerkert, A. 2016: Assessment of food self-sufficiency in smallholder farming systems of south-western Madagascar using survey and remote sensing data. Agricultural Systems 149. DOI: https://doi.org/10.1016/j.agsy.2016.09.005

North, L. A. 2007: Application and Refinement of the Karst Disturbance Index in West Central, Florida. M.Sc. thesis. University of South Florida. Tampa.

Novak, D. 1993: Hydrogeological research of the Slovenian karst. Naše jame 35-1.

O'Farrell, P.J., Anderson, P. M. L. 2010: Sustainable multifunctional landscapes: a review to Implementation. Current Opinion in Environmental Sustainability 2-1,2. DOI: https://doi.org/10.1016/j.cosust.2010.02.005

OECD core set of indicators for environmental performances reviews. A synthesis report by the Group on the State of the Environment, Environment Monographs No. 83. OECD, Paris, 1993. INTERNET: http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=OCDE/GD(93)179&docLanguage=En (9. 7. 2020).

Our Common Future. WCED, Oxford, 1987.

P. B. 1987: Pripravlja se agrokarta občine [The municipality's agricultural map is being prepared]. Naša skupnost 28-6.
Palang, H., Mander, Ü., Luud, A. 1998: Landscape diversity changes in Estonia. Landscape and Urban Planning, 41-3,4. DOI: https://doi.org/10.1016/S0169-2046(98)00055-3
Pan-European Biological and Landscape Diversity Strategy. Council of Europe, UNEP, ECNC, Strasbourg, 1995.
Paudel, S., Yuan, F. 2012: Assessing landscape changes and dynamics using patch analysis and GIS modeling. International Journal of Applied Earth Observation and Geoinformation 16. DOI: https://doi.org/10.1016/j.jag.2011.12.003
Perko, D. 1998: The Regionalization of Slovenia. Geografski zbornik 38.
Petek, F., Fridl, J. 2004: Pretvarjanje listov zemljiško-katastrskega načrta v Gauss-Krugerjev koordinatni sistem [The transformation of the sheets of the Franziscean cadastral map into the Gauss-Krüger coordinate system]. Geografski vestnik 76-2.
Plieninger, T., Hui, C., Gaertner, M., Huntsinger, L. 2014: The Impact of Land Abandonment on Species Richness and Abundance in the Mediterranean Basin: A Meta-Analysis. PLOS One 9-5. DOI: https://doi.org/10.1371/journal.pone.0098355
Plut, D. 1996: Bela krajina. Regionalnogeografska monografija Slovenije, Del 6. Ljubljana.
Plut, D. 1998: Bela krajina. Slovenija: Pokrajine in ljudje. Ljubljana.
Plut, D. 2008: Osnovne geografske značilnosti Bele krajine [Basic geographical features of Bela krajina]. Bela krajina in Krajinski park Lahinja. Ljubljana.
Plut, D., Brečko Grubar, V. 2008: Hidrogeografske značilnosti Lahinje in Krajinskega parka Lahinja [Hydrogeographical characteristics of Lahinja and Lahinja Landscape Park]. Bela krajina in Krajinski park Lahinja. Ljubljana.
Podobnikar, T. 2009: Georeferencing and quality assessment of Josephine survey maps for the mountainous region in the Triglav National Park. Acta geodaetica et geophysica Hungarica 44-1. DOI: https://doi.org/10.1556/AGeod.44.2009.1.6
Pokolpje poslovna priložnost [Pokolpje Business Opportunity]. INTERNET: https://www.pokolpje.si/ (5. 5. 2017).
Polajnar Horvat, K. 2014: Vloga socialnih dejavnikov pri razvoju okoljske ozaveščenosti in spreminjanju okoljskega vedenja [The Role of Social Factors in Developing Environmental Awareness and Changing Environmental Behaviour]. Ph.D. thesis. Filozofska fakulteta Univerze v Ljubljani. Ljubljana.
Poročilo o razvoju [Development Report]. Urad Republike Slovenije za makroekonomske analize in razvoj, Ljubljana, 2016.
Potočnik Slavič, I. 2010: Endogeni razvojni potenciali slovenskega podeželja [Endogeneous development potentials of rural areas]. Ljubljana.
Površine zemljišč z ekološkim kmetovanjem [Areas of land with organic farming]. Ministrstvo Republike Slovenije za kmetijstvo, gozdarstvo in prehrano, Ljubljana, 2015.
Prelovšek, M., Zupan Hajna, N. 2011: Pressures and Protection of the Underground Karst – Cases from Slovenia and Croatia. Postojna.
Price, B., Kienast, F., Seidl, I., Ginzler, C., Verburg, P. H., Bolliger, J. 2015: Future landscapes of Switzerland: Risk areas for urbanisation and land abandonment. Applied Geography 57.
Primdahl, J., Kristensena, L. S., Swaffield, S. 2013: Guiding rural landscape change: Current policy approaches and potentials of landscape strategy making as a policy integrating approach. Applied Geography 42.
Rajšek, B. 2016: Stariha za smrad krivi prebavne težave prašičev [Stariha blames the pig's digestive problems for the stench]. INTERNET: http://www.delo.si/novice/slovenija/stariha-za-smrad-krivi-prebavne-tezave-prasicev.html (20. 9. 2016).
Ravbar, M. 2009: Razvojni dejavniki v Sloveniji – ustvarjalnost in naložbe [Development factors in Slovenia – Creativity and investments]. Ljubljana.

Ravbar, M. 2014: Razvojni potenciali slovenskih občin [Development potentials of Slovenian municipalities]. IB revija 48-2.

Ravbar, M., Kozina, J. 2012: Geografski pogledi na družbo znanja v Sloveniji [Geographical Perspectives on the Knowledge Society in Slovenia]. Ljubljana.

Ravbar, M., Razpotnik Visković, N. 2007: Geografska analiza investicij – pasti in izzivi na poti uresničitve nacionalnih razvojnih projektov v Sloveniji [Geographical analysis of the investments – traps and challenges of the implementation of the nationaldevelopment projects in Slovenia]. Veliki razvojni projekti in skladni regionalni razvoj. Ljubljana.

Razpotnik, N. 2008: Road Distance to the Nearest Motorway or Major Road. Mapping the Alps: Society, Economy, Environment. Heidelberg.

Reambulančni kataster za Kranjsko [Revised Land Cadaster], k.o. Adlešiči, Bojanci, 1867–1882. Arhiv Republike Slovenije. Ljubljana.

Register divjih odlagališč [Register of wild landfills], 2013. INTERNET: http://register.ocistimo.si/RegisterDivjihOdlagalisc/ (8. 4. 2016).

Ribeiro, D. 2017: Impact of landscape features on land use and regional development in karst areas: a case study of Bela krajina. Ph.D. thesis. Filozofska fakulteta Univerze v Ljubljani. Ljubljana.

Ribeiro, D., Ellis Burnet, J., Torkar, G. 2013: Four windows on Borderlands: Dimensions of place defined by land cover change data from historical maps. Acta Geographica Slovenica 53-2. DOI: https://doi.org/10.3986/AGS53204

Ribeiro, D., Šmid Hribar, M. 2019: Assessment of land-use changes and their impacts on ecosystem services in two Slovenian rural landscapes. Acta Geographica Slovenica 59-2. DOI: https://doi.org/10.3986/AGS.6636

Ribeiro, D., Zorn, M., Čarni, A. 2017: Kazalniki za spremljanje trajnostnega razvoja kraških območij [Indicators to monitor sustainable development of karst areas]. Prostor, regija, razvoj. Regionalni razvoj 6. Ljubljana.

Rovan, J., Malešič, K., Bregar, L. 2009: Blaginja občin v Sloveniji [Well-being of the municipalities in Slovenia]. Geodetski vestnik 53-1.

Sayer, J., Sunderland, T., Ghazoul, J., Pfund, J.-L., Sheil, D., Meijaard, E., Venter, M., Klintuni Boedhihartono, A., Day, M., Garcia, C., van Oosten, C., Buck, L. E. 2013: Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. PNAS 110-21. DOI: https://doi.org/10.1073/pnas.1210595110

Schmithüsen, F. 2013: Three hundred years of applied sustainability in forestry. Unasylva 64-1.

Schoonenboom, I. J. 1995: Overview and state of the art of scenario studies for the rural environment. Scenario Studies for the Rural Environment. Environment & Policy 5.

Seljak, J. 2001: Kazalec uravnoteženega razvoja [An indicator of balanced development]. Ljubljana.

Seručnik, M. 2009: Reambulančni kataster za Kranjsko [The revised cadastre for Carniola]. Kronika: časopis za slovensko krajevno zgodovino 57-3.

Sket, B. 1992: Rdeči seznam ogroženih vrst dvoživk (Amphibia) v Sloveniji [The Red List of endangered Amphibia in Slovenia]. Varstvo narave 17.

Sket, B. 1996: Biotioc diversity of hypogean habitats in Slovenia and its cultural importance. Proceedings of the Biodiversity International Biodiversity Seminar. Ljubljana.

Sket, B. 1999: High Biodiversity in Hypogean Waters and Its Endangerment: The Situation in Slovenia, the Dinaric Karst, and Europe. Crustaceana 72-8.

Skokanóva, H. 2009: Application of methodological principles for assessment of land use change trajectories and processes in South-eastern Moravia for the period 1836-2006. Acta Pruhoniciana 91.

Skokanóva, H. 2010: Methodology for Calculation of Land Use Change Trajectories and Land Use Change Intensity. Brno.

Slabe, A., Kuhar, A., Juvančič, L., Tratar Supan, A. L., Lampič, B., Pohar, J., Gorečan, M., Kodelja, U. 2010: Analiza stanja in potencialov za rast ponudbe ekoloških proizvodov v luči doseganja ciljev

Akcijskega načrta za razvoj ekološkega kmetijstva v Sloveniji do 2015 [Analysis of situation and potentials for growth of supply of organic products in the context of the objectives set by the Action Plan for the Development of Organic Farming in Slovenia Until 2015]. Zaključno poročilo. Ljubljana.

Slabe, A., Lampič, B., Juvančič, L. 2011: Potenciali ekološke pridelave za trajnostno lokalno oskrbo s hrano v Sloveniji [Organic production potentials for sustainable local food supply in slovenia]. Dela 36.

Smith, M., Ceni, A., Milic-Frayling, N., Shneiderman, B., Mendes Rodrigues, E., Leskovec, J., Dunne, C. 2010: NodeXL: a free and open network overview, discovery and exploration add-in for Excel 2007/2010/2013/2016. Social Media Research Foundation. INTERNET: http://nodexl.codeplex.com/ (28. 11. 2016).

Smrekar, A., Urbanc, M., Kladnik, D., Breg, M., Erhartič, B., Nared, J., Petek, F. 2007: Kras kot razvojni potencial: v iskanju ravnovesja med varovanjem in razvojem [Karst as a development potential: in search of a balance between protection and development]. Veliki razvojni projekti in skladni regionalni razvoj. Ljubljana.

Stanje območij Natura 2000 za človeško ribico, okoljske nevarnosti na terenu in predlog ukrepov [Status of Natura 2000 sites for human fish, environmental hazards in the field and proposed measures]. Društvo Proteus, Črnomelj, 2016.

Statistični register delovno aktivnega prebivalstva [Structural data of persons in employment]. Statistični urad Republike Slovenije, Ljubljana, 2015. INTERNET: http://www.stat.si/StatWeb/en/News/Index/5198 (9. 2. 2017).

Štrukelj, A. 2011: Učni načrt [Syllabus]. Program osnovna šola. Geografija. Ljubljana. INTERNET: http://www.mss.gov.si/fileadmin/mss.gov.si/pageuploads/podrocje/os/devetletka/predmeti_obvezni/Geografija_obvezni.pdf (8. 4. 2016).

Sustainability of the Karst Environment: Dinaric Karst and Other Karst Regions. Unesco, Paris, 2010.

Suvorov, M., Rutar, T., Žitnik, M. 2010: Kazalniki trajnostnega razvoja za Slovenijo [Set of sustainable development goals indicators for Slovenia]. Ljubljana.

Swetnam, R. 2007: Rural land use in England and Wales between 1930 and 1988: Mapping trajectories of change with a high resolution spatio-temporal dataset. Landscape and Urban planning 81-1. DOI: https://doi.org/10.1016/j.landurbplan.2006.10.013

The Economic benefits of the Natura 2000 Network. European Commission, Luxembourg, 2013.

Transforming Our World: The 2030 Agenda for Sustainable Development. United Nations, New York, 2015. INTERNET: https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf (17. 10. 2016).

Tress, B., Tress, G. 2003: Scenario visualisation for participatory landscape planning–a study from Denmark. Landscape and Urban Planning 64-3. DOI: https://doi.org/10.1016/S0169-2046(02)00219-0

Uuemaa, E., Roosaare, J., Oja, T., Mander, Ü. 2011: Analysing the spatial structure of the Estonian landscapes: which landscape metrics are the most suitable for comparing different landscapes? Estonian Journal of Ecology 60-1. DOI: https://doi.org/10.3176/eco.2011.1.06

Valvasor, J. W. 1689: De Ehre des Herzogthums Crain (reprinted 1879, Krajec, Novo mesto, Slovenia).

van Beynen, P., Townsend, K. 2005: A Disturbance Index for Karst Environments. Environmental Management 36-1. DOI: https://doi.org/10.1007/s00267-004-0265-9

Van Eetvelde, V., Antrop, M. 2004: Analyzing structural and functional changes of traditional landscapes – two examples from Southern France. Landscape and Urban Planning 67-1. DOI: https://doi.org/10.1016/S0169-2046(03)00030-6

Veeneklaas, F. R., Van den Berg, L. M. 1995: Scenarios building: Art, craft or just a fashionable whim? Scenario Studies for the Rural Environment.

Vintar, K. 2003: Okoljevarstveni vidiki sonaravnega regionalnega razvoja Slovenije [Environmental aspects of Slovenia's sustainable regional development]. M. Sc. thesis. Filozofska fakulteta Univerze v Ljubljani. Ljubljana.

Vintar Mally, K. 2009: (Ne)sonaravnost razvoja slovenskih regij [(Un)sustainable development of Slovene regions]. Razvojni izzivi Slovenije. Ljubljana.

Vintar Mally, K. 2018: Regional differences in Slovenia from the viewpoint of achieving Europe's sustainable development. Acta geographica Slovenica 58-2. DOI: https://doi.org/10.3986/AGS.3309
Vulnerability and Risk Mapping for the Protection of Carbonate (Karst) Aquifers. Final report. COST Action 620, Luxembourg, 2003.
Wages and labour costs. Eurostat, 2016. INTERNET: http://ec.europa.eu/eurostat/statistics-explained/index.php?title=Wages_and_labour_costs&oldid=290800 (3. 9. 2016).
Waltert, F., Schulz, T., Schläpfer, F. 2011: The role of landscape amenities in regional development: Evidence from Swiss municipality data. Land use policy 28-4. DOI: https://doi.org/10.1016/j.landusepol.2011.01.002
Wascher, D. M. 2004: Landscape-indicator development: steps towards a European approach. The new dimensions of the European landscape: Frontis Workshop on the future of the European Cultural landscape. Wageningen.
Watson, J., Hamilton-Smith, E., Gillieson, D., Kiernan, K. (eds) 1997: Guidelines for Cave and Karst Protection. Gland.
World Conservation Strategy: Living Resource Conservation for Sustainable Development. IUCN-UNEP-WWF, Gland, 1980.
World Summit on Sustainable Development. United Nations, New York, 2002. INTERNET: http://www.un-documents.net/jburgdec.htm (17. 10. 2016).
Wu, J. 2013: Landscape sustainability science: ecosystem services and human well-being in changing landscapes. Landscape ecology 28-6. DOI: https://doi.org/10.1007/s10980-013-9894-9
Wu, J., Wu, T. 2012: Sustainability indicators and indices. Handbook of Sustainable Management. London.
Zakon o gozdovih [The Forest Act] 1993. Uradni list Republike Slovenije 30/1993, 56/1999, 67/2002, 110/2002, 115/2006, 110/2007, 106/2010, 63/2013, 101/2013, 17/2014, 24/2015, 9/2016 and 77/2016. Ljubljana.
Zakon o varstvu podzemnih jam [Underground Cave Protection Act] 2004. Uradni list Republike Slovenije 2/2004, 61/2006 and 46/2014. Ljubljana.
Zorn, M., Kumer, P., Ferk, M. 2015: Od gozda do gozda ali kje je goli, kamniti Kras? [From Forest to Forest or Where is the Bare Rocky Karst?]. Kronika 63-3.
Zuleeg, F. 2010: European Economic Sustainability Index. Brussels.
Zumaglini, M. 2008: Population. Mapping the Alps, Society, Economy, Environment. Heidelberg.

5.2 Sources of qualitative data (interviews)

AK, tourism professional, personal communication, 28 of June 2016. Dragatuš, Črnomelj.
AK, resident, personal communication, 4 of July 2016. Semič.
AP, resident, personal communication, 18 of July 2016. Semič.
BG, professional of nature protection, personal communication, 27 of June 2016. Adlešiči, Črnomelj.
BJ, representative of local government, personal communication, 4 of July 2016. Semič.
BP, farmer, personal communication, 4 of July 2016. Sela, Semič.
BR, tourism professional, personal communication, 1 of July 2016. Adlešiči, Črnomelj.
DM, resident, personal communication, 18 of July 2016. Semič.
GA, representative of local government, personal communication, 14 of July 2016. Črnomelj.
IŠ, representative of local government, personal communication, 21 of July 2016. Metlika.
JG, resident, personal communication, 16 of July 2016. Adlešiči, Črnomelj.
JJ, resident, personal communication, 13 of July 2016. Črnomelj.
JK, farmer, personal communication, 21 of July 2016. Griblje, Črnomelj.
JN, representative of local government, personal communication, 21 of July 2016. Metlika.
JV, farmer, personal communication, 5 of July 2016. Čurile, Metlika.
LB, tourism professional, personal communication, 27 of June 2016. Črnomelj.
MaP, tourism professional, personal communication, 15 of July 2016. Gradac, Metlika.
MB, resident, personal communication, 1 of July 2016. Hrast pri Jugorje, Metlika.

MI, professional of nature protection, personal communication, 24 of June 2016. Sela, Semič.
MiP, tourism professional, personal communication, 13 of July 2016. Gradac, Metlika.
MK, tourism professional, personal communication, 18 of July 2016. Rosalnice, Metlika.
MK, representative of local government, personal communication, 18 of July 2016. Semič.
MM, resident, personal communication, 21 of July 2016. Metlika.
MP, farmer, personal communication, 5 of July 2016. Čurile, Metlika.
NŠ, professional of nature protection, personal communication, 24 of June 2016. Črnomelj.
PM, farmer, personal communication, 1 of July 2016. Maline pri Štrekljevcu, Semič.
SM, farmer, personal communication, 28 of June 2016. Vavpča Vas, Semič.
SŽ, professional of nature protection, personal communication, 18 of July 2016. Krupa, Semič.
TJ, tourism professional, personal communication, 27 of June 2016. Adlešiči, Črnomelj.
VK, representative of local government, personal communication, 14 of July 2016. Črnomelj.
VŠ, farmer, personal communication, 1 of July 2016. Stari Trg ob Kolpi, Črnomelj.
VV, tourism professional, personal communication, 4 of July 2016. Veliki Nerajec, Črnomelj.

6 List of figures

7 List of tables

Daniela Ribeiro
daniela.ribeiro@zrc-sazu.si
http://giam.zrc-sazu.si/ribeiro

Daniela Ribeiro was born on 10th December, 1983 in Vila Real, Portugal. After graduating from high school, she enrolled at the University of Trás-os-Montes and Alto Douro in Vila Real, Portugal, where she graduated in 2007 with a Degree in Environmental and Natural Resources Engineering. She continued her postgraduate studies at the Graduate School of the University of Nova Gorica, Slovenia, where she completed her Master's Degree in Environmental Sciences in 2011. In the same year she enrolled in the Interdisciplinary Doctoral Programme in Environmental Protection at the University of Ljubljana and was employed as an Early Career Researcher at the Anton Melik Geographical Institute of the Research Centre of the Slovenian Academy of Sciences and Arts (ZRC SAZU). In 2017, she obtained her doctoral degree.

She is the author and co-author of several scientific and professional articles on the topics of invasive plant species distribution, landscape changes and environmental protection. She is a member of the Order of Engineers (a regulatory and licensing body for the Engineering profession in Portugal), the Eastern Alpine and Dinaric Society for Vegetation Ecology – EADSVE, the Interdisciplinary group on Ecosystem Services at ZRC SAZU – INTERECOS, and of the International Association for Landscape Ecology – IALE-Europe.

ISBN 978-961-05-0461-0
9 789610 504610
19 €