Czech University of Life Sciences Prague
Faculty of Environmental Sciences

EVALUATION OF THE IMPACT OF SKI RESORTS ON TOWNS DEVELOPMENT IN MOUNTAIN AREAS

DIPLOMA THESIS

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DIPLOMA THESIS ASSIGNMENT

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Landscape Planning

Thesis title

Evaluation of the impact of ski resorts on towns development in mountain areas

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Objectives of thesis

The aim of the thesis is to determine what is the impact of ski resort existence on the development of settlement structure in the site in Czech mountains Krkonoše. The aim of the theoretical part is to describe the problematic of landscape changes due to tourism development. The practical part has the goal in analysing the historical development of the selected areas with emphasis on linkage between mountain settlement and ski resort. The results could be used as a underlying data for future strategic planning in the studied areas or as a case studies for further research in this problematic.

Methodology

The literature review will provide explanations of the crucial terms in the problematics of impact of tourism on landscape. Second step will be the selection of the study areas, based on criteria defined as part of the work.On the base of aerial images from four different time periods, the landcover development analyses will be carried out in the GIS environment. The outcomes of the analyses will be used to determine the impact of ski resort on the mountain settlements development.

The proposed extent of the thesis

40 pages plus maps

Keywords

Landscape, Land cover, GIS, Krkonoše

Recommended information sources

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Declaration

I hereby declare, that the work presented in this thesis is, to the best of my knowledge, original work, except as cited in the text. The research was completed under the direction of Ing. Kristina Janečková, Ph.D.

Prague, 2017 Václav Táborský

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ABSTRACT

Skiing as an activity and ski resorts as a facility area have considerable impact on the environment, where the resorts are located. The same applies to the highest mountains of the Czech Republic - Krkonoše. This thesis investigates the relationship between the landscape in Krkonoše mountains and the settlements, which have been more and more used as a gateway to ski resorts. The study analyses three selected municipalities (Rokytnice nad Jizerou, Benecko, Malá Úpa), each of different size and capacity of the resort. The analyses were carried out in GIS environment, based on data acquired from aerial images taken in 1953, 1978, 1998-2000 and 2016 and census done at the same time. The results revealed an increase of urbanized areas on average by 80%, but on the other hand, a decline in population. Furthermore, a relatively big portion of land has gone through land cover change. Apart from the settlements development, the outcomes show general tendencies in afforestation of former grasslands and growth of scattered woody vegetation.

Key words: Landscape, Land cover, GIS, Krkonoše

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1. INTRODUCTION

History of skiing can be divided into two unequally long periods. First, the period about 5000 years long development, which was happening in the north of Europe and Asia and the second, approximately the last 150 years. A notional milestone between periods of using skis for hunt, harvest or military purposes and the modern sport is somewhere around the year 1860 (Kulhánek, 1989).

In countries with regular winter seasons, in Scandinavia, in the north part of Asia, in the mountain areas of Europe and North America, in Japan and also in some places in the Southern hemisphere like New Zealand, Australia and South America, in all these places skiing became very popular during the last hundred years. Step by step, skiing and the whole ski industry turned out as a global movement. During the first half of the 20th century, skiing went through a huge development especially in countries in Scandinavia, which can be seen as a cradle of skiing, and further in the Alps from where it spread all around the world with not excluding of the Czech mountains (Kulhánek, 1989).

Skiing as a sport in the Czech Republic has more than a hundred years of history. In 1887 former members of an ice skating club in Prague established an association called Czech Ski Club. Beside the ski clubs in Scandinavia, it was the first ski club established in middle Europe. By joining the Prague ski club with the other two Czech ski associations few years later was established the first national skiing organization in the world. Finally, the year 1887 can be called the beginning of organized skiing in Europe and the Czech ski movement was a pioneer of this sport in general (Kulhánek, 1989).

The history of skiing in short, should bring the reader closer to the topic of this thesis, which focuses on the relation between tourism and landscape in the most visited mountains in Czech Republic.

The number of visitors in Krkonoše mountains is growing every year. Qualified estimates states five to six million of visitors per year, which makes the Krkonoše Mountains National Park one of the most visited national parks in Europe (KRNAP, 2017). The increasing amount of tourism brings an inevitable impact on the destination, both positive and negative with all its aspects –

social, economical and ecological. This thesis aims to investigate, what was the impact of ski resort development in several settlements during the last few decades from the point of view of landscape and settlement structure change.

Picture 1. Skiing in Špindlerův Mlýn in the beginning of 60's

2. THE AIM OF THE THESIS

The aim of the thesis is to determine what is the impact of ski resort existence on the development of settlement and its surrounding in Czech mountains Krkonoše. The aim of the theoretical part is to describe the problematic of landscape changes due to tourism development. In the characteristics of the study area will be collected information about the region and the development of ski resorts.

The practical part has the goal to analyse the historical development of landscape in the selected areas with emphasis on linkage between mountain settlement and ski resort. Digitalized data from aerial images will provide information about individual landscape elements and their representation in the study area during several decades. The outcomes of the land cover change analyses in the form of tables, charts and map layouts will be compared to each other and summarized in the conclusions.

The results could be used as an underlying data for future strategic planning in the studied areas or as a case study for further research in this problematic.

3. LITERATURE REVIEW

3.1. Landscape and its character

3.1.1. Landscape

Landscape is a very complex system and its definition depends on the phenomenon in consideration. There are many different interpretations of the term "landscape". In general, it is a specific part of a land, which has a middle point, border or an edge. It is a long-term stabilized, relatively uniform set of nature and anthropogenic characteristics bounded to a certain relief, with a common historical base (Cílek and Ložek, 2011). The size of the mentioned part of land is nearly impossible to define or measure. Again, it depends on the observer's point of view and on the scale used for observation. Since each organism scales the environment differently, there is no absolute size for a landscape. In other words, landscape could range from area smaller than several square meters to almost infinite space (McGarigal, 2010).

The term landscape has also definition in legal acts valid in the Czech Republic. Landscape is defined in our law by the Act. No. 114/1992 Coll. on the Conservation of Nature and Landscape as "a part of the Earth's surface, with a characteristic relief, formed by a complex of functionally integrated ecosystems and elements of civilization" (Ministry of the Environment of the Czech Republic, 1998). Another definition is possible to find in the European Landscape Convention, which came into force in the Czech Republic in 2004. According to this definition the landscape is an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors. The nature and the landscape are interrelated and their protection can not be separated. They are also closely interconnected with other components of the environment (especially with the soil, substrate, water and the air)(Council of Europe, 2000).

Other definitions come from authors dealing with the landscape ecology. Forman and Gordon (1993) defined landscape as a heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in similar form throughout.

3.1.2. Landscape character

One of the attributes of every landscape is its character. The landscape character is a value that changes during the time, but it is always closely connected with the evolution of human kind (Vacek, 2014).

The landscape character is an important value of natural and cultural environment and it is necessary to protect it from depreciation. It is created by specific shapes and features, which make the environment unusual and unique. The elements which make environment so unique are mostly morphology, character of water features, land cover and human settlements (Vacek, 2014).

In the Czech Republic, there are several law acts that actually contain the term landscape character. The definition itself is in the Act. No. 114/1992 Coll. on the Conservation of Nature and Landscape. It interprets the landscape character and its protection as: "The landscape character of a place or area shall be its natural, cultural and historical character, and it must be protected from activities that reduce its aesthetics and natural values. Interference in the character of the landscape, especially and the approval and placing of buildings, may be carried only with regard to the preservation of the significant landscape components, specially protected areas, and cultural landscape landmarks, and for harmonious standards and relations within the landscape" (Ministry of the Environment of the Czech Republic, 1998).

3.1.3. Landscape structure

"Landscape structure means the pattern of a landscape, which is determined by its type of use, but also by its structure, i.e. the size, shape, arrangement and distribution of individual landscape elements" (Walz, 2011). Other explanation from Zonneveld (1995) sounds very simple. The landscape structure is what the bird eye sees in the perpendicular direction towards the Earth's surface. To define these landscape elements, which can be also called "patches", land use or land cover units are often used. Regarding to this context, land use rather represents the economic and social functions of the landscape and land cover describes its physical surface characteristics (Haines-Young, 2009). Moreover, there are some other spatial elements, which can be used, for instance soil units.

The most important parameter of landscape structure is the heterogeneity. The heterogeneity shows "the quality or state of consisting of dissimilar elements, as with mixed habitats or cover types occurring on a landscape". It is the "opposite of homogeneity, in which elements are the same" (Turner, Gardner and O'Neill, 2003).

3.1.4 Natural landscape and Cultural landscape

Based on the level of influence of human activities on landscape, it is possible to distinguish Natural landscape and Cultural landscape (Svobodová, 2011). Natural landscapes have been created by long-term operations of purely natural processes without any disturbance of humans. Later on, by the combination of natural and cultural processes, cultural landscapes started to appear. The cultural landscape could have many forms, from landscapes almost untouched by human activity - very close to natural one, to landscapes totally transformed. However, to define what is the threshold between natural landscape and cultural landscape is very complicated and it depends on certain criteria (Arntzen and Brady, 2008). The activities, which are the main driving forces of the transformation are agriculture, forestry and lately also tourism (Svobodová, 2011; Samsudin and Maliki, 2015).

3.1.5 Land-use

The term land-use is perceived as a human influence on natural environment and its transformation. It is dynamic notion, changing in the time according the intensity and manner of management. Factors affecting the manner of land management could be divided into cultural and natural. The former are: economic state of the country, technical equipment, nature conservation, political situation and so on. The latter can be climate, orientation and steepness, soil conditions and other (Sklenička, 2003).

Particular land-use categories can be seen as relatively homogeneous areas, which are formed by united land management and land cover. Evaluation of the land-use is an easy way to describe relations in some certain area. For example, Czech cadaster uses 11 categories of land/parcel with additional subcategories representing property type (Sklenička, 2003). But in

general, the categorization of land-use depends on the aim of the project, size of the study area, scale and methods, which are used during the process. Of course, there is always the condition of availability of the input data.

3.1.6 Land cover

Land cover represents, in the certain time period, combination of land-use, landscape structure and vegetation, which covers the Earth's surface (Sklenička, 2003).

Mapping and description of land cover play an important role in analyzing landscape development in shorter or longer time periods. It is therefore a very useful tool in landscape planning. There are several methods to obtain data for these analyses. The method is normally based on the size of the study area and the scale in which the analyze is made. At first, field investigation is usually the least demanding on data preprocessing.

The second method is the interpretation of satellite images. The advantages of these data are, that they cover a large territory and are spatially continuous. On the other hand, the interpretation is not always uniform and there are some factors that can affect the result. For example, the angle of the sunshine, wind conditions and the seasonal aspect. Hence, it is difficult to compare the same territory with data from different periods. Analysis of land cover processed with satellite images provide a wide range of uses, for example evaluation of qualitative changes in vegetation or temperature regime of the landscape (Loveland, Cochrane and Henebry, 2008).

The third method is the visual interpretation of aerial images. An advantage of this method is in the detail of the result. Also, the method of aerial imaging has been already used for many decades, so it is possible to work with data from the first half of the 20th century. For the area of the Czech Republic, the images have been taken regularly from 50' (CENIA, 2010). As for the methods above, there are some disadvantages here as well. The only way to interpret the images is by vectorization in GIS environment. In comparison with the satellite images, which could be processed automatically, this is time demanding work, which could often result in misrepresented data.

3.2 Landscape and man

The relation between the man and the landscape is not in one direction. Man is not always the creator and the cultural landscape is not a passive product. During the development of cultural landscape, the coevolution of landscape and humans has been happening. Through this coevolution, both actors have been adapting and influencing by their feedback (Sádlo et al., 2008).

The big milestone in the relation between man and landscape is the beginning of a tillage. Former gatherers and hunters became farmers, who started to build the first permanent settlements. The development of agriculture brought a sufficient amount of food and subsequently also a population growth, which resulted in increasing impact on the natural landscapes. At first, the upswing of agriculture took place in lower located areas with more favorable climatic and soil conditions, but due to the population growth, farmers had to move also to higher located areas. Therefore, agriculture is possible to mark as the most significant human activity affecting the landscape (Svobodová, 2011).

3.2.1 Landscape and tourism

Tourism is a human activity that has been growing exponentially during the last few decades. It now accounts for more than 10 percent of the world's economic activity and it is one of the biggest generators of employment. However, it also has a significant impact on the natural and cultural environment of host populations (UNEP-WTO, 2005).

Tourism is another phenomenon, which is very difficult to define. In literature it is possible to find different explanations of the term tourism. Definitions vary according to whether the focus is on economic, sociological or physiological aspect of tourism (Mihalič, 2011). The most common definition is published by the World Tourism Organization, which determines the tourism as "the activities of persons traveling to and stay in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes" (UNWTO, 2014).

Tourism as a phenomenon plays an important role in shaping the place identities and it could be the major determinant of geographical change in the landscape (Halling, 2014). "The reliance of tourism upon the natural and cultural resources of the environment means invariably that its development induces change which can either be positive or negative" (Holden, 2008). As mentioned above, landscapes affected by human activities have been called cultural landscapes. Tourism, as one of many human activities affecting the landscape, creates tourist landscapes. It is the entire physical and visual environment used and transformed by all tourism activities. Gkoltsiou and Terkenli (2012) based on Green & Hunter in Johnston and Thomas, 1995; Antrop (1998); Terkenli (2002) state that "more often than not, tourist landscapes are characterized by an insensitive use of space and land, closely related to tourism development; extensive rebuilding and expansion of tourist infrastructures; uncontrolled urbanization and multifunctional land uses; excessive road network extension; spatial fragmentation; as well as the homogenization of landscape elements, resulting in the loss of place identity."

3.2.2 Winter tourism, ski resorts and the impact on landscape

The rise of winter tourism during the 20th century brought an entire spectrum of impacts on the environment. Settlements in mountain areas, where the conditions facilitated tourism development have often changed almost unrecognizably. The reason for that could be in the inefficiency of traditional practices (agriculture, livestock, forestry) to generate satisfactory income. The development of tourism infrastructure has had several forms, which sometimes some of them work simultaneously. At first, farms and homesteads were turned into accommodation and catering services. Secondly, declaration of national parks has changed and supported the awareness of people about the location, but it has also certain legal measures, which should support the local livelihood. The third form is development of ski resorts, which has the biggest consequences on the destination (Lasanta, Laguna and Vicente-Serrano, 2007).

Development and existence of the ski resort brings many benefits to a location e.g. economic and income diversification or infrastructure and services improvement. On the other hand, there is a number negative impacts, especially of environmental character, but also landscape changes, social and

cultural degradation of local heritage and others (Lasanta, Laguna and Vicente-Serrano, 2007).

The big change in the number of people (it is not unusual that population may increase tenfold during the season) staying for certain time in a concentrated area requires special water, sewage and electricity systems. This means a great deal of construction work. To improve the quality of a ski resort, the access roads have been often repaired and expanded, which can cause problems with soil erosion. Furthermore, the salt used during the winter combines with lead and hydrocarbons from vehicles to the mountain streams with the destructive effects on the surroundings. The operation of resort is also very demanding on water, and its importance is often underestimated. Therefore, it is sometimes necessary to build a water reservoir, which can affect the whole region down the stream. The urbanization of mountainous areas can have similar consequences. Big areas of impermeable surfaces (building rooftops, car parks and roads) can change the natural flow of water, which can result in soil erosion (Chivers, 1994).

Sufficient snow cover from early winter to spring is very important for the economic success of ski a resort; due to the lack of it in past two decades, many resorts, including those in Czech mountains, have been forced to an increase the use of artificial snow. The process of snow making is expensive and consumes large amounts of water, which as a result increases the necessity of reservoirs. Furthermore, the unnatural snow often stays on the slopes longer than the natural snow would, which makes time for vegetation to revitalize shorter and can result in land degradation and decrease of biodiversity (Rixen, Stoeckli and Ammann, 2003).

4. CHARACTERISTICS OF THE STUDY AREA

4.1 Krkonoše

The Krkonoše mountains represent region, where the tourism has significant potential. The rise of tourism activities has been here already in 19th century, when the first associations occurred and the former homestead cabins partly turned into accommodation facilities. Publishing of the first maps and tourist guides supported the development even more. The Krkonoše mountains are one of the very first areas on Czech territory, where tourism actually started. Therefore, when the broader selection of the study area for the research of this kind was made, the Krkonoše mountains were the first on the list.

4.1.1. Landscape character

The landscape character in the Krkonoše mountains belongs to one of the most unique in central Europe, due to its natural but also cultural-historical evolution. The combination of arctic and alpine nature, so called arctic-alpine tundra, brings the unique mosaic of ecosystems characteristic for the Alps but also for Scandinavia and makes the nature very valuable. The homesteads cabins in the higher locations and scattered huts in grassland enclaves are the proof of specific cultural historical development. Preserved settlement structure and significant representation of timber huts is the great wealth of the region. According to the character, there are three types of landscape in the Krkonoše:

I. Primary treeless plains and the upper forest boundary
II. Forest complexes and permanent grassland enclaves
III. Foothills, rural settlements and towns

I. Primary treeless plains and the upper forest boundary

Ridges and crests are the most valuable, the most protected and the most known parts of the Krkonoše mountains. The landscape beyond the natural boundary of the forest is characterized by flattened, slightly undulated surface of tablelands with separated peaks of individual mountains. Apart from

that, cirques created by glacial activity with the steep cliffs and deep hollows make the landscape unique. The places where the flattened plains are cut by the steep cliffs are impressive as well. Typical landscape elements in this area are stone seas and protruding granite rock formations with cuboid shapes. From the vegetation point of view, most of the areas belong to the subalpine and alpine vegetative stage. The upper boundary of coniferous forests passes by its loose edge into dwarf mountainpine scrubs, which are supplemented by subalpine meadows and peat-bogs. Despite the fact, that is the landscape beyond the natural boundary of forest exposed to the extreme climatic effects, it is the landscape of many colors: from the grey and green lichen covering the stone seas; over rusty colors of grasses during summer and autumn; to the deep green of mountainpine scrubs. Although the landscape at ridgelines is very close to the natural landscape, even here are mountain huts. Simple solitaire structures began to emerge during the Thirty Years' War, when people sought safety in those areas. Original simple structures were gradually reconstructed from the end of 18th century, mainly for recreational purposes (Flousek et al., 2007).

Picture 2. The landscape of large plains on the mountain ridges

II. Forest complexes and permanent grassland enclaves

From the main ridgelines, the landscape continues by a forked long and wide minor ridges, which are separated by the deep valleys. The slopes on the south side slowly descend to the Czech inland, while the slopes on the north side fall steeply right to the basis of the mountains. Characteristic deep river valleys, which were created during millions of years due to complex geological structure, are splitting the south side of the Krkonoše mountains. The vegetation cover is formed mostly by forest complexes, which spread from the loose edge in higher locations down by the steep slopes of mountain valleys. Upper parts of coniferous forests pass in some locations to preserved, formerly typical natural mixed forests with the dominance of beech and fir trees. Most of the natural forests are nowadays replaced by spruce monocultures, which are often harmed by industrial emissions. The settlement of mountain slopes at the end of 18th century permanently transformed parts of the forest complexes into permanent grassland enclaves. The enclaves have been defined and often irregularly divided by wide and tall stone hedges, which are nowadays covered by some linear vegetation. Simple structures of mountain cabins, spread between individual hedges, complement the general look of the enclaves. Together with preserved species-rich mountain meadows, create the enclaves unique landscape character.

Development of tourism at the turn of 19th century caused that many formerly mining and timber settlements were turned into mountain resorts. Initially, at the beginning of the 20th century, the mountain resorts kept a looser arrangement of buildings with the linkage to the nature. Later on, during the second half of the 20th century, the built-up structure got denser, many large hotels were built and the recreation sites were extended. These tendencies continue even in present and the requirements on sport activities are constantly growing. The resorts are getting more and more a monofunctional appearance and the former nature close landscape is often regulated (Flousek et al., 2007).

Picture 3. The grassland enclave in Javoří důl

III. Foothills, rural settlements and towns

In comparison with the highest parts of the Krkonoše mountains, the foothills belong to the least known part of the region. On the other hand, the preservation and the visible linkage with the peaks make the landscape very interesting and valuable as well. The terrain of foothills is softly modeled with a wide range of spatial division. The land cover is usually changing from bigger or smaller forests to agricultural land, which creates significant diversity in the area. Agricultural land is typically divided radially or in parallel by overgrown stone hedges into smaller parcels. The division of parcels was often irregularly adapted to the terrain and to the possibilities of use. Most of the deforested land has been used as meadows and pastures. Unfortunately, not that many of them retained their former abundance of species. Whole landscape mosaic is than complemented by small parts of arable land, which occur more rarely nowadays. The Krkonoše foothills have also been the most urbanized type of landscape of all three, with a wide range of settlements from tiny villages to the biggest towns of the region (Flousek et al., 2007). The settlements of the whole region are the topics of following chapter.

Picture 4. The foothills of the Krkonoše mountains – Mladé Buky

4.1.2. Historical character of settlements

The settlements of the region can be historically divided into two basic types according to their shape. In the lower areas, valleys and foothills are mostly linear shaped settlements, which are formed by structures on one or both sides along the road and often a river stream. In the locations with higher elevation, it is solely scattered settlements, where it is very difficult to find any order. Structures are randomly allocated on the mountain slopes, sometimes denser around churches. Based on those two types it is possible to estimate the period in which the settlements were founded. The older type, linear structured settlements are the result of colonization of the foothills during 13th and 14th centuries. The settlements were based on plans and their purposes were mainly agricultural and later on industrial. The scattered settlements in higher locations started occurring in the 16th century. These structures were mainly built by woodcutters, miners and glassblowers usually without any plans. Structures – huts or cabins in the highest parts, which stand mostly alone are very specific for the Krkonoše mountains.

The basic type of structures is timbered or half-timbered house. Residential parts were mostly wooden, but the cattle sheds were reconstructed

with stones during the time. For the construction was commonly used material, which was available around (granite stones, fir and spruce trees). From the end of the 19th century, the structures were characteristically painted with different colors of clefts and window frames.

4.1.3. Development of tourism

Man has influenced the natural evolution of mountainous environment in Krkonoše, for more than eight centuries, seeking to exploit all the natural resources, which the mountains offer. The spatial aspects of this exploitation, its duration and intensity can vary, however, to find a part of mountains, which has not been affected by human activity is barely possible. Therefore, human activities and their impact is an inseparable component of landscape structure, landscape character and even genius loci of Krkonoše (Klapka and Martinát, 2005).

The first phase of foothill colonization took place from the 12th till the 14th century followed by quarrying of the mineral resources, particularly iron, copper, arsenic and silver ore. The medieval mining and metallurgy were the first driving forces of the settlement development in the region. Later on, during the 16th and the 17th centuries, glassblowing industry spread around and triggered another expansion of settlements. Intensive mining and glass manufacture, both highly demanding on wood, resulted in exploitation of mountain forests.

Decline in the forest volume followed by the displacement of extraction of natural resources led to a change in life style of local inhabitants. People in the mountains started to farm the land, graze the livestock and turned deforested areas into pastures and meadows. During that time, often called as the period of cabin homesteads, the face of the mountains was significantly changed by the creation of permanent grassland enclaves. At the turn of the 18th and the 19th century, more than 1600 of cabin homesteads were spread around the Krkonoše mountains. Later on, the existence of those cabins supported the first signs of tourism in the area (KRNAP, 2017).

The general development of tourism, which was happening globally at the beginning of the 19th century reached the Krkonoše mountains by that time

as well. The wealthier part of society was no longer entertained in "safe" towns and began to seek pleasure in wilderness. Visits to the mountain regions became very popular, at first during the warmer periods, especially in summer, later on also during the wintertime. As the time went on, the activities linked to the tourism overcame the former usage of mountain homesteads, which resulted in new possibilities of livelihood for highlanders. Beside these homestead cabins, brand new mountain hotels started to being built. During that time, the Krkonoše mountains were one of the most frequently visited places in the central Europe (Flousek et al., 2007; Group SPF v.o.s., 2012).

During the whole 19th and at the beginning of the 20th century, tourism was developing faster on the north side of the mountains. That was caused mainly by better accessibility due to existing infrastructure in foothills, where many spa towns existed (Flousek et al., 2007). Growing popularity resulted in the foundation of several associations (German and Czech) at the turn of 19th and 20th century, which aimed to improve the conditions for visitors. Great upswing of tourism came together with the development of skiing and other winter sports, which increased the number of visitors during the winter seasons. Growing volume of traffic requested construction of new communications, which supplied the current path network. Also the first ski tows and chairlifts were built. The Krkonoše mountains can be seen in that time period as a cradle of skiing in central Europe (Kulhánek, 1989).

An increasing onslaught of visitors was slowed down at the beginning of 20th century by the First World War. Fortunately, the Krkonoše mountains were spared from war damage and the development could continue. Establishment of the independent Czechoslovakian Republic supported the enhancement of tourism. The positive course and the economical growth of the region was corrupted by the crisis. Increasing threat of conflict with Germany resulted in the construction of defensive line of bunkers, which intersects our highest mountains. The Second World War completely stopped the development of tourism. Although the peaks of the Krkonoše mountains were one of the safest place in Europe during the war, the area was strictly guarded and ordinary tourists were replaced by German army officers (Flousek et al., 2007; Group SPF v.o.s., 2012).

The post-war period can be seen as a milestone in the tourism infrastructure development. The reason for that was the change in the property ownership. The whole tourism infrastructure became the property of the state and the further development was focused only on recreation. New construction of large accommodation facilities, ski lifts and ski slopes made a big impact on the former architectural and landscape character of the region, consequently also a change in socio-economical conditions.

Another shift came with the era after the Velvet revolution in 1989. Property privatization and the upsurge of private business lead to quantitative increase in the tourism infrastructure development. The abolishment of the Iron curtain opened the access to the Czech part of the Krkonoše mountains for foreigners, especially for Germans and Poles. The latest era is characterized by the construction of mainly apartment accommodation (Group SPF v.o.s., 2012).

4.1.4. Nature conservation

The wealth of Krkonoše nature has been an object of exploitative interest for many centuries. Huge devastation and decrease in forest volume in the middle of the past millennium followed by natural disasters induced the first efforts of remediation. By the end of 19th century, people started to realize the threads of the increasingly frequent interventions in vulnerable mountain ecosystems. The beginning of sensible use of natural wealth in Krkonoše is linked with the change in the attitude to the forest management. Increasing harm to the nature in the mountains lead to endeavors to legitimize the nature conservation at the end of 20th century. It was partly succeeded by legal decree about flora conservation in 1904 and 1919. Unfortunately, in practice it was not very effective due to the lack of controlling authority. Difficulties also occurred with the protection of certain species without the protection of environment where they grow. Therefore, the first thoughts of overall protection of the entire mountain environment came around the year 1924. Due to the complicated political situation in the region and misapprehension of relevance at necessary political positions, the idea had not been implemented. Instead of conservation the nature was even more burdened by construction of a new infrastructure caused by the tense situation on Czech and German sides of the mountains during the 30's. Occupation and war period meant a cessation of

all efforts in nature protection, moreover, heavy traffic caused significant damage, which is distinct until now and which clearly documents, how sensitive the mountain environment is, when any disturbance of vegetation cover, soil or water regime occur. Post-war period brought a resumption of efforts in nature conservation, resulting in establishment of eight natural reserves covering the area around 8 000 hectares. Than followed a few years of negotiating between Czech and Polish environmentalists, but the complicated political relations did not support the cooperation. Fortunately, the exponents of nature conservation were not discouraged and the national parks were finally established on both sides of the mountains. At first in 1959 on the Polish side followed by the Czech side in 1963 (Flousek et al., 2007).

Nowadays, the national park covers the area of around 550 kilometers square including the buffer zone. The responsibility for the park management lies holds, from its foundation in 1963, the Administration of Krkonoše Mountains National Park based in the town of Vrchlabí. It is a state-run organization, overseen by the Czech Ministry of Environment. The area of the National park is divided into three zones with a different regime of protection.

4.1.5. Demography of Krkonoše

The number of inhabitants of the Krkonoše region was increasing relatively quickly until the year 1910, when it achieved its maximum. The First World War slowed down the growth, but the prosperity during the first Czechoslovakian Republic got the increasing tendencies back. The impact of the Second World War was much worse and in some cases the area was affected permanently. Each of the influencing factors is explained in following the text based on the research done by Klapka and Martinát (2005).

The first important factor influencing the changes in population, which can be documented by data of modern census, was the industrial revolution followed by the urbanization processes. Its final phase ended in Krkonoše around 1890. It can be mainly characterized by shifts of the inhabitants from the upper locations to the towns in the foothills. The increase of population in the industrial towns, which were dependent in particular on water was apparent in the valleys of the mountain rivers. On the other hand, in the municipalities, where the industry did not develop, the population started to decline. Another

significant demographic change can be registered during the First World War. The decline in population was a consequence of the lower marriage rate and the combination of a low birthrate and high a death rate during the conflict. The most negative population shifts of last two centuries occurred between the years 1930 and 1961, when another global conflict happened. The Second World War brought about a similar demographic decline as the first one, but in this case it was followed by massive forced migration of German inhabitants. Some of the mountain villages, which were populated primarily by Germans before the war totally disappeared. During the post-war period some of the settlements were artificially resettled, but in many cases the newcomers did not stay. The development of tourism in mountain resorts and work opportunities in the bigger towns supported the rehabilitation of the region. Until the Velvet revolution the population remained without any bigger deflection. In the new economical and political conditions in the late 80's and beginning of 90's of 20th century certain changes in demographic tendencies arrived. Meanwhile the population decline was documented in outlying villages, an increase occurred in more popular mountain resorts and also in hinterlands of towns in foothills. However, some differences can be found in the origin of the incoming inhabitants. Whilst, the suburbia of towns in lower locations have been populated by people from close surrounding, the mountain resorts have often been populated by owners of accommodation facilities, who come from bigger cities and decided to move.

Finally, apart from quantitative, qualitative demographic changes also happened. A nationality composition can be seen as one of them. In the first half of 20th century, Krkonoše were inhabited mainly by Germans. In 1921 69% of population avowed to the German nationality and 31% to Czechoslovak, thus to Czech. Moreover, the population was divided relatively clearly. The area, which was populated chiefly by Czech speaking people was located in the south-west of the region. The origin of this composition is based on historical existence of a route connecting Prague with Wroclaw. At the turn of the millennium, the nationality composition was completely changed. After the forced migration of Germans, the Krkonoše mountains became nearly a homogeneous Czech territory.

4.1.6. Ski resorts

The Krkonoše mountains have been stably the most popular Czech mountains in terms of winter sports and other recreational activities. According to the recent research, Krkonoše are the most attractive place of the Czech Republic during the winter period and more than 30 percent of all Czech skiers have been heading right there (Klapka and Martinát, 2005; CzechTourism, 2017). Favorable snow conditions are supported by easy access and very good facilities for skiing. Small and big resorts are scattered along the entire mountains, varying in capacity and their importance. Generally, there is more than 20 different ski areas, where some of them are partly interconnected by ski lifts, ski buses and other means of transport. The operational capacity, which is usually measured by the number of users transported by ski lifts or tows, varies from around 500 people per hour to more than 20 000 people per hour. Altogether, the resorts in the Krkonoše mountains offer an operational capacity of around 150 000 users per hour and more than 160 kilometers of regularly groomed ski slopes (Kozák, 2008). Among the biggest resorts, which are also the biggest in the Czech Republic, belong Špindlerův Mlýn, Rokytnice nad Jizerou and Černá hora – Pec pod Sněžkou. These resorts have the longest tradition of skiing and have been affecting the development and living in the adjacent mountain towns for many decades. Some of the medium sized resorts are Benecko, Herlíkovice, Harrachov and Mladé Buky. These resorts are mostly visited by families with children and skiing beginners. Their biggest expansion took place on the turn of the millennium, when the chairlifts became a common sight. The smallest resorts mostly offer just several ski tows and and their slopes are moderate. This group is represented by resorts in Poniklá, Malá Úpa, Stážné or Jablonec nad Jizerou.

4.2. Rokytnice nad Jizerou

4.2.1. History and current state

The first mentions about settlements in this locality are already from the middle of 16th century. The first inhabitants were mostly Germans, who came there during the colonization of the mountain area. The main reasons for inhabiting those unpleasant sites for agriculture were harvesting of timber and ore mining, mostly silver, copper and lead. The big expansion of Rokytnice nad

Jizerou took place in the middle of 19th century by merging several small mountain villages. By that time, the former settlement turned into a small town focusing on glassblowing and textile industry. New constructions took place mainly along the Huťský stream, where many factories were built (Koláček, 2015). The growth of the town was also supported by the construction of railway at the turn of 19th century. The development of the tourism during 20th century lead to a gradual decline of the manufacture industry and transformed Rokytnice nad Jizerou into one of the most visited ski resorts in the Czech Republic (MPČR, 2017).

Nowadays Rokytnice nad Jizerou has a status of town and consists of seven cadastral units – Dolní Rokytnice, Horní Rokytnice, Františkov, Hleďsebe, Hranice, Studenov and Rokytno.

4.2.2. Geography

The total area covers almost 37 square kilometers and the municipality lies in the altitude from 447 to 1417 meters above the sea level (Městský úřad Rokytnice nad Jizerou, 2014). The municipality territory includes several peaks, where the most significant is Lysá mountain (1344 m). Water regime is represented mainly by Huťský stream and the Jizera river in lower parts. Also several springs are located at the hilltops. Most of the urban area is placed in the protection zone of the Krkonoše Mountains National National Park, the upper parts around Lysá mountain gradually continue through III., II. into the I. zone of protection.

4.2.3. Ski resort

The history of ski the resort in Rokytnice nad Jizerou dates back to the middle of 20th century. The first temporary ski tow was constructed in 1955 and 10 years later was replaced with the regular ski lift. As a result of spreading of skiing between common people, other ski lifts were constructed during the following 15 years. By that time, the resort could already offer skiing conditions for professional skiers but also for beginners. The construction of chairlift to Lysá mountain in 1996, which followed the global trends, changed the stagnation of development during 80's and the beginning of 90's (Hampl, 2010).

On the mountain slopes surrounding Rokytnice nad Jizerou currently exist more than 20 of ski tows and two modern chairlifts. The chair lift on Lysá mountain belongs to the longest in the Czech Republic and the ski slopes offer the best conditions for skiing in Krkonoše. The resort is also equipped with a system for artificial snow making and lighting for the night operation. Local ski facilities are part of the skiing area called Skiregion.cz, where the visitors can use the same ticket in a several resorts. Besides downhill skiing, Rokytnice nad Jizerou is a well known area for cross-country skiing with many kilometers of groomed tracks connected to the main ski path crossing the whole region. Therefore, Rokytnice nad Jizerou belongs to the top resorts in the Czech Republic and has national significance (Městský úřad Rokytnice nad Jizerou, 2014).

4.3. Benecko

4.3.1. History and current state

The center of development in the region of Benecko was remodeled several few times in the course of time according to the predominant economic activities. Historically, the original settlement was around the medieval castle Štěpanice, founded in the 14th century. The small mountain town lost its status in 1526 when the owners moved out. The first mention of Benecko comes from the year 1628, when a member of the Benedictine order called Beneš settled there (Koláček, 2015). At first, people made their living by mainly working in the woods. Other parts of the present municipality were settled during 17th and 18th centuries. Deforested areas were turned into farmland, several iron and gold mines were founded and linen production spread around.

More than other villages, Benecko has been affected by the development of mountain tourism, especially skiing, from the end of 19th century. Local ski production and organization led by Norwegian instructors made the area truly the basis of Czech skiing. Development of the sport meant, that one of the poorest and the highest located villages in the Krkonoše region began to thrive.

Nowadays, the municipality of Benecko consists of four cadastral units – Horní Štěpanice, Dolní Štěpanice, Benecko and Mrklov, which merged in 1960. The entire municipality is focused almost exclusively on tourism and other activities associated with that (Obecní úřad Benecko, 2017).

4.3.2. Geography

Benecko is located in the western part of Krkonoše, on the slopes of Žalý mountain. The total area covers 16,5 square kilometers and the municipality lies in the altitude from 682 to 1010 meters above the sea level. Despite the recent trends, Benecko has preserved it scattered urban structure with one uncommon fact – none of the former separated villages created its own square. The major part of the territory is located inside of the III. zone of the Krkonoše Mountain National park and the lower section is in its protection zone (Obecní úřad Benecko, 2017).

4.3.3. Ski resort

First ski lifts in the area started to appear already during 60's. Benecko became the base for members of Czech SKI club, which bought a cottage there and organized popular ski tours into the surroundings.

The slow development of resort changed in 2006, when the new chairlift was built. The ski resort in Benecko offers mainly moderate ski slopes with a total length of 5,5 kilometers, equipped with 12 ski tows and one chairlift. Most of the ski slopes are covered with the system for artificial snow making and the resort also offers skiing in the evening. The area is also connected to the path network for cross-country skiing and hiking. The resort is known for its good orientation, which ensures the sunshine entire daytime and magnificent views of higher peaks of the Krkonoše mountains. The ski resort in Benecko belongs to the middle category with the regional importance (Obecní úřad Benecko, 2017).

4.4. Malá Úpa

4.4.1. History and current state

The first settlement in this area was officially founded in 1566 by newcomers from Alpine countries. They came at the request of local the owner to extract timber and transport it to the lower areas. The mountain village was named after the stream that springs there. Experienced loggers cut down almost all wooden vegetation during a very short period of time, which lead to a significant change in their way of living. Some of the deforested areas were turned into grassland enclaves, where the former timber loggers started to farm, and created the typical cabin homesteads. Another natural resource, which was later extracted in the locality was ore. For several centuries farming, mining and smuggling were the most common source of livelihoods.

More prominent signs of tourism development came after the First World War. Fortunately, unlike some neighboring villages e.g. Velká Úpa and Pec pod Sněžkou, the municipality preserved its agricultural character with scattered building structures around the slopes. Since its beginning, the settlement was divided into two main parts – Horní Malá Úpa and Dolní Malá Úpa. The current municipality consists of both of them. Malá Úpa is nowadays mostly a tourism oriented mountain village with operating border crossing (Malá Úpa, 2016).

4.4.2. Geography

The municipality of Malá Úpa is located in the eastern part of the Krkonoše mountains and belongs to the highest municipalities in the Czech Republic. The total area is more than 26 square kilometers and the village rises from 720 to 1602 meters above the sea level. The boarder of the municipal area reaches the highest point of the Czech Republic – Sněžka. Two main streams – Malá Úpa and Jelení creek, collect the water from surrounding slopes and both empties into the Úpa river lower in valley. The municipality is the only one, which is completely lies in the Krkonoše Mountain National Park, with the I. zone around Sněžka mountain.

4.4.3. Ski resort

Malá Úpa belongs to the oldest ski areas equipped with a facility for transportation of skiers in the Krkonoše mountains. The first ski tow was constructed already in 1961. Nowadays the resort offers several tows on moderate ski slopes with the total length of 3,7 kilometers. The artificial snow making system and night operation became a standard during the last decade. Furthermore, in the surrounding is more than 10 kilometers of groomed tracks for cross-country skiing. Because of its size and steepness of ski slopes, the resort in Malá Úpa belongs to the smaller ones in the Krkonoše mountains (SKIMU a.s., 2017).

5. METHODOLOGY

5.1. Defining the area of interest

Krkonoše mountains are a relatively large territory for detailed analyses of landscape changes on the scale of individual settlements. Therefore, it is necessary to define an area of interest, which would be suitable for the aims of the research and would well represent the whole region.

5.2. Selection of study areas and the criteria

The practical part of this thesis is focused on three areas located in the Krkonoše mountains. As a base unit for the analyses, separate areas of three municipalities were chosen. The region of the Krkonoše mountains consists of 65 municipalities with a wide range of size, population and character. It was then necessary to set up certain criteria to make the selection correctly.

To keep the focus on the influence of tourism, the potential list of considered municipalities contains only those, where the ski resort exists and where the tourism plays a key economical role. This selection is based on the analysis made in 2012 for strategy of further development of the region (Group SPF v.o.s., 2012). Furthermore, the history of ski resort was another condition. Since the aim of the thesis is to determine the impact of ski resort during the last several decades, there is a requirement of existence of a resort (at least some sort of a ski tow) during the observation period. Therefore, only those localities were chosen, where the ski resorts have existed already around the time of acquisition of the first input data.

Another criterion was the capacity of the current ski resort. All municipalities were divided into three categories according to the number of users transported per hour. The categories were specified as follows: 0 - 5 000, 5 000 - 10 000 and 10 000 or more based on data provided by the website Lyžařská střediska (Kozák, 2008). To ensure a greater insight of the research, each chosen municipality represents one of these categories.

After fulfilling all conditions, the following municipalities were selected: Rokytnice nad Jizerou as a municipality with the ski resort with the importance

on the national level, Benecko as a municipality with the ski resort on the regional level and Malá Úpa as a municipality with the ski resort on the local level.

Next step was acquisition of suitable data for landscape changes monitoring. For these purposes was selected a method of aerial images processing. Due to limited availability of aerial images of selected areas, it was decided to work with four time periods, as much regularly distributed as possible, which cover almost entire existence of ski resort in Krkonoše mountains. Finally, the acquired data are from 1953, 1978, 1998-2000 and 2016.

5.3. Input data preparation

The basic input data for GIS analyses are digitalized layers of land cover. These were acquired by vectorization of historical and current aerial images and then processed in software ArcGIS 10.3.

5.3.1. Historical aerial images

Availability of aerial images of Czech Republic is nowadays still relatively limited. The images of three historical periods were gained as follows. The images from 1953 were acquired from the Faculty of Environmental Sciences at Czech University of Life Sciences.

The images from 1978 were acquired from Military Geography and Hydrometeorology office in Dobruška. These images were delivered based on the order from the author of the thesis, in the form of 10 separated JPEG files. Before the images were prepared for digitalizing, it was necessary to georeference them. That was made above the aerial images from 2016 in the S-JTSK Krovak East North coordinate system. Obtained data unfortunately do not cover the entire area of selected municipalities. Approximately 7% of the total area could not be processed.

Another set of aerial images was taken during years 1998 and 2000. Images of the western part of Krkonoše mountains were taken in 1998 and the eastern part followed in 2000. Both are accessible on the website of Czech

Office for Surveying, Mapping and Cadastre. With the exception of aerial map from 1950, the map from 1998-2000 is the oldest aerial map freely available online. To obtain this map it was necessary to do, one by one, screenshots of the map in geoportal and then put them together by using another software – Adobe Photoshop CS6. United map was than imported to ArcGIS and georeferenced in the same manner as the images before.

5.3.2. Color aerial images

For the current state of land cover freely accessible images were used provided by Czech Office for Surveying, Mapping and Cadastre. The map was connected as WMS (web map services) to ArcGIS.

5.4. Vectorization of aerial images

Firstly, three geodatabases were created in ArcGIS, one for each municipality, which were later consecutively filled with vectorized data of land cover. All data was processed in the S-JTSK Krovak East North coordinate system. The basic outcome of vectorization is twelve maps of land cover, four time periods for each of three municipalities.

Division of land cover types was inspired by similar researches (Drahoňovská, 2009), but it was adjusted to local conditions and purposes. Since the processed data come from a time period longer than sixty years, the analyses were focused on landscape structures, which are the most stable and create its character. The permanent landscape structures are also the most important ecological part of the landscape and form the basis for territorial system of ecological stability (Sklenička, 2003). It was defined ten categories of land cover:

- Forests: areas covered continuous and dense woody vegetation
- Mountainpine scrubs: areas at the mountain ridges covered by low pine vegetation
- Scattered woody vegetation: vegetation outside the forests, linear vegetation along the roads, watercourses and hedges
- Tundra: areas at the highest parts of the mountains, covered by grass and rocks

- Deforested areas: bare forest areas after extraction or natural disaster
- Grasslands: areas covered by grass and herbaceous vegetation, meadow and pastures sometimes used for agriculture
- Built-up and paved areas: urban areas including gardens and public spaces
- Other urban areas: other areas intensively used by people, railway, sport fields, cemetery
- Roads: main roads and paths visible in aerial maps
- Watercourses: main water courses visible in aerial maps

Vectorization was always done in order from the newest input data to the oldest (2016 – 1998 -1978 – 1953). Reason of that was the quality of aerial images. Color images of current state are easier to digitize than the older black and white images. Layer created for one period was than copied and used as a base for older period, where it was edited according to the situation. This approach ensures a minimal divergence in places, where no changes occurred.

The method of manual vectorization is always associated with a certain level of generalization. Therefore, it has to be calculated with a possible error deviation. It is very important to set the proper scale, which is then used for the whole process. Since the focus was on the settlement structure, it was necessary to keep the scale such, that the individual buildings remain distinguishable. In this case, the scale was set at 1:2 500. For the more accurate location of roads and watercourses, which often intersect the forest, were used base maps of the Czech Republic with the scale 1:10 000.

Figure 1. Example of digitalized image from 1953

5.5. Analysis of landscape changes

New vector data, which were created by digitalizing of aerial images, were used as an input data for subsequent analyses. At first, the areas of individual polygons, representing different landscape elements, were calculated. By using *Summarize* and *Table to Excel* tools in ArcGIS were created spreadsheets for Microsoft Excel. Each studied municipality has its own sheet, where the total area of every land cover category was compared across all four time periods. The values are represented in hectares and also in percentage from entire municipality area.

5.5.1. Development of settlements

Beside the spatial data acquired from aerial images, also data from census were collected. As a source was used official historical lexicon of

municipalities of the Czech Republic (Růžková et al., 2006) and website of Regional Information Service, which is managed by the Ministry of Regional Development (Ministry of Regional Development, 2016). Data were collected from a census done during years 1961, 1970, 1980, 1990, 2001, 2011 and 2016.

Data from census were put on Microsoft Excel spreadsheet together with data of land cover categories built-up and other urban areas. Thereafter were created charts, which show the development of population and urban areas in each municipality.

To compare the development between studied municipalities it was necessary to calculate percentage increase during all time periods of only urbanized areas without context of entire municipal area. Only then the development was comparable between municipalities with different areas.

5.5.2. Topological overlay

For another analyses of landscape changes in studied municipalities was used a method of topological overlay. This method was used to find out the rate of changes between land cover categories during the monitored time periods. The outcome of the analyses is a spreadsheet showing spatial amount of changed land cover category.

Areas, where the land cover has changed were detected by the tool Intersect in ArcGIS. Input data were always two vector maps of following time periods. The process created a new vector map, where the attributes contain information of land cover from both time periods. The attribute table were then converted in the same manner as in the previous method on the Microsoft Excel spreadsheet. Spatial values were inserted into a pivot table, where they were summarized. The outcome tables show spatial increase and decrease of each land cover category and total rate of change in hectares and percentage.

5.5.3. Analysis of the spatial dynamics of the landscape changes

Analysis of the spatial dynamics of the landscape changes by using map algebra can be done by two basic methods. Differences are in calculations of

individual changes. While the first method counts land cover 1 -> land cover 2 -> land cover 1 as two changes, the second method counts it as only one. Selection of method depends on the purpose of the research. In this case, both of them were carried out and the results can be compared. This analysis was based on instructional text for the course Modelování změn v krajině, provided by the Faculty of Environmental Sciences at Czech University of Life Sciences (Faculty of Environmental Sciences, 2012).

First method

Digitalized data of land cover were converted into raster format by the tool *Polygon to Raster* based on land cover categories. To keep the proper detail in outcomes, the cell size was set to 2, which means that one cell represents four meters square. The rasters were used as an input data for *Cell Statistics* tool, with the focus on the variety of individual cells in different time periods. For better legibility, the cell values were decreased by one using *Minus* tool. The outcome raster map contains areas with three, two, one or none change in land cover.

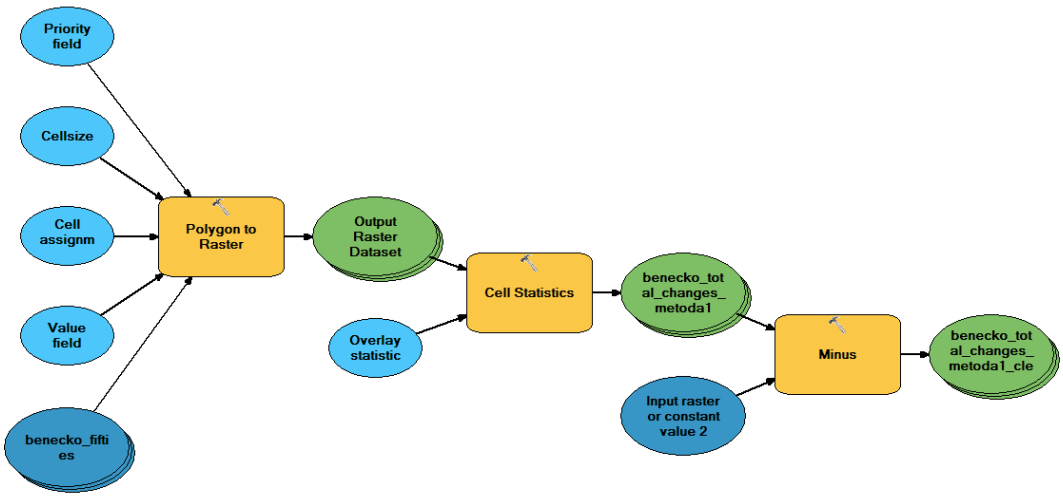

Figure 2. ModelBuilder in ArcGIS – model used for calculation of spatial dynamics of the landscape changes – first method

Second method

Similarly, as in the first method, data had to be at first converted into the raster format. During the next step, data for two followed time periods were processed by the tool *Cell Statistics* separately. Outcome of this step is raster

map with values 1 (no change) and 2 (change). All new raster data were than decreased by one in the same manner as previously and finally summarized by *Cell Statistic* one more time. Again, the result raster map consists of cells, which contains values 0,1,2 or 3 for representation of land cover changes.

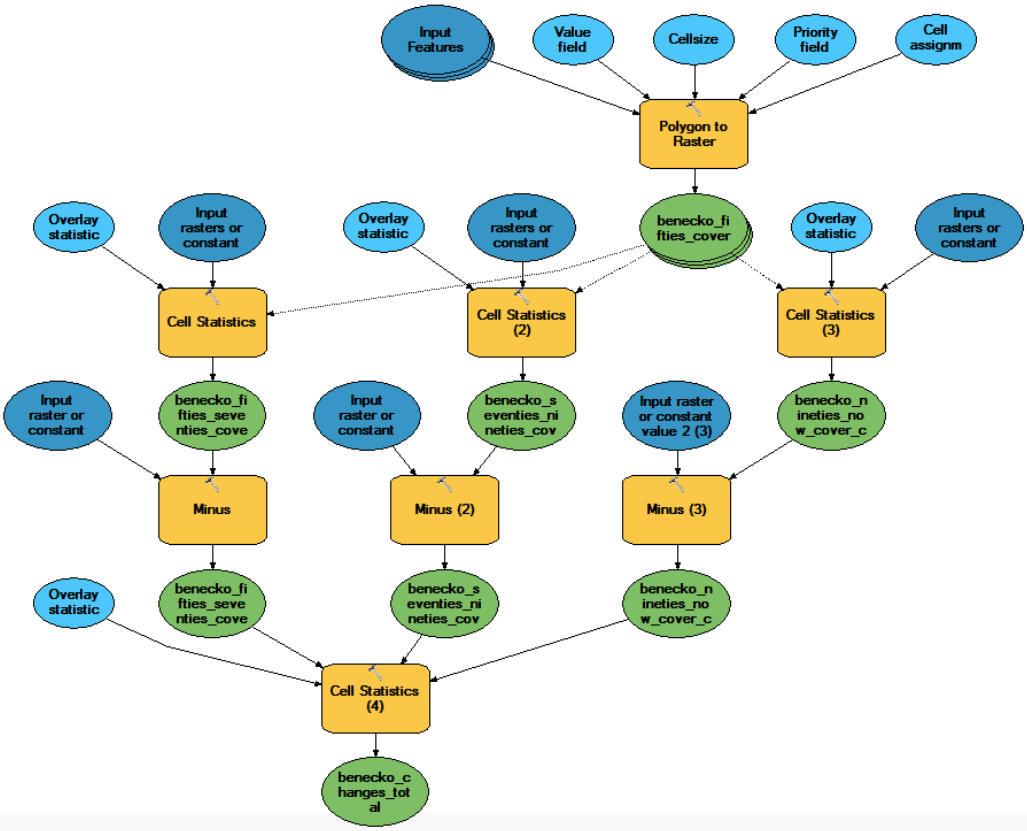

Figure 3. ModelBuilder in ArcGIS – model used for calculation of spatial dynamics of the landscape changes – second method

In the end, the outputs of the analyzing tools were placed into map layouts with all essential map elements. The maps are attached in appendences.

6. CURRENT STATE OF PROBLEM

The topic of landscape change and its linkage to tourism development is nowadays studied in different forms all over the world. Ecologists are investigating the environmental impacts, spatial and urban planners focus on geographical impacts and sociologists and economist are interested in demographical or financial consequences of tourism. Researches have been also made on prediction of sites, where the development should take a place. Skiing as an activity is very dependent of the environmental conditions (snow conditions, terrain), is in the focus of research as well.

There is a several researches, with aims related to the aims of this thesis. The most similar research was carried out by Bucała (2014), who focused on impacts of human activities on land use/cover change in Gorce Mountains, Poland. Amici et al. (2017) carried out GIS based assessment focused on changes of cultural landscapes due to abandonment of traditional rural systems in Mediterranean area. Samsudin and Maliki (2015) investigated the relationship between cultural landscape and sustainable tourism. Silberman and Rees (2010) did a GIS based research, which aims to identify former mining settlements with the biggest potential for a future development of ski resort in Rocky Mountains, U.S. Lasanta, Laguna and Vicente-Serrano (2007) examined effects of tourism on demography in Pyrenees Mountains. Chaplin and Brabyn (2013) used remote sensing data to assess the impact of tourism on the forest volume in Nepal. In Czech Republic, Boori, Voženílek and Choudhary (2015) did a GIS based research using remote sensing to determine land cover/use disturbance due to tourism in Jeseníky mountains. Since almost every research focuses on different location with different conditions it is difficult list the most relevant.

7. RESULTS

7.1. Areas of land cover categories in different time periods

The outcome of vectorization is twelve vector maps, which are attached in appendices of this thesis. The following tables and charts show summarized areas of individual land cover category in the all studied time periods. These first results work as an overview of the land cover development, which is then further investigated by followed analyses.

Land cover category	1953		1978		1998		2016	
	ha	%	ha	%	ha	%	ha	%
Forest	1223,6	33,1%	1409,5	38,1%	1420,1	38,4%	1606,2	43,5%
Deforested areas	53,1	1,4%	91,9	2,5%	160,5	4,3%	3,5	0,1%
Mountainpine	515,7	14,0%	485,9	13,2%	473,0	12,8%	448,0	12,1%
Tundra	343,6	9,3%	345,6	9,4%	354,0	9,6%	408,3	11,1%
Grasslands	1264,9	34,2%	1013,5	27,4%	853,7	23,1%	835,1	22,6%
Scattered woody vegetation	120,9	3,3%	126,7	3,4%	175,5	4,7%	128,7	3,5%
Watercourses	15,1	0,4%	15,1	0,4%	15,1	0,4%	15,1	0,4%
Built-up and paved areas	112,4	3,0%	159,7	4,3%	190,9	5,2%	197,8	5,4%
Other areas	2,9	0,1%	5,2	0,1%	9,2	0,3%	9,3	0,3%
Roads	42,9	1,2%	41,9	1,1%	43,0	1,2%	43,1	1,2%
Total	3695,2	100,0%	3695,2	100,0%	3695,2	100,0%	3695,2	100,0%

Table 1. Rokytnice nad Jizerou - Land cover categories in different years

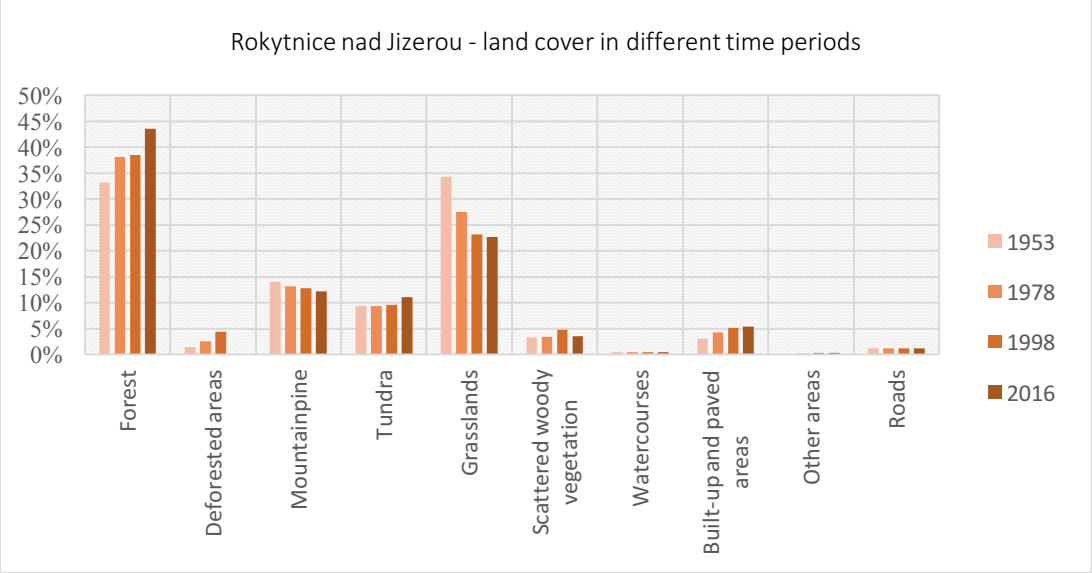

Figure 4. Rokytnice nad Jizerou - Land cover portions

The processed data show that two thirds of the entire area is covered by forests and grasslands. The rest consists of mainly tundra and mountainpine scrubs on the hilltops. Increase in forest volume and decrease in grasslands

indicate the tendency in reforestation of some former grassy areas, which ceased to be used for agricultural purposes.

Land cover category	1953		1978		1998		2016	
	ha	%	ha	%	ha	%	ha	%
Forest	618,1	37,4%	727,5	44,0%	703,5	42,6%	773,2	46,8%
Deforested areas	6,8	0,4%	34,4	2,1%	90,2	5,5%	27,1	1,6%
Grasslands	848,6	51,4%	654,5	39,6%	591,1	35,8%	570,1	34,5%
Scattered woody vegetation	83,7	5,1%	117,1	7,1%	125,8	7,6%	127,1	7,7%
Watercourses	4,7	0,3%	4,7	0,3%	4,7	0,3%	4,7	0,3%
Built-up and paved areas	54,1	3,3%	77,6	4,7%	99,4	6,0%	112,2	6,8%
Other areas	1,1	0,1%	1,1	0,1%	2,1	0,1%	2,5	0,2%
Roads	35,2	2,1%	35,4	2,1%	35,4	2,1%	35,4	2,1%
Total	1652,2	100,0%	1652,2	100,0%	1652,2	100,0%	1652,2	100,0%

Table 2. Benecko - Land cover categories in different years

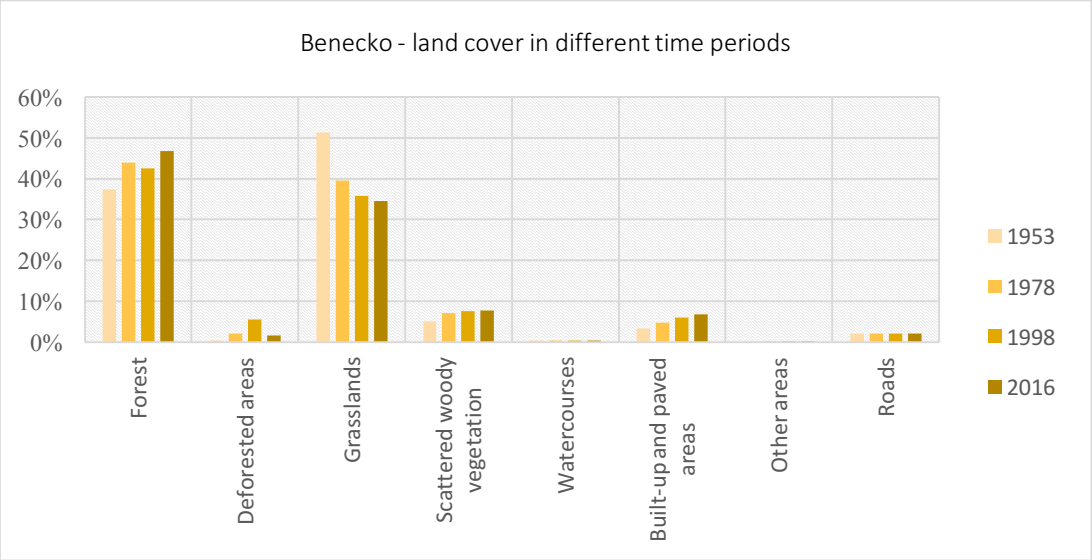

Figure 5. Benecko - Land cover portions

Similar as previous, also in Benecko the major part of territory is covered by forests and grasslands. In the 50's the grasslands covered even more than 50% of the entire area. During the studied time, the former grasslands were replaced with forests but also with built-up areas and scattered vegetation. Land cover categories mountainpine scrubs and tundra are not represented in area of Benecko municipality at all, so they were not included in any of the tables and charts.

Land cover category	1953		1978		2000		2016	
	ha	%	ha	%	ha	%	ha	%
Forest	1994,8	74,8%	1963,0	73,6%	1495,7	56,1%	1810,8	67,9%
Deforested areas	107,9	4,0%	207,6	7,8%	674,3	25,3%	355,7	13,3%
Moutainpine	116,1	4,4%	116,2	4,4%	116,1	4,4%	116,1	4,4%
Tundra	11,6	0,4%	11,6	0,4%	11,6	0,4%	11,6	0,4%
Grasslands	371,6	13,9%	290,4	10,9%	283,5	10,6%	280,7	10,5%
Scattered woody vegetation	15,4	0,6%	24,4	0,9%	30,5	1,1%	33,3	1,2%
Watercourses	6,5	0,2%	6,5	0,2%	6,5	0,2%	6,5	0,2%
Built-up and paved areas	15,2	0,6%	17,0	0,6%	18,5	0,7%	21,7	0,8%
Other areas	0,0	0,0%	0,8	0,0%	0,8	0,0%	1,2	0,0%
Roads	27,4	1,0%	28,8	1,1%	28,8	1,1%	28,8	1,1%
Total	2666,4	100,0%	2666,4	100,0%	2666,4	100,0%	2666,4	100,0%

Table 3. Malá Úpa - Land cover categories in different years

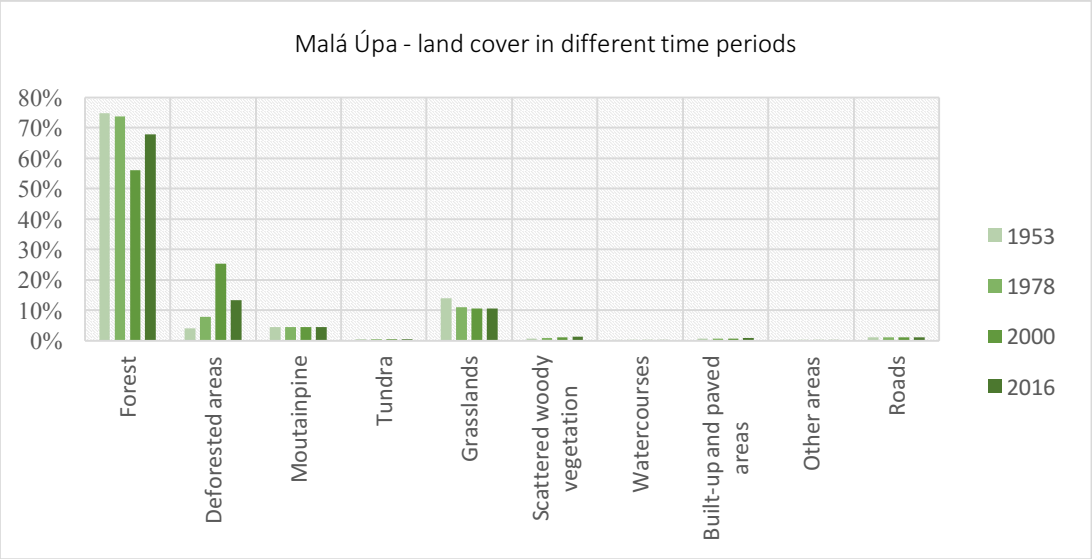

Figure 6. Malá Úpa - Land cover portions

The land cover of Malá Úpa is significantly dominated by forests. That is caused by the location of the municipality inside of the Krkonoše Mountains National Park and its proximity to Sněžka mountain. Development of other land cover categories is almost negligible except deforested areas.

7.2. Development of settlements

Since the first overview is a bit distorted by total area of municipality, for showing the development of settlement it was necessary to take out only the data for built-up and other urban areas and determine their progress individually. The following charts show the development of population and urbanized areas in individual municipalities. The left axis shows the number of inhabitants and the right axis shows urbanized area in hectares.

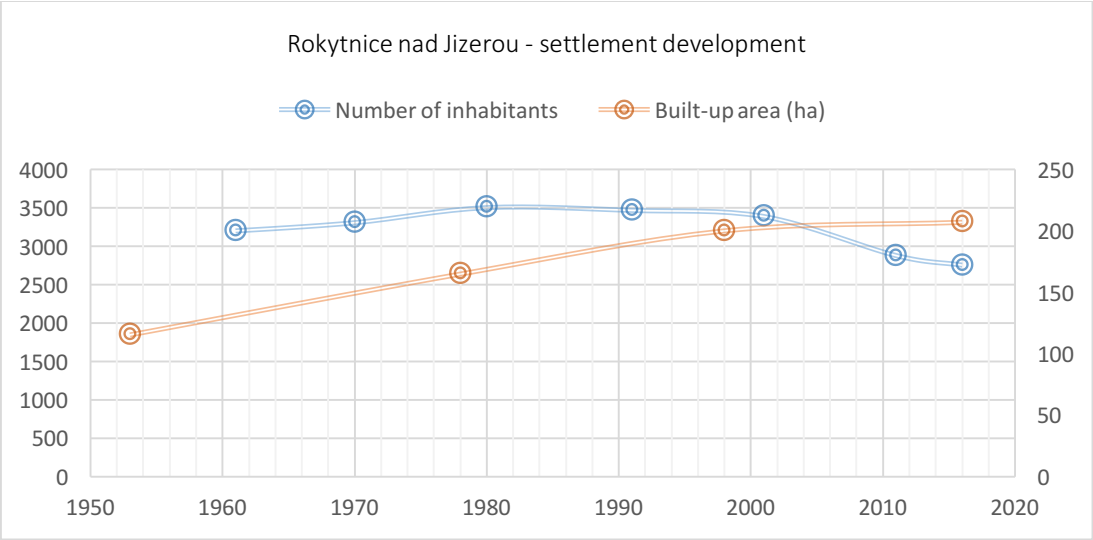

Figure 7. Rokytnice nad Jizerou – settlement development

The number of inhabitants in Rokytnice nad Jizerou was slightly growing during the 60's and the 70's, which can be seen as a result of artificial resettling after the decrease in population caused by the Second World War. Since the town contained operating industrial sites, it offered work opportunities and profit for the entire region. Development of urbanized area was growing too until the last two decades, when it slowed down. In comparison to previous time periods, when some bigger complexes and part of the town arose, the construction of the last period has been consisting of smaller objects.

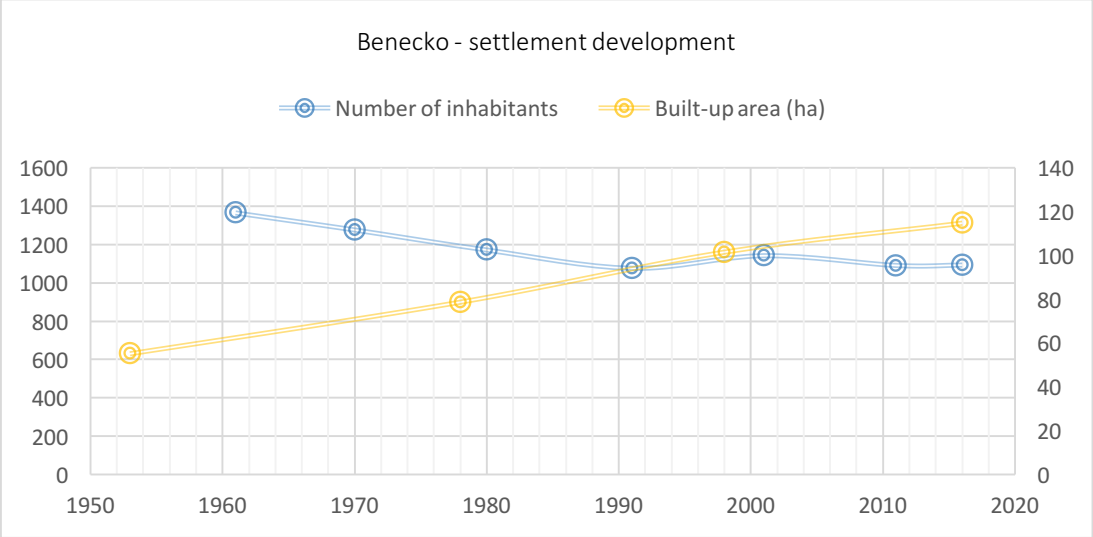

Figure 8. Benecko – settlement development

The population of Benecko was decreasing until the 90's. During the last thirty years the population is quite stable. The artificial resettling after the Second World War either was not successful or did not happened at all. That could be caused by absence of bigger industrial sites. The development of urbanized area is very consistent during the whole studied time. The reason for that is in the structure of built-up areas, which is with few exceptions consisting of individual dwelling buildings.

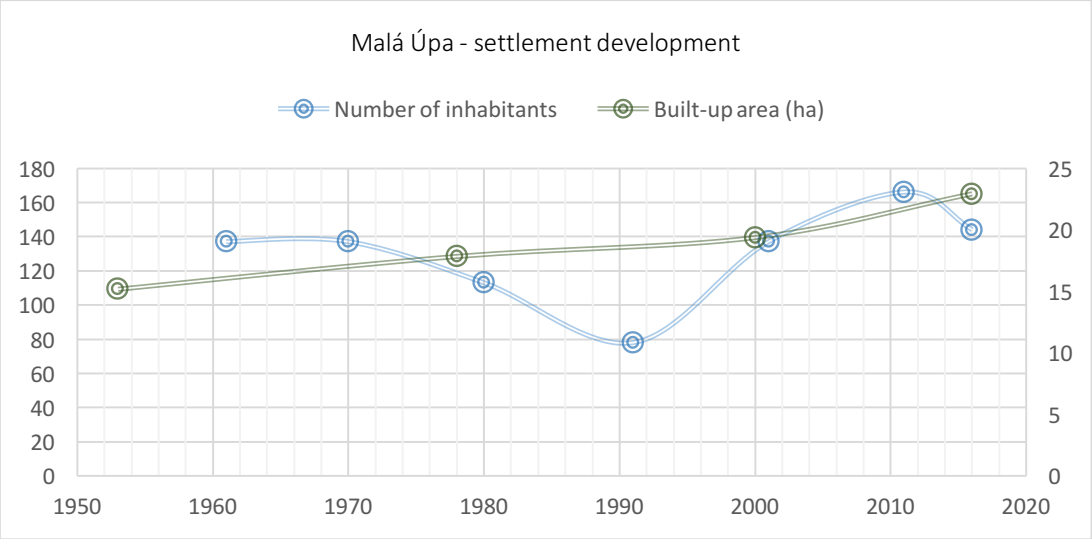

Figure 9. Malá Úpa – settlement development

Number of inhabitants of Malá Úpa is in comparison to both previous municipalities very small. That causes significant fluctuations in the presented chart. On the other hand, the population nowadays is the same or a bit bigger than in the 50's, which is different than in both previous municipalities. Also in urbanized areas it has to be calculated in a different scale than in other municipalities, but the development has been slightly rising during the last two decades.

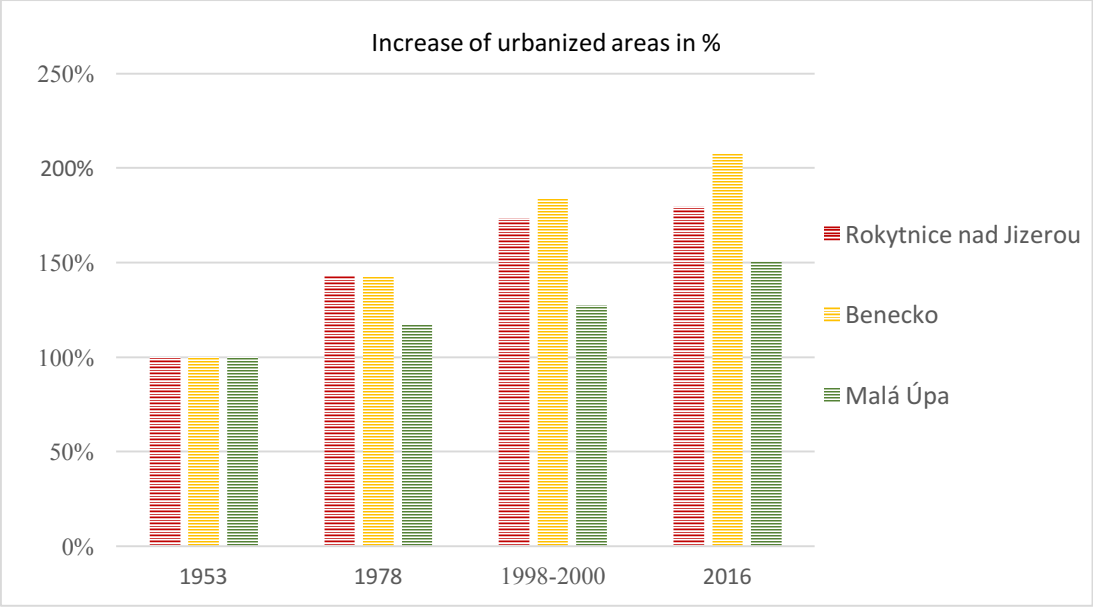

Figure 10. Development of urbanized areas 1953-2016

The last chart of this analysis shows clear expansion of urbanized areas, without context of the total municipality area. During the studied era, each municipality developed by its own rhythm with a quite regular differences in the end. Development of Rokytnice nad Jizerou was relatively big in the 80's but then it slowed down and in 2016 the urbanized areas were around 180% of the original in the 50's. Development of urbanized areas in Benecko was relatively stable. In 2016 the urbanized areas were more than 200% of the original areas, which is the most of all three settlements. Urbanized areas in Malá Úpa expanded also relatively regularly. In 2016, the built-up and other urban areas covered almost exactly one and half the area of the original settlement.

The analysis of settlement development showed relatively stable expansion of urbanized areas in all three settlements. Development of population is not that clear. Basically the data revealed that in a settlement with big ski a resort there is decline of permanent residents, whilst in a settlement with smaller resort the number of inhabitants remains the same or slightly increases. The analysis only confirmed the fact, that more and more buildings in study areas serve as a short-time accommodation for visitors instead of homes for permanent residents.

7.3. Land cover changes determined by topological overlay

For each municipality there were created three tables, one for every land cover change between two followed time periods. The tables show the land cover category, which replaced the previous one and the rate of the change. Therefore, this analysis even more confirms the results of the first overview.

Land cover category	Built-up areas	Deforested areas	Forest	Grasslands	Mountainpine	Other urban areas	Roads	Scattered woody vegetation	Tundra	Watercourses	Decrease from 1953 to 1978
Built-up areas	x	0,00	0,25	3,85	0,00	0,00	0,01	0,11	0,00	0,00	4,22
Deforested areas	0,00	x	48,18	0,00	0,77	0,00	0,00	0,00	0,00	0,00	48,94
Forest	0,02	57,83	x	26,86	0,00	0,43	0,00	5,76	0,00	0,00	90,89
Grasslands	48,57	6,01	206,29	x	0,00	1,52	0,00	45,88	0,00	0,00	308,26
Mountainpine	0,05	22,87	3,49	4,17	x	0,00	0,00	0,00	0,00	0,00	30,58
Other urban areas	0,04	0,00	0,00	0,03	0,00	x	0,00	0,00	0,00	0,00	0,07
Roads	0,00	0,00	0,87	0,23	0,00	0,00	x	0,01	0,00	0,00	1,11
Scattered woody vegetation	2,79	0,79	19,01	22,94	0,00	0,20	0,12	x	0,00	0,00	45,86
Tundra	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	x	0,00	0,00
Watercourses	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	x	0,00
Increase from 1953 to 1978	51,47	87,49	278,09	58,08	0,77	2,14	0,13	51,75	0,00	0,00	
Balance between 1953 and 1978	47,25	38,55	187,20	-250,18	-29,81	2,07	-0,98	5,89	0,00	0,00	
Total change in land cover (ha)	529,93										
Total change in land cover %	14,34%										

Table 4. Rokytnice nad Jizerou 1953-1978: Land cover changes

Land cover category	Built-up areas	Deforested areas	Forest	Grasslands	Mountainpine	Other urban areas	Roads	Scattered woody vegetation	Tundra	Watercourses	Decrease from 1978 to 1998
Built-up areas	x	0,00	0,30	0,09	0,00	1,06	0,00	0,23	0,00	0,00	1,69
Deforested areas	0,00	x	12,32	0,00	23,64	0,00	0,00	0,00	0,00	0,00	35,96
Forest	0,57	75,40	x	1,75	0,00	0,00	0,87	2,13	0,00	0,00	80,74
Grasslands	31,78	3,04	56,79	x	0,00	3,18	0,23	67,99	0,00	0,00	163,00
Mountainpine	0,00	26,17	0,00	0,00	x	0,00	0,00	0,00	10,40	0,00	36,56
Other urban areas	0,00	0,00	0,00	0,00	0,00	x	0,00	0,00	0,00	0,00	0,00
Roads	0,00	0,00	0,00	0,00	0,00	0,00	x	0,00	0,00	0,00	0,00
Scattered woody vegetation	0,57	0,25	19,36	1,50	0,00	0,00	0,01	x	0,00	0,00	21,68
Tundra	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	x	0,00	0,00
Watercourses	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	x	0,00
Increase from 1978 to 1998	32,92	104,86	88,77	3,34	23,64	4,24	1,11	70,35	10,40	0,00	
Balance between 1978 and 1998	31,23	68,90	8,03	-159,66	-12,92	4,24	1,11	48,67	10,40	0,00	
Total change in land cover (ha)	339,63										
Total change in land cover %	9,19%										

Table 5. Rokytnice nad Jizerou 1978-1998: Land cover changes

Land cover category	Built-up areas	Deforested areas	Forest	Grasslands	Mountainpine	Other urban areas	Roads	Scattered woody vegetation	Tundra	Watercourses	Decrease from 1998 to 2016
Built-up areas	x	0,00	0,57	0,65	0,00	0,00	0,00	0,08	0,00	0,00	1,30
Deforested areas	0,00	x	131,11	0,00	29,37	0,00	0,00	0,00	0,00	0,00	160,48
Forest	0,47	3,41	x	0,54	0,00	0,00	0,00	0,00	0,00	0,00	4,41
Grasslands	7,00	0,00	8,29	x	0,00	0,00	0,02	5,67	0,00	0,00	20,98
Mountainpine	0,00	0,00	0,00	0,00	x	0,00	0,00	0,00	54,34	0,00	54,34
Other urban areas	0,00	0,00	0,00	0,00	0,00	x	0,00	0,00	0,00	0,00	0,00
Roads	0,00	0,00	0,00	0,00	0,00	0,00	x	0,00	0,00	0,00	0,00
Scattered woody vegetation	0,59	0,00	50,90	1,16	0,00	0,00	0,00	x	0,00	0,00	52,65
Tundra	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	x	0,00	0,00
Watercourses	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	x	0,00
Increase from 1998 to 2016	8,06	3,41	190,87	2,35	29,37	0,00	0,02	5,75	54,34	0,00	
Balance between 1998 and 2016	6,75	-157,08	186,46	-18,63	-24,97	0,00	0,02	-46,90	54,34	0,00	
Total change in land cover (ha)	294,17										
Total change in land cover %	7,96%										

Table 6. Rokytnice nad Jizerou 1998-2016: Land cover changes

Between 1953 and 1978, the grasslands were mainly reforested and also used for building constructions. Similar tendency was also between 1978 and 1998. Some of the former grassy areas were overgrown by scattered woody vegetation and some of the forest areas were deforested. During the last period some of the scattered woody vegetation created regular forests and the number of deforested areas decreased. The general rate of land cover changes gradually slowed down from around 14% to almost 8%.

Land cover category	Built-up areas	Deforested areas	Forest	Grasslands	Other urban areas	Roads	Scattered woody vegetation	Watercourses	Decrease from 1953 to 1978
Built-up areas	x	0,01	0,23	2,88	0,00	0,00	0,37	0,02	3,51
Deforested areas	0,05	x	6,48	0,00	0,00	0,00	0,00	0,00	6,53
Forest	0,01	27,35	x	8,43	0,00	0,01	1,30	0,00	37,09
Grasslands	24,79	6,07	115,24	x	0,00	0,12	68,68	0,00	214,90
Other urban areas	0,00	0,00	0,00	0,00	x	0,00	0,00	0,00	0,00
Roads	0,00	0,00	0,01	0,02	0,00	x	0,01	0,00	0,03
Scattered woody vegetation	2,16	0,74	24,82	9,09	0,00	0,06	x	0,00	36,88
Watercourses	0,02	0,00	0,00	0,00	0,00	0,00	0,00	x	0,02
Increase from 1953 to 1978	27,03	34,16	146,78	20,42	0,00	0,19	70,36	0,02	
Balance between 1953 and 1978	23,52	27,63	109,69	-194,48	0,00	0,15	33,48	0,00	
Total change in land cover (ha)	298,96								
Total change in land cover %	18,09%								

Table 7. Benecko 1953-1978: Land cover changes

Land cover category	Built-up areas	Deforested areas	Forest	Grasslands	Other urban areas	Roads	Scattered woody vegetation	Watercourses	Decrease from 1978 to 1998
Built-up areas	x	0,00	0,24	1,24	0,00	0,00	0,00	0,02	1,50
Deforested areas	0,00	x	15,90	0,00	0,00	0,00	0,00	0,00	15,90
Forest	1,26	70,40	x	0,17	0,31	0,01	0,75	0,00	72,90
Grasslands	20,79	1,27	19,45	x	0,72	0,00	23,67	0,00	65,90
Other urban areas	0,00	0,00	0,00	0,00	x	0,00	0,00	0,00	0,00
Roads	0,00	0,00	0,01	0,00	0,00	x	0,00	0,00	0,01
Scattered woody vegetation	1,21	0,00	13,52	1,05	0,00	0,01	x	0,00	15,79
Watercourses	0,02	0,00	0,00	0,00	0,00	0,00	0,00	x	0,02
Increase from 1978 to 1998	23,29	71,67	49,13	2,46	1,03	0,01	24,42	0,02	
Balance between 1978 and 1998	21,78	55,77	-23,77	-63,44	1,03	0,00	8,63	0,00	
Total change in land cover (ha)	172,04								
Total change in land cover %	10,41%								

Table 8. Benecko 1978-1998: Land cover changes

Land cover category	Built-up areas	Deforested areas	Forest	Grasslands	Other urban areas	Roads	Scattered woody vegetation	Watercourses	Decrease from 1998 to 2016
Built-up areas	x	0,00	0,00	1,24	0,00	0,00	0,02	0,02	1,28
Deforested areas	0,00	x	74,01	0,00	0,00	0,00	0,00	0,00	74,01
Forest	0,71	10,66	x	5,99	0,36	0,01	1,25	0,00	18,98
Grasslands	12,28	0,27	9,46	x	0,00	0,00	6,05	0,00	28,06
Other urban areas	0,00	0,00	0,00	0,00	x	0,00	0,00	0,00	0,00
Roads	0,00	0,00	0,00	0,00	0,00	x	0,00	0,00	0,00
Scattered woody vegetation	1,25	0,00	4,53	0,20	0,00	0,00	x	0,00	5,99
Watercourses	0,02	0,00	0,00	0,00	0,00	0,00	0,00	x	0,02
Increase from 1998 to 2016	14,26	10,93	88,01	7,44	0,36	0,01	7,33	0,02	
Balance between 1998 and 2016	12,97	-63,09	69,03	-20,63	0,36	0,01	1,34	0,00	
Total change in land cover (ha)	128,35								
Total change in land cover %	7,77%								

Table 9. Benecko 1998-2016: Land cover changes

Also in Benecko, the grasslands started to wane and were replaced by forests and scattered woody vegetation between 1953 and 1978. Between 1978 and 1998 the biggest changes occurred in forests, which had been deforested, but on the other hand some woody vegetation accrued. The last table shows reforestation of some deforested areas and regular increase in built-up areas. Basically, the land cover development is very close to the one in Rokytnice nad Jizerou and the ratio of changes is also declining.

Land cover category	Built-up areas	Deforested areas	Forest	Grasslands	Mountainpine scrubs	Other urban areas	Roads	Scattered woody vegetation	Tundra	Watercourses	Decrease from 1953 to 1978
Built-up areas	x	0,00	0,00	0,72	0,00	0,16	0,13	0,08	0,00	0,00	1,10
Deforested areas	0,06	x	89,31	0,90	0,00	0,21	0,00	0,00	0,00	0,00	90,47
Forest	0,27	187,62	x	1,52	0,00	0,03	0,28	0,38	0,00	0,00	190,09
Grasslands	2,56	2,56	62,22	x	0,00	0,44	0,99	16,79	0,00	0,00	85,56
Mountainpine scrubs	0,00	0,00	0,00	0,00	x	0,00	0,00	0,00	0,00	0,00	0,00
Other urban areas	0,00	0,00	0,00	0,00	0,00	x	0,00	0,00	0,00	0,00	0,00
Roads	0,03	0,00	0,04	0,00	0,00	0,00	x	0,00	0,00	0,00	0,06
Scattered woody vegetation	0,00	0,09	7,24	1,04	0,00	0,00	0,09	x	0,00	0,00	8,45
Tundra	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	x	0,00	0,00
Watercourses	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	x	0,00
Increase from 1953 to 1978	2,91	190,27	158,80	4,17	0,00	0,85	1,48	17,25	0,00	0,00	
Balance between 1953 and 1978	1,81	99,80	-31,29	-81,39	0,00	0,85	1,42	8,80	0,00	0,00	
Total change in land cover (ha)	375,73										
Total change in land cover %	14,09%										

Table 10. Malá Úpa 1953-1978: Land cover changes

Land cover category	Built-up areas	Deforested areas	Forest	Grassland	Mountainpine	Other urban areas	Roads	Scattered woody vegetation	Tundra	Watercourses	Decrease from 1978 to 2000
Built-up areas	x	0,00	0,00	0,15	0,00	0,00	0,00	0,00	0,00	0,00	0,15
Deforested areas	0,00	x	126,71	0,21	0,00	0,00	0,00	0,20	0,00	0,00	127,12
Forest	0,00	593,62	x	3,37	0,00	0,00	0,04	0,84	0,00	0,00	597,86
Grassland	1,45	0,15	1,81	x	0,00	0,23	0,00	7,20	0,00	0,00	10,83
Mountainpine	0,00	0,00	0,00	0,00	x	0,00	0,00	0,00	0,00	0,00	0,00
Other urban areas	0,24	0,00	0,00	0,00	0,00	x	0,00	0,00	0,00	0,00	0,24
Roads	0,00	0,00	0,04	0,00	0,00	0,00	x	0,00	0,00	0,00	0,04
Scattered woody vegetation	0,00	0,00	1,97	0,18	0,00	0,00	0,00	x	0,00	0,00	2,15
Tundra	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	x	0,00	0,00
Watercourses	0,00	0,00	0,04	0,00	0,00	0,00	0,00	0,00	0,00	x	0,04
Increas from 1978 to 2000	1,69	593,76	130,57	3,91	0,00	0,23	0,04	8,24	0,00	0,00	
Balance between 1978 and 2000	1,54	466,64	-467,29	-6,92	0,00	-0,01	0,00	6,08	0,00	-0,04	
Total change in land cover (ha)	738,44										
Total change in land cover %	27,69%										

Table 11. Malá Úpa 1978-2000: Land cover changes

Land cover category	Built-up areas	Deforested areas	Forest	Grassland	Mountainpine	Other urban areas	Roads	Scattered woody vegetation	Tundra	Watercourses	Decrease from 2000 to 2016
Built-up areas	x	0,00	0,00	0,15	0,00	0,00	0,00	0,00	0,00	0,00	0,15
Deforested areas	0,16	x	574,58	1,58	0,00	0,00	0,00	0,00	0,00	0,00	576,32
Forest	0,00	257,76	x	2,90	0,00	0,00	0,04	0,18	0,00	0,04	260,92
Grassland	3,13	0,00	1,13	x	0,00	0,22	0,00	2,93	0,00	0,00	7,40
Mountainpine	0,00	0,00	0,00	0,00	x	0,00	0,00	0,00	0,00	0,00	0,00
Other urban areas	0,00	0,00	0,00	0,00	0,00	x	0,00	0,00	0,00	0,00	0,00
Roads	0,00	0,00	0,00	0,00	0,00	0,00	x	0,00	0,00	0,00	0,00
Scattered woody vegetation	0,00	0,00	0,18	0,18	0,00	0,00	0,00	x	0,00	0,00	0,36
Tundra	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	x	0,00	0,00
Watercourses	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	x	0,00
Increase from 2000 to 2016	3,29	257,76	575,89	4,81	0,00	0,22	0,04	3,11	0,00	0,04	
Balance between 2000 and 2016	3,14	-318,56	314,97	-2,59	0,00	0,22	0,04	2,75	0,00	0,04	
Total change in land cover (ha)	845,14										
Total change in land cover %	31,70%										

Table 12. Malá Úpa 2000-2016: Land cover changes

Development of land cover in Malá Úpa is highly affected by the large portion of forests in the whole municipality area. All three tables show the rate of deforestation followed almost complete reforestation in the last period. Unlike both previous municipalities, the rate of land cover change has been increasing in Malá Úpa.

7.4. Spatial dynamics of the landscape changes

The outcomes of the last analysis are schematic maps representing number of land cover changes in a particular place. The maps are attached in appendices. Following tables are summarized values of them.

Land cover changes	First method		Second method	
	area ha	%	area ha	%
0	2825,60	76,47%	2827,37	76,52%
1	793,03	21,46%	585,36	15,84%
2	75,81	2,05%	272,67	7,38%
3	0,37	0,01%	9,42	0,25%

Table 13. Rokytnice nad Jizerou – Number land cover changes

Slightly more than three quarters of Rokytnice nad Jizerou land cover did not change during the entire studied era. More than twenty percent changed at least once and only two percent of land cover changed two times. Comparing of both methods shows that around six percent of land cover changed back into the original category.

Land cover changes	First method		Second method	
	area ha	%	area ha	%
0	1189,61	72,03%	1189,63	72,04%
1	432,26	26,17%	335,14	20,29%
2	29,58	1,79%	123,88	7,50%
3	0,00	0,00%	2,80	0,17%

Table 14. Benecko – Number land cover changes

Also this analysis confirms the similarity between land cover development of Rokytnice nad Jizerou and Benecko. Here, more than seventy percent did not change. Around quarter of the area changed the land cover al least once and less than two percent two times.

Land cover changes	First method		Second method	
	area ha	%	area ha	%
0	1415,40	53,09%	1415,46	53,09%
1	1237,30	46,41%	552,53	20,72%
2	13,35	0,50%	690,25	25,89%
3	0,00	0,00%	7,81	0,29%

Table 15. Malá Úpa – Number land cover changes

The differences between the methods are in Malá Úpa the most evident. A bit more then half of the land cover in the area did not change. Almost the same part changed at least once, but twenty percent of it turned back to its original. The portion of land cover with three changes is negligible.

8. DISCUSSION

8.1. Methodology

One of the crucial factors affecting the results of the research is the selection of area of interest. The selection of areas from the same locality – the Krkonoše mountains, should have ensured similar conditions during the centuries, which was required in order to be comparable. On one hand, it turned out as a good approach, but on the other hand, it proved to be as a limitation in a certain way. Since all three areas are more or less within the territory of the Krkonoše Mountain National Park, their development from the foundation of national park in 1963 has been influenced by that. A research in areas from different mountains of the Czech Republic may have brought different results. Another criterion used for the selection was the existence of a ski resort with a certain history. Three settlements with different sizes of ski resort served well as sufficient source for the analyses but for more thorough research it would be preferable to add another settlement, where the tourism does not play such an important role. Nevertheless, the selection turned out as satisfying.

Using aerial images as a main source of data has, same as any other kind of source, its advantages and disadvantages. Aerial images provide unadjusted image of reality, which is a great advantage. On the other hand, the quality of old images is not as good as the new ones, which makes it very hard to distinguish some elements. Further, unlike the cadastral maps, aerial images do not provide the information about the land ownership, which can help with defining of individual elements. However, it provides much more detailed data than the satellite images, which are often used in land cover/use changes (Chaplin and Brabyn, 2013). The method of manual interpretation of aerial images is a time-consuming activity and demands full concentration of the author. Deviations, which can sometimes occur during the interpretation of aerial images by more authors, should not affect this research, since the entire work was carried out by one person in a relatively short time period. The division of land cover categories turned out mostly satisfying. However, the differentiation of forests, mountainpine scrubs and tundra seems slightly unnecessary and irrelevant for the purpose of the research. Moreover, Strand, Dramstad and Engan (2002) investigated the accuracy of aerial images

interpretation and came up with a statement that increasing number of land cover categories causes excessive errors.

Unlike Boori, Voženílek and Choudhary (2015) and Chaplin and Brabyn (2013), who all examined the impact of tourism on landscape with satellite images, the data acquired by interpretation of aerial images where used for further GIS analyses. The level of detail in acquired data used for topological overlay analysis enabled to discover, for example, whether the new building development took place in former grasslands or forests. The aim of the last GIS analysis was to find out, whether the landscape close to ski resorts underwent a bigger change than the rest. The outcome provides solid information about the spatial dynamics of landscape and the analysis partly confirmed the assumptions.

Even though the classification contains classes of roads and watercourses, their development seems to be negligible. That is caused by incongruity of aerial images as input data for their clear identification. Linear elements are often covered by woody vegetation and are impossible to be defined. Nevertheless, their analyses would bring another interesting information about tourism impact on landscape development, especially in case of roads. For their execution, it would be necessary to use historical maps.

8.2. Results

The results clearly proved that the settlements located near the ski resorts have been expanding since the ski industry occurred. Even though all three municipalities are within the Krkonoše Mountains National Park, the urbanized areas increased from 1953 to 2016 by more than 50%, and in Benecko actually by more than 100%. New construction has taken place mostly around existing buildings close to the ski facilities, but beyond that also arose houses scattered around the grassy enclaves. Similar trends were observed also by Boori, Voženílek and Choudhary (2015), who worked in the area of the Jeseníky Mountains, the Czech Republic.

Expansion of settlements does not always mean an increase in population. The results show that the number of permanent residents has been decreasing, especially in settlements with bigger ski resorts. It is caused most

likely by the seasonality of local livelihood possibilities. Similar results were achieved by Bucała (2014) who focused on landscape changes in the Gorce mountains, Poland. What is interesting is that different results were presented by Lasanta, Laguna and Vicente-Serrano (2007) who did deep demographical research in the Pyrenees. The outcomes show an increase in population in settlements affected by ski resort development, whilst the settlements further from ski resorts registered population decline.

The analyses further revealed general tendencies in of reforestation of former grasslands and increase of scattered vegetation, especially along linear elements in all three areas. This result fully coincide with the results of Bucała (2014) from Polish mountains. On the other hand, the results of Boori, Voženílek and Choudhary (2015) show that these tendencies do not occur in all sites of mountains on Czech and Polish border. It should be noted again that the research in the Jeseníky Mountains was carried out using different methods and input data, which could result in slightly different outcomes.

The outcomes of spatial dynamics analysis provided clear information about the distribution of land cover changes across the areas and well complemented the exact numbers from vector topological overlay analysis. The assumptions that the dynamics of landscape changes is increased within and in the surroundings of the ski resorts, were partly confirmed, especially in Rokytnice nad Jizerou and Malá Úpa.

9. CONCLUSION

Despite the fact, that the Krkonoše Mountains National Park in a certain way restricts the development of settlements located inside of the park, this study revealed, that the landscape and the settlements as well have gone through a considerable change during the last several decades. The results declare, that more than 33% of land cover in the entire area have changed at least once and more than 13% changed even more times. Moreover, the outcome data show a significant increase in urbanized areas between 1953 and 2016 on average by 80%. Individual results for each municipality proved that the size of the ski resort, thus its capacity, may affect the scope of development, but on the other hand it is certainly not the only factor.

The increase of urbanized areas is not the only tendency in landscape. The research further detected overall afforestation and growth of scattered vegetation outside the forests, which supports the ecological stability. In general, it seems that there is a certain balance between nature conservation and making use of economical potential.

This study provides some fundamental results which could be complemented by further researches. A comparison with a settlement located in another mountains of the Czech Republic, especially those which are not affected by landscape protection, would bring remarkable insight. Furthermore, a comparison with a mountain settlement, which has not been affected by tourism would be also useful. Regarding to practical approaches, an analysis of road network would show different intervention in the landscape. Finally, a comparison of land cover changes with digital terrain model would provide interesting results as well.

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