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Land Use Changes in the Czech Republic 1845–2010

Socio-Economic Driving Forces

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Ivan Bičík
Faculty of Science, Department of Social Geography and Regional Development
Charles University in Prague
Prague 2
Czech Republic

Lucie Kupková
Faculty of Science, Department of Applied Geoinformatics and Cartography
Charles University in Prague
Prague 2
Czech Republic

Leoš Jeleček
Faculty of Science, Department of Social Geography and Regional Development
Charles University in Prague
Prague 2
Czech Republic

Jan Kabrda
Faculty of Science, Department of Social Geography and Regional Development
Charles University in Prague
Prague 2
Czech Republic

Přemysl Štych
Faculty of Science, Department of Social Geography and Regional Development
Charles University in Prague
Prague 2
Czech Republic

Zbyněk Janoušek
Faculty of Science, Department of Social Geography and Regional Development
Charles University in Prague
Prague 2
Czech Republic

Jana Winklerová
Faculty of Science, Department of Social Geography and Regional Development
Charles University in Prague
Prague 2
Czech Republic

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Contents

Chapter 1
Introduction

Abstract This chapter defines the major aims of this book and presents its structure. The geographical approach towards land use/land cover is explained with special emphasis on social, economic, political, and other "driving forces" of landscape changes. The main focus is put on land use/land cover changes in the Czech Republic (Czechia). Land use patterns are primarily studied at the national and regional levels; in some cases, detailed research is carried out in selected model areas. Researchers utilize large amount of data that form the "LUCC Czechia Database 1845–2010". The whole book consists of two major parts. The first part is more theoretical and includes a number of concepts and approaches used in land use/land cover studies in the past and present. It also describes the structure of the database and the statistical methods used. The second part of this book presents the main research results—analysis of land use changes and their driving forces on the territory of Czechia between 1845 and 2010. The text is accompanied by a number of maps and cartograms. At the end of the first chapter, the authors of this book and their research history are presented—altogether six scholars contributed to this publication, headed by Prof. Ivan Bičík (*1943). The scientific team is based at the Faculty of Science, Charles University in Prague, where land use/land cover studies have a long tradition. Various international cooperations are mentioned, including that with the International Geographical Union Commission on Land Use and Land Cover Changes (IGU LUCC).

Keywords Land use · Land cover · Driving forces · Model areas · Research team

Geographers have traditionally studied various aspects of landscapes since early times. Landscapes are found "everywhere" (cover the whole Earth's surface), are well visible (provide enough information), and such a research usually includes a

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pleasant stay in a landscape. First of all, landscapes are the "playgrounds" where human–nature interactions take place and where natural and social processes can be studied in time and space. Various approaches towards landscape studies exist; historical land use research is one of them. Land use has been studied especially by social geographers who try to uncover social, economic, political, and other "driving forces" of landscape changes. The rather anthropogenic term "use" indicates that the socio-economic function of the landscape and purposes of use are at the centre of such research projects.

This publication focuses on land use in the Czech Republic (Czechia in short). As a landlocked country in Central Europe, situated in the transition zone between Western and Eastern civilizations, Czechia possesses an interesting combination of general and special "driving forces" that influenced land use patterns in the Modern Era. On the one hand, Czechia shows similar signs as other highly developed, densely populated European countries that have experienced early industrialization and modernization in the nineteenth century, emergence of consumer society and consequent environmental problems in the twentieth century, and globalization and recent political and economic integration (European Union). On the other hand, Czechia has been plagued by the effects of Communist dictatorship (1948–1989) that included economic downturn, destruction of political and social structures, and severe environmental damage. It is fascinating to observe how these factors—often contradictory ones—mutually reacted and influenced the landscapes.

1.1 Major Aims, Contents, and Structure of This Book

This publication examines land use changes in the Czech territory since the mid-nineteenth century till the present. Land use patterns have been studied at the national and regional levels as well as in selected small model areas. The authors aim to show how land use and its regional patterns have changed, what the major social, economic, political, institutional, and other "driving forces" were over different periods of time, and the consequences of such changes. Attention has also been devoted to which phenomena and processes were regionally specific, and which were rather general or similar as in other areas.

The basic premise of this research includes a steady increase in regional differences of land use structure over the time and emergence of large typological regions with rather homogeneous land use (functions). As a theoretical base we use the general theory of geographical systems (Hampl 2000, etc.) that mentions other socio-economic phenomena (settlement, economy) in a similar context. Hampl (2000) emphasizes that humans keep increasing the spatial scope of activities and the same is true when it comes to competition and selection. As a result, the spatial division of labour, specialization, regional differences, and spatial concentration increase. Thus, differentiation (in a general sense) moves towards a higher level of spatial order.

This book summarizes two decades of land use research and utilizes the giant amount of data collected that form the "LUCC Czechia Database 1845–2010". It is a follow-up to an earlier book written in Czech (Bičík et al. 2010). The concept of this book, however, is entirely new. Many relevant topics are discussed in a more detailed way; on the contrary, some other issues are omitted. It aims to attract foreign readership.

The text consists of two major parts. The first, shorter part is a sort of an introduction to land use studies. At the very beginning, the term "land use" is defined, including broader scientific and practical use. Past and present theories of land use, concepts, and approaches in Czechia and in the world are presented and discussed (Chap. 2). Concepts that are of special importance for our research are underlined. As we understand landscape as a result of nature–society interactions, a special interest is devoted to how land use patterns are influenced by natural conditions (Chap. 3) and society (Chap. 4). Theoretical outline of the general effects of natural and social factors on land use patterns is followed by explanations of how these effects materialize in Czechia. The aim is to show that spatial distribution of land use patterns has some basic general regularities. Later, the structure of our database is described as are the statistical methods used in various analyses.

The second, longer part of this book presents the main results of our research—analysis of land use changes, and their driving forces on the territory of the present-day Czechia between 1845 and 2010 (Chap. 6). Four Sects. (6.4–6.7) deal with changing land use patterns in periods that historically differ from each other (1845–1896, 1896–1948, 1948–1990, and 1990–2010) and form the core of this publication. The years 1845, 1896, 1948, 1990, and 2010 have been chosen with respect to data availability, but, by coincidence, also correspond to crucial events of the Czech modern history. 1845 marks the eve of capitalism; 1896 beginning of general intensification that also included agricultural intensification; 1948 Communist coup d'état; 1990 restoration of modern capitalism and democracy. Though our research is a geographical one, the facts are basically presented in chronological order to stress the importance of how "driving forces" were changing over the time.

Each of the Sects. 6.4–6.7 is divided into four parts: description of major "driving forces", changes in land use patterns at the national level, analyses of regional differences, and synthesis. A number of thematic maps (cartograms) are presented. Given the limited space, it has been decided to include only maps that show the spatial distribution of the most important land use classes: arable land, permanent grassland, forests, and built-up areas. Two maps showing basic natural and socio-economic phenomena in Czechia are inserted for the sake of better understanding. Section 6.1 includes the concise description of how Czech landscapes have changed since the Neolithic Era till the nineteenth century. Section 6.2 outlines the major "driving forces" of land use changes in the period 1845–2010. Sections 6.3 (6.8) analyse the land use patterns in 1845 (2010), and Sect. 6.9 presents the results.

The analysis of land use patterns on the national level is complemented by detailed comparisons (ca. 1840 vs. 2000) in four cadastral areas (Chap. 7). In this

way, we aim to show the regional differences of land use patterns, and also to underline the dramatic changes at the micro-regional level (size, arrangement of plots). Cadastral areas with diverse natural, social, and economic conditions have been selected: suburban zone near Prague, fertile plain, "inner periphery" (average natural conditions), and mountainous frontier.

The publication features many charts and tables, including explanations and interpretation of the quantitative data. Available publications, articles, etc., of other scholars (namely from the fields of economic and social history, agriculture, and environmental sciences) are widely referred to; consequently, there is a vast list of references at the end of each chapter. The main part of this publication (Chaps. 6 and 7) includes partial conclusions of the previous parts of the text and these are finally summarized at the end of this book (Chap. 8).

1.2 About the Authors and Their Research History

This publication presents long-term research of small scientific teams based since the mid-1990s at the Faculty of Science, Charles University in Prague. Bičík, head of the research team, has been studying land use since the mid-1980s; in that time, the first regional studies using extensive cadastral data (especially the so-called "stable cadastre") were carried out. These studies employed statistical data as well as maps from the mid-nineteenth century, scale 1:2,880—see Sect. 5.1. The interest in land use studies was inspired by major landscape changes, especially sharp decrease in arable land, that were taking place in Communist Czechoslovakia. For geographers, land use presented a difficult, yet exciting challenge: it is a kind of multifaceted research that examines the interaction of natural and socio-economic driving forces.

Six scholars contributed to this publication. First, chief aims and structure of this book were defined; later, chapters were distributed to the authors and texts prepared. In the end, all chapters were reviewed by other research team members and remarks/objections were taken into consideration. Thus, the presented text combines an active authors' approach with critical reviewing within the research team.

Prof. Ivan Bičík (*1943), head of the research team, has been working at the Department of Social Geography and Regional Development, Faculty of Science, Charles University in Prague since 1966. After 1989 Bičík served for 10 years as head of department. His research and lectures are focused on geography of agriculture and regional development of rural areas. Bičík has so far produced more than 100 articles and a number of textbooks on this subject (plus textbooks on regional geography); historical land use changes are among his main research interests. Since 1993, Bičík has repeatedly succeeded to get financial backing for land use research from the Czech Science Foundation (GAČR). This research includes, inter alia, extensive database of historical land use in Czechia, now available online at www.lucc.ic.cz. Since 1997, Bičík has been collaborating with the International Geographical Union Commission on Land Use and Land Cover

Changes (IGU LUCC); in 2006 he was elected Commission chair. Bičík organized a number of events focused on land use/cover change; since 2004, these include international LUCC conferences and workshops. He closely collaborates with IGU vice-president Prof. Yukio Himiyama on historical land use research in Europe and in the world; this collaboration produced a series of publications Land Use/Cover Changes in Selected Regions of the World (Volumes I–IX).

Prof. Leoš Jeleček (*1945) graduated in geography; his research and lectures focus mainly on historical geography, economic, and environmental history. He has produced a number of scientific works dealing with historic agricultural systems and rural areas before World War I. Jeleček worked in the Institute of History and Institute of Geography (Czechoslovak Academy of Sciences) in the past; at present, he is member of the Department of Social Geography and Regional Development, Faculty of Science, Charles University in Prague. In the period 2001–2009 he was member of the Board of European Society for Environmental History. In total, Jeleček has published tens of articles in scientific magazines.

Dr. Jan Kabrda (*1980) received his PhD in Geography from the Department of Social Geography and Regional Development, Faculty of Science, Charles University in Prague. He helped to create the LUCC Czechia Database 1845–2010 and used this opportunity to publish about eight scientific articles. Kabrda gives lectures on geography of agriculture, rural geography, land use/cover, and troubled regions of the world.

Dr. Lucie Kupková (*1971) graduated in environmental sciences at the Faculty of Science, Charles University in Prague. Her thesis focused on the use of land use data in environmental and ecological research. At present, she works at the Department of Applied Geoinformatics and Cartography. In her research, Kupková makes use of remote sensing data, especially image and laboratory spectroscopy to study land cover changes in protected areas (The Krkonoše Mts. National Park) and in metropolitan areas (suburbanization).

Dr. Přemysl Štych (*1974) got his PhD at the Faculty of Science, Charles University in Prague, and at present he serves as head of Department of Applied Geoinformatics and Cartography. His research mostly deals with detailed analyses of land use changes in model areas in various parts of Czechia. He investigated 3D modelling of abandoned landscapes and villages. Štych collaborates with NASA while assessing land use/cover projects in Central and Eastern Europe. Together with Bičík and Kupková he created tens of maps showing land use/cover changes in Czechia that appeared in the Landscape atlas of the Czech Republic, the Academic Atlas of Czech History, and in other atlases.

Dr. Zbyněk Janoušek (*1985) works on his PhD at the Department of Social Geography and Regional Development, Faculty of Science, Charles University. He received his master's degree at the above-mentioned department. His contribution to the graphics in this book was crucial.

Dr. Jana Winklerová (*1957) has done the lion's share of the hard job at the LUCC Czechia Database 1845–2010 which is widely used in this publication. Winklerová also secured the technical preparations and control of all chapters in this book.

A number of other scholars contributed to this book indirectly, for instance by having worked at earlier projects. Some also helped to create the original database and to interpret the results of long-term land use changes. Two of these deserve special credit: Prof. Zdeněk Lipský, landscape ecologist and chair of the Czech IALE, and Dr. Luděk Šefrna, pedologist. Both work at the Department of Physical Geography and Geoecology, Faculty of Science, Charles University in Prague. In the past, Lipský and Šefrna researched natural driving forces of landscape changes and their contribution to this book was considerable.

Land use research proved to be quite attractive to a number of students at the above-mentioned departments; many chose land use as the main subject of their theses. All of them should be credited, too, as they contribute to the very high level of land use/landscape studies at the Faculty of Science.

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LUCC Czechia Database: database of long-term land use changes in Czechia (1845–2010)

Chapter 2
Land Use Research

Abstract Basic terms, including "land use" and "land cover" are defined. Land use patterns are seen as a result of long-term interaction between humans and natural environment. Practical applications of land use research are discussed, namely with regard to land management and policy and land use planning. Later, the history of land use in the world is outlined. Four scientists that contributed most to land use research in the past are mentioned. First, Johann Heinrich von Thünen, who formulated the intensity theory and theory of crop zones. Second, Karl Marx, author of the term "differential ground rent". Third, British geographer L. D. Stamp who is considered founder of modern land use research. Last, but not least, the Polish geographer J. Kostrowicki who focused on typology and classification of agricultural systems in the second half of the twentieth century. Current approaches in land use research in the world are also discussed. Special attention is given to the DPSIR model that works with "drivers" and "pressures", "impacts" and "responses". The multi-level explanatory scheme, formulated by Scottish geographer A. Mather, is seen as the most complex concept used in land use research so far. Mather worked with proximate, intermediate, and underlying factors and he is also the author of the "forest transition" concept. In Czechia, the first research projects focused on land use were carried out in the early 1960s. At the moment there are two main research directions: analyses of small areas, and complex land use studies carried out by the so-called "Prague school". The latter studies often span a long period of time, starting in late eighteenth century. Old maps are utilized for comparisons; recently also remote sensing data have become available.

Keywords Human–nature interaction · History of land use · von Thünen · L. D. Stamp · Land use factors · DPSIR · Czech research

This research focuses on landscape and its use by humans. "Landscape" is understood as the result of long-term interaction between society and environment. There are several approaches to landscape studies; the difference between

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micro- and macrostructure of landscape (Lipský 2000) is seen as crucial. Landscape macrostructure is understood as the share of different land use types (arable land, forests, built-up land, etc.) on the selected area. On the other hand, landscape microstructure includes different landscape elements (for instance small areas, lines and other items) and its size, shape, spatial distribution, and mutual interaction. The social-geographical research in general examines mostly the landscape macrostructure—as does this publication.

2.1 Land Use or Land Cover?

Apart from "landscape", also the expressions "land use" and "land cover" are very frequent and can be easily confused. Thus, we feel that sound definitions are important.

FAO (2000) defines land cover as "the observed bio-physical cover on the Earth's surface". As such, land cover reflects the real (de facto) land cover, in other words what grows on the examined plot, what can be "seen". Land cover is usually examined by means of field mapping or remote sensing; the expression is traditionally used in natural sciences—landscape ecology or physical geography. The approach towards land cover research much depends on the purpose of study which influences classification, legend, scale, minimal size of the grid, etc. To a certain degree, land cover research can be subjective, depending for instance on research teams.

The term land use was first used by Stamp (1948)—see Sect. 2.3. It can be understood as a secondary concept as "land use" also includes the use of "land cover" by humans plus the social, economic, political or cultural "function" of land cover (Aspinall and Hill 2008). As a result, land use is seen either as a human activity as such (physical use of an area) or as an existing situation that reflects human activities in the landscape. FAO (1998) defines that land use "is characterized by the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it". Thus, this expression "establishes a direct link between land cover and the actions of people in their environment". Similarly, Lambin et al. (2006, p. 4) defines land use as "the purpose for which humans exploit land cover". Land use includes "both the manner in which biophysical attributes of the land are manipulated and the intent underlying that manipulation, i.e., the purpose for which the land is used".

Land use reflects the state of the landscape "*de iure*" and it is influenced by the attitude of owners and users, and also by the authorities. Thus, also land use research can be affected by the approach adopted by authorities and owners/users of respective area. Land use researchers usually rely on cartographic and statistical data that are typically used in social sciences, including social geography.

Our approach is closer to "land use" as we mostly use statistical data collected from cadastral registers. In these files, for instance, forest that would grow on a

plot labelled as “permanent grassland” is registered as “PG” until a formal change of land use is made by the authorities; the same, however, may apply vice versa. Since 1850, land owners have been obliged to report such a change to authorities no later than 1 year after it had occurred; in 1990 this deadline was extended to 2 years.

As an example, forest (land use type) often includes temporarily forest-free plots (clearings, roads, swamps, etc.). Paradoxically, forests within national parks that enjoy the highest degree of protection are sometimes formally part of the so called “other areas” (for details see Chap. 5).

The term “land use”, however, is also used in environmental sciences including social ecology (Fischer-Kowalski and Haberl 2007). This approach considers land use being part of “colonization of terrestrial ecosystems” by man. Sometimes, human dominance over ecosystems and human appropriation of photosynthesis products are discussed. Colonization of ecosystems can be explained as planned human intervention in ecosystems (landscape, nature) with the aim to make the system more suitable for use by people. Such a colonization can be analysed through social and economic activities that influence the ecosystems or through changes within the ecosystems that were caused by human interventions (Krausmann 2001).

Ecosystems tend to keep returning towards climax; consequently, humans must struggle to retain the “colonized state” by constant inputs of energy, material, and labour. This is close to the concept of “landscape stability”. Though definitions of landscape stability vary and some scholars even reject the concept as a whole, our approach defines it as a state that is inversely related to the amount of energy, material, and labour invested by the society so that the landscape would stay in balanced state (Lipský 2000).

2.2 Importance of Land Use Research, Practical Use

There are at least two reasons why land use research brings fruitful results. First—given the fact that land use patterns result from long-term interaction between humans and the natural environment, and use research provides information on changes in this interaction, being on the frontier between natural and social sciences. The word “provides” is appropriate here as land use is just a sort of a mirror that reflects human interventions in the environment. It is an important mirror, but it does not tell us much about the nature of the driving forces. As a result, these driving forces behind land use changes and their changing nature must be examined with equal interest.

Second—when it comes to comparison with most other scientific fields—land use research can make use of vast databases containing precise and well-structured data (sometimes even “data surplus” is mentioned!). Thus, outcomes of various land use research projects are highly accurate and provide precise analyses in terms of time, space, and territory.

Historically, the popularity of land use research has been influenced by increasing interest in environmental sciences after World War II, especially during the so-called "environmental decades" (1960s, 1970s). This growing interest has been driven by mounting global and local environmental problems (air and water pollution, soil contamination, deforestation, habitat loss, decrease of biodiversity, soil erosion, ozone depletion, climatic changes, etc.) as well as by changing attitudes in western societies (material well-being, post-materialism). Establishing of the Club of Rome (1968) or the Earth Summit Rio in 1992 which resulted in Agenda 21 can be named as important milestones. This growing interest in sustainable development contributed to more intensive environmental research and to emergence of a whole cluster of sciences that can be collectively called "sustainability science" (Aspinall and Hill 2008). It is a complex issue on the boundary between natural and social sciences that reflects the increasing importance of interdisciplinary approach since the 1990s.

Landscape includes a whole array of natural elements (soil, climate, habitats, biomass production, and natural cycles) as well as many social elements (agriculture, extraction of raw materials, built-up areas, infrastructure). As a result, land use research can form just a part of the above-mentioned "sustainability science": it offers links, interaction, and methodological contacts among social sciences (economics, history, sociology, social, economic, and historical geography), natural sciences (physical geography, biology, landscape ecology, and environmental science) and economic-technological sciences (agriculture, chemistry, mechanics).

The emerging "land-change science" (Lambin et al. 2006) contributes to studies of climatic changes and global carbon cycle ("carbon sink/sequestration—see Gingrich et al. 2007), to studies of biodiversity and its changes (Haberl et al. 2004). Data and findings resulting from land use research help to explore the "ecological footprint" (Lustigová and Kušková 2006), "socio-economical metabolism" (Krausmann et al. 2003; Fischer-Kowalski and Haberl 2007; Kušková et al. 2008; Grešlová-Kušková 2013), or "ecosystematic services" (Lorencová et al. 2013). Land-change science can also contribute to geobotanical research (Vojta 2007). There are strong links between research of land use changes on one side and environmental history, historical geography (Jeleček 1994, 2007; Worster 1979, 1986, 1990; McNeill 2001; McNeill and Winiwarter 2004) on the other side: these subjects have common interests in nature–society interactions and their driving forces. Growing importance of the above-mentioned scientific fields are reflected in the existence of the European Society for Environmental History (ESEH) founded in 1999 (Jeleček et al. 2003; Jeleček 1994).

The importance of land use research is underlined by a number of international research groups and panels. To name a few: IGU Commission on Land Use and Land Cover Changes that originated as IGU study group as early as 1997; Land Use and Land Cover Change Project, part of the International Geosphere-Biosphere Programme (IGBP) and International Human Dimension Programme (IHDP), followed by series of projects Earth System Science Partnership (ESS-P); Global Land Project (GLP), originated in 2001.

Practical applications of land use research can be found in two fields—both are related to "land management and policy" (Aspinall 2008, p. 3). This is explained in the world's first Encyclopedia of Land-Use and Land-Cover Change (Geist 2006).

First, there are a number of aspects related to "land use planning and environmental management and care" (Aspinall 2008, p. 11). This includes spatial and metropolitan planning, landscape planning, and prevention of natural hazards (for instance flood prevention which is especially important in Czechia—see Váňová and Langhammer 2011). Important part of landscape planning is also planning of environmental networks. In Czechia these are called "Spatial Systems of Environmental Stability" (ÚSES, see Buček and Lacina 1993) and form a network of environmentally important habitats and wildlife corridors. Special attention should be devoted to urban planning, too, including development of brownfields (Ilík and Ouředníček 2007) and greenbelts and greenways planning (Fábos 1985; Fábos and Ahern 1996). Spatial modelling and prediction of urban development are related to this as well (Koomen et al. 2007; Kolejka 1991).

Second, results of land use research find a number of practical applications in decision-making processes related to landscape and soil management. Aspinall (2008, pp. 10–11) argues the necessity "to explore impacts and consequences of particular policies (and alternatives) and to contribute to the development of strategies to adapt to and manage change and its impacts". In Czechia and in Europe as well a good deal of land use research focuses on agricultural policies—subsidies aimed at landscape maintenance, reforestation, increase of grasslands, and aid to farmers in less favoured areas (LFA) (Štych and Stránský 2005; Kabrda and Jančák 2007; Doucha 2001; Doucha and Divila 2005). Conditions for biomass production as renewable energy source are also being assessed (Haberl et al. 2003; Campbell et al. 2008). Also, various environmental policies use results of land use research—which include "traditional" conservation issues (Natura 2000, different types of other protected areas), too.

Land use research, however, should not be understood just as a data source in this context. The greatest contribution is the analysis and explanation of spatial patterns, factors, and relations with respect to practical use of given area. Land use research helps to reveal trends that change over time and the role of different driving forces. Thus, it can formulate realistic prognoses of future land use.

2.3 History of Land Use in the World

A number of noted scholars have studied land use over the past two centuries (Geist 2006). In the following text four scientists who contributed most to land use research are mentioned. They either created the base of modern land use mapping (Stamp, Kostrowicki) or analysed regularities of spatial patterns reflecting the use of land by humans and formulated theories that are still valid, with interdisciplinary consequences (von Thünen, Marx).

Von Thünen was a German economist and landowner, pioneer of spatial economy in economic geography. In 1826 he published "The Isolated State" (von Thünen 1990), book that included basic analysis of factors influencing spatial patterns of agricultural production (Grigg 1995). Von Thünen was influenced by classical liberal economists (including Smith 2001 and Ricardo 1973) and based his theory on simplified model of an ideal "isolated state". He used two key values: land rent (understood as profit from land seen as a factor and mean of production) and intensity of production (labour force needed per one hectare). Von Thünen argues that it is the geographical location of any piece of land that influences most the structure and intensity of agricultural production (and consequently also the local land use). In von Thünen's terms geographical location means distance from the market and transport costs.

In fact von Thünen formulated two theories—intensity theory and that of crop zones. The intensity theory which describes differences of production intensity of a given crop in an "isolated state" is, though less known, more general and of higher value nowadays. It stipulates that going from the "centre" towards "periphery", land rent decreases due to rising transport costs. Consequently, the production intensity of any given crop decreases, too. What really counts is the "limiting productivity" and dwindling profits (Grigg 1995)—farmers distant from the "centre" must pay higher transport costs and these are balanced by lower inputs (lower intensity).

Von Thünen's theory of crop zones is well known but it much reflects the conditions of early nineteenth century. In that time carts pulled by animals were used as the only means of transport of agricultural products—it was slow, costly, and limited to short distances. According to the theory of crop zones, the land rent which decreases from centre towards periphery influences also the structure of crops grown and animals bred. This fact results in a sort of concentric "rings" of agricultural activity, i.e. areas of different land use (see Fig. 2.1). The sequence of rings is linked to the intensity theory, especially when it comes to rings 3, 4, and 5:

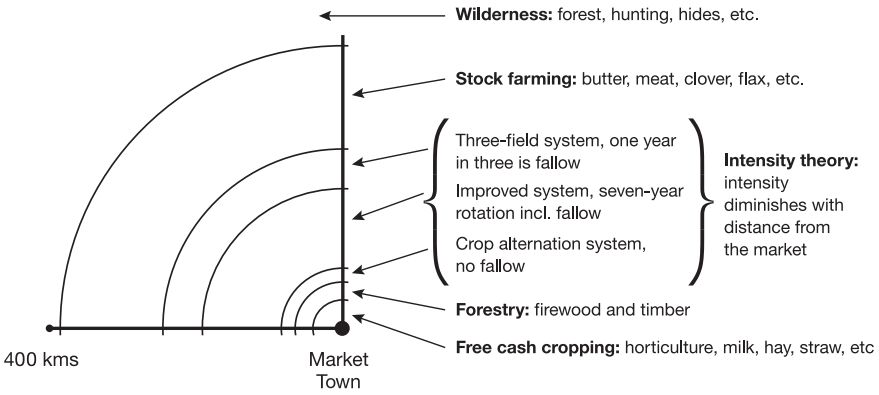

Fig. 2.1 Von Thünen's theory of crop zones—concentric rings of different land use. *Source* adapted according to Grigg (1995, p. 116)

the portions of fallow land rises, intensity diminishes (see Fig. 2.1). Von Thünen's rings also reflect the durability of products (milk, vegetables vs. cheese, wine) and value per kilo (hay, wood vs. wool, tobacco).

A critical approach should be adopted for von Thünen's theories nowadays, especially for crop zones. These theories reflect conditions in the early nineteenth century and show a number of imperfections typical for classical economic theories. However, it was one of the first attempts to explain spatial distribution of agriculture and von Thünen's ideas were applied also outside agricultural geography (see Peet 1970). The intensity theory is partly valid also at the present time. Geographical location, especially with respect to transportation network, does influence land use—as it will be shown later in this publication.

A number of economists studied land rent in the course of the nineteenth and twentieth centuries. It reflected the transition towards free market capitalism, towards "new modes of production" and "new ways of life/human existence". Marx coined the term "differential land rent" (DLR in further text) in his key work "Capital", namely in vol. III/2, Sect. 6 (Marx 1967). Jeleček studied the Marxist approach towards DLR with respect to land use changes in Czechia (Jeleček 1985, 2002; ibid, in Geist 2006).

Unlike Marx, von Thünen defines the differential rent "…as an index of natural scarcity whether of locations or differentially fertile lands, while in the Marxist account it is an expression of the monopoly power of capital as a whole." (Jeleček in Geist 2006, II, p. 356).

The term "differential land rent" equals "surplus profit". The effects of such a rent change over time as a result of economic, technological, and population changes and remain one of the key factors of changing land use patterns.

Marx argues that DLR is influenced by different natural and geographical conditions for agriculture; the rent has a profound spatial effect. Marx distinguishes between two types of differential land rent. DLR I has two parts and it is related to pieces of land that differs in two aspects: (a) in geographical position (distance from market), (b) in natural fertility of land. The geographical position allows producers to move from quality soils to less fertile ones (this was also agreed by Ricardo 1973) or vice versa: from low quality soil (in better location though) towards fertile soil in less favoured position. Thus, agricultural productivity can be improved in all cases.

"DLR II is viewed as a factor of agriculture intensification. It represents an extra profit that is created by unequal investments of capital into plots of land with the same natural fertility and/or geographical position DLR II of their soils. DLR II is related to more effective capital (e.g. by use of fertilizers, mechanization, breeding, etc.). Its affects fertile land as well as land in less fertile regions" (comp. Jeleček in Geist 2006). DLR II much enhanced the importance of geographical location as such. The railway boom at the end of the nineteenth century brought a number of local railways that secured the links between sugar beet production and sugar factories (in fertile regions) and among potato production, distilleries, and starch factories (in less fertile regions). DLR II formed the mutual links between agricultural production and the food industry. It became crucially important at

the end of the nineteenth century when more advanced technologies started to be used in agriculture after the long agrarian crisis in the 1880s (Jeleček 1985; ibid in Geist 2006, II, pp. 588–590).

DLR II is inevitably linked to use of more advanced agricultural technologies and to growing cooperation between farmers on one side and various industries (machinery, chemical industry) on the other side. In such a way, agricultural–industrial complex gradually came into existence. New, often expensive technologies included use of fertilizers, modern machines, and energy sources as well as drainage, irrigation, terraced fields, etc.

In free market economy the effects of ground (land) rent are beyond dispute. It is very different, however, in centrally-planned economies (under Communism—compare for instance the so-called "differential payments". Land use changes that have occurred since 1990 in Czechia, both at microregional and national levels, verified this hypothesis—a fact that we see as an important result of this research. The combined size of disused land has increased to 350,000 hectares between 1990 and 2005, which equals to 12 % of all arable land. DLR I and DLR II have been much influenced by the transformation of Czech agriculture since 1990, by increasing capital inputs and by fierce competition on the agricultural markets where farmers had to cope with imports of more subsidized products from EU countries (meat, milk, fruits) and other regions (Argentine beef).

The British geographer Stamp is considered the founder of modern land use research; he also established this term. Stamp organized "Land Utilisation Survey", i.e. land use mapping of British Isles. It was carried out in the 1930s with the idea of "a field-to-field survey of the whole country, covering every acre and recording its use" (Stamp 1948). Thousands of volunteers, first of all school children, did the mapping parish by parish. Scale of the maps was 1:10,560 and six basic land use types were distinguished: bog and heath, grassland, forests, arable land, gardens, and "non productive land" which included also built-up land, i.e. plots that were not subject to agricultural tax.

During World War II, these maps were used to identify soil suitable for food production. With a certain degree of exaggeration one can say that Stamp's Land Utilisation Survey helped to save Britain from famine. In the post-war period these maps were used for greenbelts planning—A vision of Britain through time (2014) and now are available online (http://visionofbritain.org.uk). Stamp later became adviser to the former British Ministry of Agriculture, received the Order of the British Empire, and held important posts within the International Geographical Union (IGU).

When compared with cadastral maps that had been compiled a hundred years earlier on the territory of Austro-Hungarian Empire (see Chap. 5), the British maps were less detailed, less accurate, and had a simpler structure. In spite of this Stamp's contribution is indisputable. In Great Britain, Land Utilisation Survey was the first systematic survey since the eleventh century when Domesday Book (survey of villages and domains containing individual houses and farms including holdings and values to determine taxes) had come to existence in England in 1086. On the world scale, Stamp was the first

geographer ever who focused on systematic mapping and scientific assessment of land use. Consequently, he is widely considered the founder of land use research.

Polish geographer Kostrowicki (Jerzy) successfully developed Stamp's ideas. Kostrowicki focused on typology and classification of agricultural systems in the second half of the twentieth century and published a number of scientific books containing detailed surveys and analyses of agricultural systems in the world. He also held high posts within the IGU.

Kostrowicki led a number of projects that carried out land use mapping in Poland and other Central European Countries between the 1950s and 1970s (Kostrowicki 1965)—for this reason he is especially important for Czech geography. It was mostly very detailed mapping in small areas (municipalities), typically at scales 1:10,000–1:25,000; the main focus was on agricultural land. Kostrowicki's maps do not show the use of land in one moment (year), but rather identify long-term land use of large homogeneous units. The map's symbology is a very detailed one showing among other things ownership, land fragmentation, crop rotation and—most important—also dominant crops (structured by several criteria) and its share on the arable land (Kostrowicki 1965). Kostrowicki's maps and analyses show in detail spatial patterns of agricultural production in the landscape and are unique at the world scale.

2.4 Current Approaches in Land Use Research in the World

Among the most frequent questions land use researchers presently ask are: What are the driving forces behind land use changes? What is more important, natural structure or human factors? Are natural conditions more important than the social ones or vice versa? What are the crucial factors of natural and social driving forces?

Seeking answers to the above-mentioned questions brings a number of benefits for land use research. It allows to formulate research schemes and relevant hypotheses and to choose an appropriate method which consequently helps to analyse, interpret, and explain research results. Most researchers, however, have not tried hard so far to find satisfactory answers. There is nothing like a widely shared paradigm in land use research and the same applies to major research methods—not to speak about the essence of examined phenomena.

Most researchers just state that land use changes are the result of nature–society interaction. The equation "land use = nature + society" is sometimes explained in a formalized version as a diagram containing boxes (sub-systems) and arrows (links). Such schemes can be helpful, but remain too vague and broad; Lambin argues that in the past it "provided theoretical guidance but were not theories per se. Rather, they tended to have a more ad hoc quality which recognized the

underlying complexity of the determinants of land cover/use change" (Lambin et al. 2006, p. 5). The same author (Lambin et al. 2006, p. 7) calls for a more elaborated, detailed, and complex theory of land use. Most scholars agree on that such a theory has not yet appeared. Land use studies have not been fully integrated into one complex system also due to the fact that land use is studied by scholars from at least three different broad scientific fields: natural, spatial, and social sciences. It is a highly interdisciplinary issue.

This publication does not aim at providing a full list of existing theories, concepts, and approaches that are used in land use research; more information on this can be found in comprehensive Encyclopedia of Land-Use and Land-Cover Change (Geist 2006), published in two volumes. Concepts we see as crucial plus those that influenced most our research will be discussed in further text. It should not be confused with real "theories"—we rather explain concepts and approaches that also may include theoretical ideas of land use changes as well as methodological frameworks suggesting appropriate research methods.

The DPSIR model belongs to such concepts—see EEA (1999), Feranec et al. (2001) and Bičík and Kupková (2007). It is a formalized analysis that allows to explain land use changes as part of a whole network of relations between humans and the environment (see Fig. 2.2). The DPSIR model is sometimes understood as a general logical framework that sets directions and modality of our analyses. It can also be viewed as a mathematical model allowing quantification of variables.

The DPSIR model works with "drivers" which means social and economical development (for instance high world prices of ethanol fuel caused by attempts to reduce the amount of energy generated from non-renewable resources). Drivers induce "pressures" on the environment (for example higher demand for sugar cane in Brazil). Pressures cause changes in the "state", i.e. in the existing environment, landscape, and land use structure (deforestation in the Amazon Basin). Land use changes have "impacts" on the society (higher crime rate, social differences, migration…) and especially on nature and habitats. These impacts can be both local (erosion, floods, biodiversity reduction, habitat loss) and global (climatic change, carbon cycle). Impacts lead to human "responses" (search for alternative energy sources, higher forest protection, emission control, etc.). Responses are in

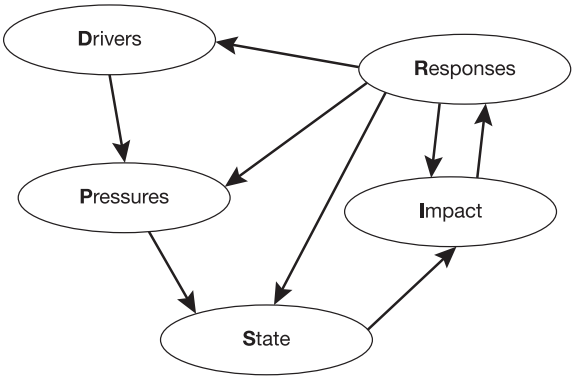

Fig. 2.2 DPSIR concept—scheme. *Source* Adopted by EEA (1999); explanations in text

fact a sort of a feedback—attempts to reduce negative aspects of human behaviour. Responses can be aimed at all preceding parts of the scheme, yet mostly at drivers.

EEA (1999, p. 7) argues that it makes sense "to focus on the *links* between DPSIR elements", as these links have effects on functioning of the model. As an example, relations between "drivers" and "pressures" are influenced by the technology used. Relations between "state" and "impact" depend on threshold values and absorbing capacity. Quantification of DPSIR model (in other words, definition of valuables and relations among them) can help to predict future changes according to the scenarios defined—it allows to test the behaviour of the model when selected parameters are changed. Though DPSIR shows a high practical potential, it should be considered that it is a *mathematical* model: as such, it reflects only variables that can be quantified, and relations that are known.

In our opinion, the "multi-level explanatory scheme" is the most complex concept used in land use research so far. It was formulated by Scottish geographer Mather (2002). The author attempted to generalize the causes of land use changes and to set the main concepts of land use research. Mather defines three key groups of factors that influence land use changes and regional patterns (see Fig. 2.3).

First, there are "proximate" factors, i.e. indicators/facts that can be quantified and that have a direct relation (statistical correlation) to land use—natural conditions or population changes, for example. Most researchers focus just on these factors. This is a fact criticized by Mather; he argues that identifying of these proximate factors is insufficient for explanation of land use changes. Mather (2002), p. 29 stipulates that proximate factors are "*contingent* and have *relative*, rather than *absolute*, effect". Directions and intensity of proximate factors change over time and depend on "intermediate" factors. These are economic and technological tools used by humans to alter the environment; Mather (2002, p. 29) calls

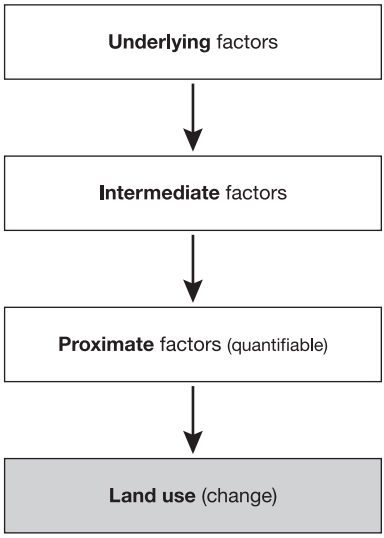

Fig. 2.3 Multi-level explanatory scheme according to Mather. *Source* Mather (2002); explanations in text

it "mode of production". Intermediate factors, however, are not fully stable either; their changes, according to Mather, are caused by changing "underlying" factors, i.e. by political, institutional, and cultural conditions.

Proximate factors are quantifiable and related to the smallest territorial units examined (plots, municipalities). On the contrary, intermediate and underlying factors have rather qualitative characters and are related to large areas (national, global levels). Mather underlines the importance of culture in broad sense, i.e. including the system of rules, habits, beliefs, ideology, ethic rules, interest in environmental issues, etc. Such a view is antagonistic to Marxist approaches that favour materialism and advocate the crucial importance of economic base.

According to Mather, any prediction of future land use changes must be preceded by a sound assessment of intermediate and underlying factors—a very difficult task. Prediction that would be based just on proximate factors is too simple and incomplete.

Mather used the multi-level explanatory scheme while examining changes within forested areas in Western Europe, especially in France. He is one of the key authors of the "forest transition" concept (Mather and Needle 1998). Mather's idea was that the forest cover in developed countries has followed the "U" curve—in a certain time, long-term decrease of forests was replaced by increase.

Decrease of forest cover (in terms of area) was typical for the Middle Ages and early modern history. It was caused by growing population (proximate factor) and rather primitive agricultural practices (intermediate factor) which required more and more agricultural land and led to deforestation. The whole process happened in non-democratic systems (underlying factor). This trend, however, changed in the nineteenth century and forests began to expand, though at the same time population was still growing. The influence of population growth as a proximate factor reversed due to changing nature of intermediate factors—more advanced agricultural practices (which made possible to cultivate less land) and decreasing demand for wood which was gradually replaced by other materials (iron, concrete, fossil fuels). Also, the underlying factors changed: Age of Enlightenment, democratization, conservation laws. As an example, forest management rules in Bohemia were in effect as early as in the mid-eighteenth century, and in 1852 a modern Forest. Act No. 252 was passed.

The forest transition concept brings a number of challenges. Is it a global model? According to Mather (2002), probably so—the main driver is progress, though the exact form and timing depends on local cultural and political contexts and it can be stimulated by crises (erosion, floods, devastation). And let us go further: if forest transition really was global as a product of the Modern Age, how is the model going to look like in the Post-Modern Era? While seeking answers to the above questions, the multi-level explanatory scheme seems to be an appropriate base.

Mather's approach to land use changes was later elaborated by other scholars like Lambin, Geist, and Aspinall. These researchers accept the idea of proximate and underlying factors though definitions differ slightly from that of Mather (Aspinall 2008). Lambin and Geist (2007) argue that factors influencing land use

changes should be sorted by time. On the one hand there are long-term factors that have gradual effects and determine natural qualities of respective regions. These include biophysical factors (climate, topography, biota) and social and economic factors (economic conditions, political system). On the other hand there are also factors that function as "trigger events". In Mather's concept these are crises that influence the timing of crucial processes. Some trigger events are of biophysical nature (droughts, tropical cyclones), other have socio-economic roots (wars, economic crises).

Lambin and Geist underline the importance of "agents". These "constantly make trade-offs between different land-use opportunities and the constraints imposed by a variety of external factors". Consequently, in order to identify causes of land use changes it is crucial to understand "how people make land-use decisions (decision-making processes) and how specific environmental and social factors interact to influence these decisions (decision-making context)". In this sense the activity of "agents" equals to local proximate factors; on the other hand, underlying factors reflect more the broader context and structure. This approach brings land use research close to the "structuration theory" proposed by Giddens (1984) and "method in social science" by Sayer (1984).

The ideas of Giddens and Sayer were elaborated by Lambin and Geist (2007), who argue that "despite the diversity of causes of land-use change, there are some generalizable patterns". Though mechanisms and factors driving land use changes show an extreme complexity, there are a few processes that keep repeating. Understanding these processes "may confer some predictive power by analogy with similar pathways in comparable regional and historical contexts" (ibid.).

The above-mentioned examples suggest that though no kind of a compact theory of land use changes exists so far, some basic ideas are gradually being generally accepted. Here are a few examples of such widely shared concepts: (a) land use patterns result from long-term interactions between nature and society, with important feedbacks; (b) landscape has a sort of a "memory", current land use is influenced by present and past processes; (c) "mode of production", i.e. economic and technological driving forces are important (Bürgi et al. 2004); (d) factors influencing land use patterns can be divided into two groups: proximate factors (on local level) and underlying factors (at national and global levels). The fact that Mather, Lambin, Geist, Aspinall, and other scholars reached a consensus of opinion on basic issues forms a sound basis for a potential "big" future theory of land use (Aspinall 2008). Publications of the above mentioned researchers were an important source of inspiration also for the findings presented in this book.

2.5 Land Use Research in Czechia: Past and Present

The first research works dealing with land use and changes of landscape structure on the Czech territory appeared after World War II. Regarding theory and methods, Czech authors elaborated the ideas of Stamp (1948) and especially that of

Kostrowicki (1965). The first Czech studies focused on land use were conducted by Häufler (1955, 1960) and Brinke (1975). The Häufler's publication dealing with land use of mountainous areas in Czechoslovakia was an important one as it constituted the first geographical analyses of Czech borderland after the post-war transfer of Czechoslovak Germans to Germany and Austria. Historical approach to land use was adopted by Pokorný (1959).

Czech researchers have been examining land use patterns in middle-sized regions since the 1970s. The concept of detailed land use analysis (by cadastral units) was created by Bičík and later tested in North West Bohemia (Bičík 1998; Bičík and Štěpánek 1994). Analysis of land use changes in the second part of the nineteenth century in ca. 200 so-called judicial districts was carried out by Jeleček, with respect to the final phase of "agricultural revolution" (Jeleček 1985, 1995, 2002). Vondruška (1984) studied the influence of natural conditions on agriculture and also land use patterns in agricultural landscape in the early nineteenth century. Černý (1988) devoted his attention to why mediaeval villages ceased to exist in less favoured areas of Central Moravia.

In the world context, the maps (scales 1:1,000,000–1:5,000,000) that became part of the World Atlas of Agriculture (1969) were very important for land use studies. Later, similar maps became part of national atlases (scales 1:400,000–1:1,000,000). In accordance with this trend also the Czechoslovak National Atlas (Atlas ČSSR 1966) included land use map of Czechoslovakia (scale 1:1,000,000), which was also published separately in 1967 (scale 1:500,000). These maps brought at least a general picture of land use patterns of that time. The progress of remote sensing in the 1980s opened new horizons in land use studies; digital maps of large areas became commonly used and all this brought fundamentally new qualities and also new challenges. Land use maps became part of Czechoslovak (Czech) national atlases also under new political conditions after 1989. The Atlas of the Environment and Health of the Population of the ČSFR (1992) and especially the Landscape Atlas of the Czech Republic (Hrnčiarová et al. 2009) are important examples; the authors of this book contributed to the latter. The maps of land use/cover change, carried out by Bičík and his team and forming part of the Academic Atlas of Czech History (Semotanová et al. 2014), are the latest examples.

Basic research of land use fully developed in Czechoslovakia (Czech Republic) only after 1989. There are two main research directions at the moment (Kolejka 2002): analyses of small areas, and the so-called "Prague school".

Analyses of small regions (consisting of one or more cadastral areas) focus on the role of local factors on land use changes (Kolejka 2002, p. 150). Land use types are usually related to natural landscape types. Interdisciplinary approach is essential as is the accent on historical geography and environmental history. Detailed maps related to different years are mostly used, as well as the outcomes of field land use research. This combination allows comparison of land use changes over time which is necessary for future predictions.

The utilization of geographic information systems (GIS) since the 1990s has enabled old maps to be more widely excerpted. Digitized historical maps of old

manors, lakes, villages, and pieces of landscape became an important source of knowledge as regards historical land use. Now it is possible to trace landscape changes over the past three centuries, i.e. including the pre-industrial period. Such old maps (ca. between the early eighteenth and mid-nineteenth century), however, are often rather simple and not fully accurate. This also applies to the maps (scale 1:28,800) that resulted from the 1st Military Survey carried out under Emperor Joseph II between 1785 and 1789 (for more information see Chap. 5). The 2nd Military Survey, started under Emperor Francis II was much more accurate and is compatible with modern maps. The 2nd Military Survey had begun in Lower Austria in 1817 and was finalized in Tyrol in 1861. Maps of the Second Military Survey were derived from the so-called "stable cadastre", i.e. from very precise map of scale 1:2,880 that were compiled in Bohemia (1826–1843) and Moravia and Silesia (1824–1836). (For the location of historical lands of Czechia see Fig. 4.1). These maps constitute a priceless source of information for researchers studying long-term land use changes and are directly linked to more recent cadastral maps up to present—only the scale (now 1:2,000) has changed since (Mašek 1948; Kain and Baigent 1992; Bumba 2007; Jeleček 2006).

In land use research, maps from the 1st Military Survey were first used in the North Bohemian Coal Basin by Brůna (in Beneš et al. 1993). Copies of all maps from the first and second Military Survey, covering the whole Czech territory, were bought from Austria by the Ministry of Environment of the Czech Republic in 2001. Currently these copies are deposited in the Laboratory of Geoinformatics, University J.E. Purkyně, Ústí nad Labem—1. a 2. vojenské mapování (2014), and can be accessed online (http://oldmaps.geolab.cz/). The Laboratory has published guidelines for use of these maps in land use and landscape research (Uhlířová 2002; Brůna et al. 2003).

This publication presents research results of the so-called Prague school, group of researchers headed by Bičík at the Faculty of Science, Charles University, Prague. The main focus has always been on long-term land use changes in Czechia, often including statistical methods. The research team was established in the mid-1990s; apart from Bičík, also Jeleček, Štěpánek, and Lipský were among the founding members. Over time, more and more young researchers became team members and the use of GIS technologies grew. Social geographers, however, are still the key team members—consequently, the research keeps focusing on social driving forces of land use changes. Among collaborators there are physical geographers, environmentalists, and cartographers, too, which makes the research a truly interdisciplinary one.

Bičík with his team focuses mostly on the changing nature of Czech landscape in the course of the past two centuries, i.e. in the age of modernization and technological advance. Crucial is the search for "driving forces" of land use changes, including social, economic, political, institutional, cultural, and other factors (Bürgi et al. 2004). Rather than just detailed analyses of individual components (natural, social), complex, systematic approaches towards human–nature interaction (Hampl 2000) are preferred.

Bičík and his research team created "Database of long-term land use changes in Czechia (1845–2010)" which is based on statistical data concerning land use

structure in all 13,000 cadastral areas in Czechia. Thus, the extraordinary historical records of land ownership and use of plots that have been founded in Cisleithania already in 1817 (Jeleček 2006; see Chap. 5) are being utilized and complemented. In Transleithania (eastern part of Austro-Hungarian Monarchy) all mapping was carried out much later. The Slovenian research team, headed by Gabrovec, uses the same source of data for land use research in Slovenia (Gabrovec and Kladnik 1997; Gabrovec et al. 2001).

Bičík and his research team have published a number of scientific publications since the early 1990s. These mostly focus on analyses and interpretation of the above-mentioned data, at the national and regional levels (regions, protected areas, metropolitan regions, etc.). Let us cite at least a few of the many articles and chapters: Bičík (1995, 1998); Bičík and Jeleček (2005, 2009); Bičík and Kupková (2007); Bičík et al. (2001, 2002, 2010a); Jeleček (1995, 2002); Kabrda (2004, 2008); Kupková (2001); Kupková et al. (2013); Mareš and Štych (2005); Mareš et al. (2013). Of special importance is publication summarizing the existing research results (Bičík et al. 2010b). The research team also contributes to the series of atlases "Land Use/Cover Changes in Selected Regions in the World", published by the IGU-LUCC Commission: Volume I (Himiyama et al. 2001), Volume V (Bičík et al. 2010c). Two of these atlases are dedicated solely to Czechia (Volume VII, IX in Bičík et al. 2012, 2014).

The data used, however, lack territorial details and the explanatory value diminishes (see Chap. 5 and Sect. 6.7). To overcome this problem and to verify and complement research results, Bičík and his team also carry out detailed analyses of small areas (cadastral units). In this way, maps from different years and compared with each other and with satellite images; field mapping are also used (Kupková 2001; Mareš and Štych 2005; Bičík et al. 2012). In most cases these detailed analyses compare maps from early nineteenth century (cadastral maps), mid-twentieth century (ortophoto), and present (field mapping). Such analyses, however, are time-consuming and cover just small areas.

Recently, remote sensing data became available. The European Land Cover Database CORINE (http://www.eea.europa.eu/data-and-maps, see Chap. 5) is an ideal data source—CORINE Land cover (2014). It was created by interpretation of Landsat images; at the moment, data from 1990, 2000, and 2006 are available. CORINE data are being used by Slovak research team headed by J. Feranec (Feranec et al. 2001, 2007). CORINE data cover whole Europe, but the grid is not much detailed (square equals 5 or 25 ha) and the land cover classification is complicated with a number of heterogeneous classes. Moreover, CORINE data (that show land cover) are not easily comparable with cadastral data (that show land use; see Sect. 2.1), and are available for a rather short period of time—last two or three decades.

As a result, land use research in Czechia faces an important challenge: in the future it seems necessary to elaborate a new methodological concept that would enable to combine at least three different data sources, taking into account different size of regions and different years. These data sources include statistical land use data from cadastral sources (since 1845), detailed land use/cover maps from

small regions, and remote sensing data (ideally Europe-wide CORINE data plus data collected by LANDSAT, Spot, and other satellites).

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Chapter 3
Influence of Natural Conditions on Land Use

Abstract This chapter deals with the influence of natural conditions on land use patterns. It also examines the human impacts on land use. Basic overview of natural conditions in Czechia is outlined with special regard to geology, climate and soils. Geological conditions are seen as the key factors that form landscapes and influence the diversity of soils. Climate, of course, also has profound influence on regional farming patterns; very warm (VW) and warm climatic regions are best suitable for agriculture. The biggest part of the Czech territory is covered by moderately heavy soils. Soil types are crucial for the spatial distribution of forests, arable lands, and permanent grasslands. Climatic zones and soil types are shown in maps. Regional patterns of Czech agriculture are discussed and the so-called less-favoured areas (LFA; important for allocation of EU subsidies) are explained. The history of human impacts on land use patterns over the past two centuries (covered by this research) has three phases. First, important changes in agriculture were taking place (changing balance between extensive and intensive farming). Second, forests began to shrink as more agricultural land was needed; with the advance of intensive farming, however, this process was reversed ("forest transition"). Third, new technologies and pressures exerted by the modern society brought a significant rise of built-up land and "other" areas. The ways how recent trends influenced the natural environment are explained. Changing political climate, especially the collapse of Communism and reintroduction of market conditions, has had profound effects on land use. The same applies to mining that caused large-scale devastation in some areas. Conservation programmes that accelerated after 1990 are seen as a "return to nature".

Keywords Natural conditions · Geology · Climate · Soils · Human impacts on land use · Ecological balance

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3.1 Natural Conditions as Limits to Agricultural Land Use

Hampl (2000) argues that there are three phases of nature–society interaction depending on how developed the society is: dependence, competition, and cooperation. Humans, first of all, try to adapt to the natural conditions during the first phase and also exploit the nature. In the second phase, the society is developed enough to be able to transform the natural environment to a greater extent. The last phase (cooperation) applies to selected areas in rich countries only. It should be based on a harmony between nature and society and includes institutional environmental protection plus reclamation schemes.

Location of Czechia (landlocked state on the main European watershed) has a great influence on natural conditions (for overview of natural conditions in Czechia see Physical map in Fig. 3.1). Korčák (in: Häufler et al. 1960) draws attention to the fact that the confluence of Vltava (Moldau) and Berounka in Prague is equally distant from the Baltic and Adriatic Sea and thus supports the thesis that Bohemia is in the centre of Europe. Some 98 % of the Czech territory is drained by three rivers: Labe (Elbe), Morava, and Odra (Oder) (see Fig. 3.1). Each of these rivers, however, empty to a different sea. Prevailing winds blow from North West and bring enough precipitation (500–750 mm per year in most cases) to balance the evaporation. The altitude ranges from 1603 m a.s.l. (Sněžka) down to 115 m a.s.l. (Hřensko). Height above sea level influences temperatures and precipitation and consequently also conditions for farming.

Terrain and climate have had profound effects on natural land cover; until centuries ago, mixed forest prevailed. Lipský (1994) specifies that forests covered some 80 % of Czechia at the turn of first and second millennium A.D. In that time, exploitation of nature by humans was limited to hunting, fishing, and gathering, plus there were patches of fields created by early farmers.

Until the tenth century, Slavic tribes have practised the so-called bush fallow system (*příloh* in Czech); the more advanced grass fallow system (three-field rotation) was introduced only at the turn of twelfth and thirteenth centuries. In the Middle Ages, forests were being gradually cleared and transformed to arable land and pastures. This process, however, was not a continuous one as due to numerous wars and epidemics the size of agricultural land fluctuated widely (Lipský 2000). The population increase, though a modest one, should be seen as the main driving force behind the transformation of most natural areas into cultural landscape. Subsistence farming was practised on more than 60 % of the territory (agricultural land) in the early nineteenth century. Moreover, at least one third of all forests were utilized by humans for logging, collection of wood for heating, gathering, etc.

3.2 Basic Overview of Natural Conditions in Czechia

Geology plays the key role in forming landscapes and influences the diversity of soils. On the Czech territory, much of the bedrock consists of Palaeozoic rocks, especially granite and gneiss. These rocks were overlain by varying sequences of

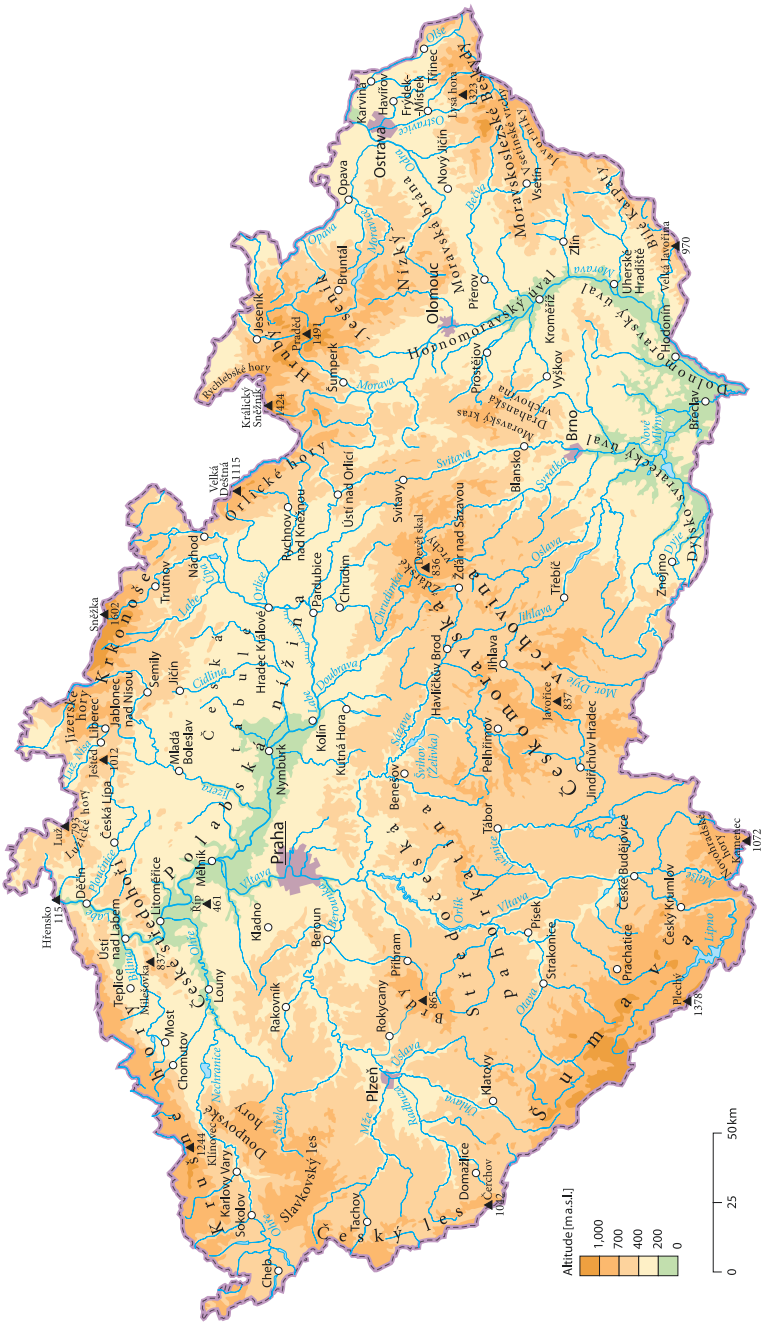

Fig. 3.1 Physical map of Czechia. *Source* Authors

Table 3.1 Proportion of arable and agricultural land by inclination of slopes (%)

	Inclination of slopes				
	0–3° flat terrain	3–7° gentle slope	7–12° middle-graded slope	12–17° steep slope	17–25° very steep slope
Agricultural land	44	41	11	3	1
Arable land	45	44	10	1	0

Source ČSÚ (1996)

marine sediments in the Mesozoic era. During the Alpine Orogeny, which also formed the Carpathians, these were significantly deformed and uplifted, especially on the margins of Bohemian Massif. The Carpathians cover the easternmost part of Czechia (Eastern Moravia) near the Slovakian border and show more varied landscapes than the Bohemian Massif (for the location see Figs. 3.1 and 4.3).

The Mesosoic sediments have been heavily eroded since the Tertiary uplift. Nowadays, their remnants have the form of isolated "islands", so-called rocky towns (picturesque sandstone formations). Rocks of varying composition and age formed the current terrain and, together with climatic conditions, influenced the composition of soils (Král in: Häufler et al. 1960). Geology also has important effects on the degree of sloping. Bičík and Jančák (2005) and also Voltr et al. (2011) argue that the inclination of slopes affects the farming methods significantly: the use of machinery is limited or even impossible on too steep slopes (Table 3.1). Most authors agree that farming is viable only on slopes up to 12–20° of gradient. In other words, geology influences the character of agriculture including the production costs. In the past, even very steep slopes were cultivated using animals and manual work.

Climate is the key factor when it comes to regional patterns of farming with regard to structure, intensity, total output, and land use. Detailed climatic studies have been published a number of times by climatologists, geographers, and agronomists (Král in: Häufler et al. 1960; Quitt 1971; Jůva et al. 1975; Hrnčiarová et al. 2009; Tolasz 2007, etc.). A comprehensive information on climate including maps (scales 1:500,000 and 1:1 mil.) and methods can be found in the Landscape Atlas of the Czech Republic (Hrnčiarová et al. 2009).

Climatic classification by Quitt (1971) is used in this publication. Quitt defines five basic climatic regions on the Czech territory: very warm (VW), warm (W, with three subregions), moderately warm (MW, with four subregions), moderately cold (MC), and cold (C). It is the climate (and also geology) that has profound effects on soils and consequently also on the spatial distribution of forests and fields, including the way of cultivation (Fig. 3.2).

The areas best suitable for farming are located in VW, W, and MW climatic regions. These areas produce most crops and also include the major economic and population centres—an important fact in a densely populated country.

Population numbers and economic performance still keep increasing in the VW and warm climatic regions with strong influences on land use patterns. As farmers

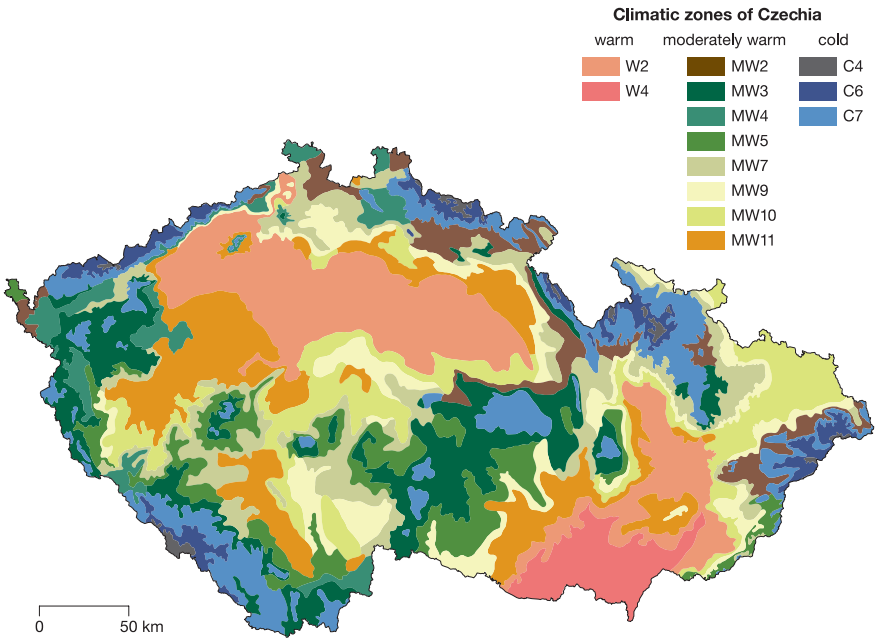

Fig. 3.2 Climatic zones of Czechia. *Source* Quitt (1971)

Table 3.2 Proportion of agricultural and arable land by Czech climatic regions

	Climatic region										
	VW	W1	W2	W3	MW1	MW2	MW3	MW4	MC	C	Total
Agricultural land	5	5	6	14	5	21	4	26	11	3	100
Arable land	6	6	6	16	6	21	4	25	9	1	100
Proportion of arable land on agricultural land	96	92	90	92	88	82	80	75	65	40	

Source ČSÚ (1996)

tend to abandon poor soils, the VW and warm regions with fertile soils account for an increasing share of agricultural production. Thus, the fact that more and more quality farmland is being developed should be seen as a threat for future self-sufficiency in food production. This problem occurs especially in the close vicinity of cities and towns where new suburban settlements, warehouses and commercial centres mushroom on former farmland (Bičík et al. 2012; Spilková and Šefrna 2010; Ouředníček 2007, etc.).

MC and cold (C) climatic regions are less favourable for farming (Table 3.2) and usually suffer from long-term depopulation.

Three basic soil classes are recognized in Czechia: light soils (9 % of agricultural land), moderately heavy soils (83 %), and heavy soils—clays (8 %). Such distribution is favourable for farming (Häufler et al. 1960, p. 197; Hrnčiarová et al. 2009).

Table 3.3 Soil types in Czechia

Soil type	KA	KAd	PG	CE	LU	HN	KP	FL	PZ	PR	PE	O
Proportion of total area (%)	42.19	12.83	8.73	7.77	6.64	6.46	3.72	3.15	2.40	1.53	1.30	3.28

Explanations KA—cambisol, KAd—dystric cambisol, PG—stagnosol, CE—chernozem, LU—luvisol, HN—brown earth, KP—entic podzols, FL—fluvisol, PZ—podzol, PR—haplic leptosol, PE—haplic cambisol, O—other soil types
Sources Own calculations; Půdní mapa Česka 1:500,000, Sedláček et al. 2009; Šefrna in: Bičík et al. 2010)

Light soils are mostly found in the Elbe Plain in Central-Eastern Bohemia and along the lower course of Morava. These soils are prone to erosion, can easily dry up, and usually are not really suitable for farming. Such areas are often covered by pines, oaks, and black locusts (Šefrna in: Bičík et al. 2010). Heavy soils are usually found on tertiary sediments in the Northern Bohemian Basin and also on Permian-Carboniferous sediments (environs of Rakovník, Český Brod, Trutnov, etc.; for the cities location see Fig. 4.3) (Häufler et al. 1960, p. 197; Hrnčiarová et al. 2009). Heavy soils are difficult to cultivate and do not absorb water easily. Most Czech agricultural regions are covered by moderately heavy soils that are best for cultivation.

Soil types are more complex. Cambisol is the most widespread soil, covering 55 % of agricultural land in Czechia (see Table 3.3) and found mostly in hilly regions with sloping grounds (Šefrna in: Bičík et al. 2010, p. 57).

The structure of soil types has been undergoing gradual transformation recently. Especially, the most fertile soils, usually found in the plains, are under a strong pressure from developers. Though these quality soils enjoy legal protection and developing such areas requires special payments, the total area of fertile soils is shrinking.

Territorial patterns of soil types are rather scattered due to varying climate and landscape types. It is common that a number of different soil types are found within just one small cadastral area. Figure 3.3 shows STUs where the proportion of one soil type on agricultural land was more than 75 % or 50–75 %. Only the most important soil types are taken into consideration. Great many white spaces on the map reflect the very complex patterns of soil types in general plus the fact that apart from the soil types selected there are many more types. The average STU area is just 700 ha; even in such small units it is often impossible to define a single soil type that would account for more than one half of the agricultural land.

Soil types are crucial for the spatial distribution of forests, arable land, and permanent grassland. The soils best for farming are mostly found in South East Moravia and to a certain extent also in the Elbe Plain (Polabská nížina; see Fig. 3.1); forests cover only a very small portion of these areas. On the contrary, the least fertile soils (acidic soils) are covered by forests by more than 80 %. Šefrna (in: Bičík et al. 2010, p. 58) claims that "…The potential fertility of soils, including soil texture and inclination of slopes, is crucial for the way how landscape is used by humans—either for farming or forestry."

A very detailed soil mapping (scale 1:5000) was carried out in former Czechoslovakia during 1960s and 1970s. It included soil quality, slope orientation, climatic data and enabled to create the network of so-called soil-ecological units (BPEJ in Czech) (Jůva et al. 1975). Thanks to this network, potential conditions

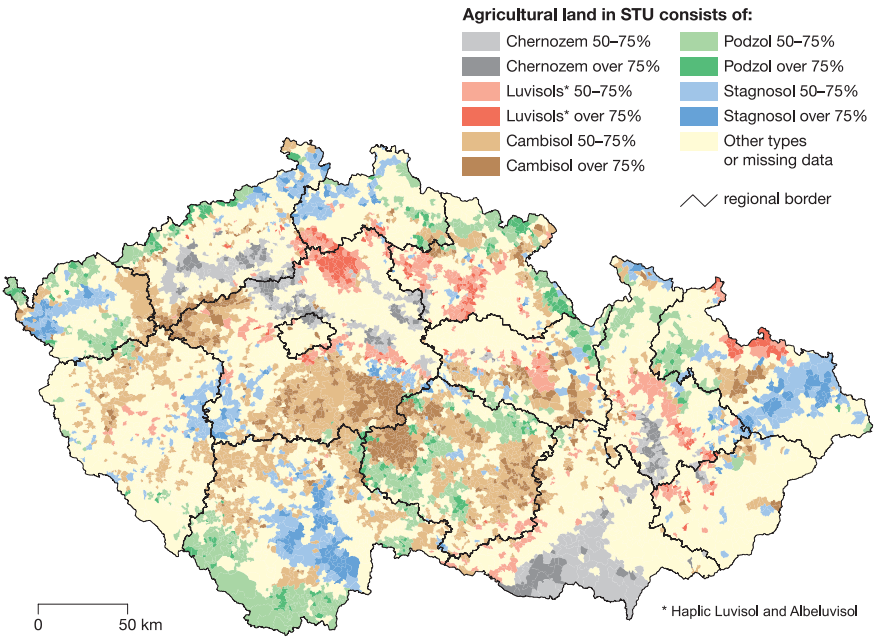

Fig. 3.3 Selected soil types in Czechia by stable territorial units (STU). *Source* Kabrda et al. (2006)

for agriculture can be attributed to any plot, cadastral unit, or larger area. The network has been updated in 2013; at the moment, there are 2278 soil-ecological units in Czechia. Each of them is identified by a five digit code (climatic region, main soil unit, inclination of slopes and slope orientation, soil texture, and depth of soil). Based on soil-ecological units average official price of soil for each cadastral unit has been calculated (see Fig. 3.4). However, real market price differs.

General geographical and ecological rules that influence the utilization of landscape (with regard to natural conditions) were published by Lipský and Brabec (2007) and further developed by Lipský (in: Bičík et al. 2010, p. 52–53). It is emphasized that "… the form in which humans utilize the landscape is influenced by all physico-geographical components; the effects of each component vary spatially. Certain modes of landscape utilization are fundamentally conditioned (and limited) by the character of natural environment."

3.3 Typology and Regional Patterns of Czech Agriculture

In the interwar period, the networks of "agricultural production areas" and "natural agricultural areas" were compiled by Novák et al. (1925). Spatial patterns of natural conditions with regard to agricultural production have been repeatedly analyzed in Czechia for the sake of tax assessment. Under the Communist regime, agricultural businesses were subject to different taxes or eligible for different subsidies (see

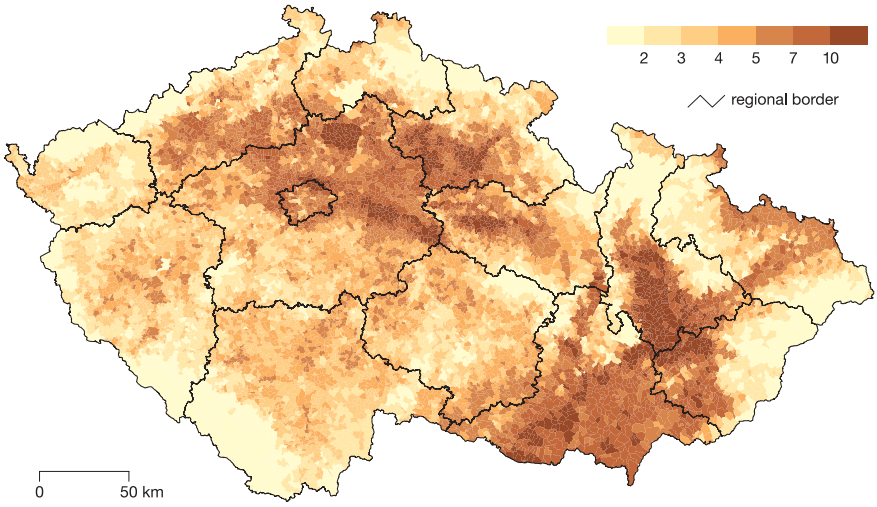

Fig. 3.4 Official price of agricultural land (CZK/m^2, 1996; by cadastral units). *Sources* Vyhláška č. (412/2008) Sb., ve znění pozdějších předpisů; LUCC Czechia Database (1845–2010)

Sect. 6.6, Table 6.12). A number of scholars have produced regional divisions of Czechia based on natural conditions (Novák et al. 1925; Jůva et al. 1975; Jančák and Götz 1997; Bičík and Jančák 2005; Voltr et al. 2011).

An extensive analysis which aimed to create a system of agricultural production types and subtypes has been carried out after World War II (Hamerník et al. 1960).

After the political changes of 1989, new agricultural production regions (APR) and subregions were created (Němec 2001)—see Fig. 3.5. The following APR were defined: APR corn (C); corn-sugar beet-potato type (6.7 % of agricultural land); APR sugar beet (SB); sugar beet-grain type (24.3 %); APR grain (G); grain-fodder type (40.5 %); APR potato (P); potato-grain type (18.5 %); APR forage (F); forage type with animal husbandry (10 %).

The regional patterns of land use/cover in Czechia are also influenced by the so-called less-favoured areas (LFA). These have been important for allocation of EU subsidies—before and after the accession to the EU—as LFA should primarily serve as a tool to assist regions with less advantageous conditions for farming. First, population stability and maintenance of cultural landscape are among the chief targets. Second, many LFAs are located in regions protected by law (national parks etc.—see Fig. 6.37) where cultivation and farming in general is either restricted or impossible. As natural conditions vary to a great extent in Czechia, the network of LFAs is a complicated one. In total, LFAs cover about one half of the national territory. The eligibility is specified in Governmental Order No. 75/2007 (Mareš and Štych 2005; Voltr et al. 2011).

The LFA scheme (see Fig. 6.29) is fundamental for retaining the agricultural functions in such regions. It also constitutes a big change as during 1990s schemes aimed at assisting farmers were rare. As a result, the agricultural transformation in the last decade of the twentieth century was chiefly influenced by natural conditions. Since 2013, farmers and cooperatives in Czechia are eligible for subsidies comparable with those in EU-15. This fact and also the changing character of EU Common Agricultural Policy

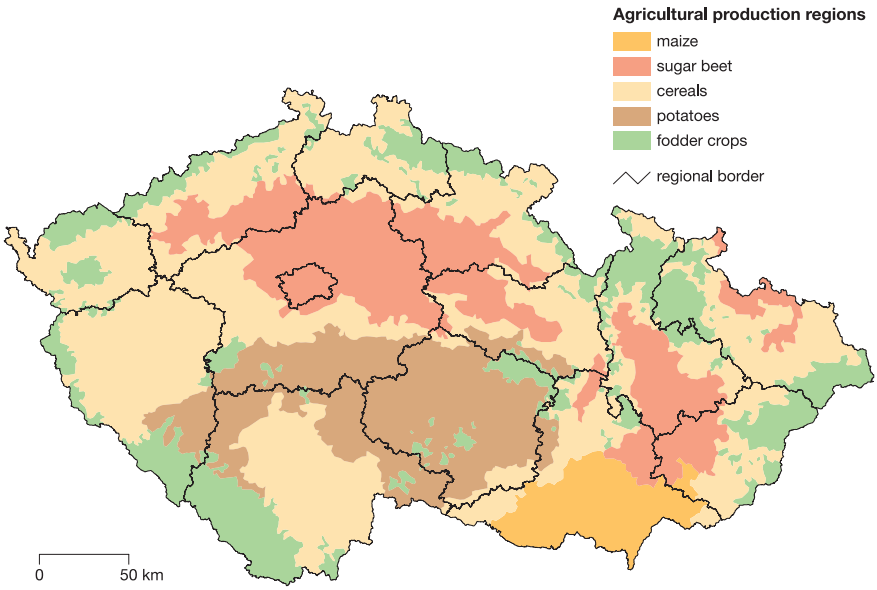

Fig. 3.5 Agricultural production regions (generalized). *Source* Němec (2001)

will definitely shape Czech agriculture in the following years. The present patterns of land use/cover in Czechia are demonstrated on the following photos (Figs. 3.6, 3.7, 3.8, 3.9, 3.10, 3.11, 3.12, 3.13, 3.14, 3.15, 3.16, 3.17, 3.18, 3.19, 3.20, 3.21, 3.22, and 3.23).

Fig. 3.6 Picturesque rocky formations in Český ráj ("Bohemian Paradise") near Turnov provide sweeping view towards Kozákov hill (744 m a.s.l.) in the background. The scene shows a mixture of small fields, meadows, and forests that are typical for the Czech cultural landscape. *Photo* Ivan Bičík

Fig. 3.7 Rapeseed field in blossom bisected by a former field road, now overgrown by bushes and trees: typical scene from Central Bohemia south of Prague near Neveklov. A patch of former agricultural land converted into "new wilderness" can be seen in the foreground. *Photo* Ivan Bičík

Fig. 3.8 Gently sloping highlands, often covered by agricultural land, form a typical feature of Czech landscape. In many places, the use of modern machines is complicated or even dangerous. *Photo* Radim Perlín

Fig. 3.9 Small fragmented fields worked by private farmers had been replaced by large ones managed by cooperatives and state estates after 1948. Since 1990, former arable land has been converted to permanent grassland and used for organic farming, especially cattle breeding, around 1994 (Vysoký Újezd, ca. 450 m a.s.l., some 40 km south of Prague). *Photo* Ivan Bičík

Fig. 3.10 Landscape changes on the territory of abandoned village Stodůlky (Southwestern Bohemia, altitude 850 m a.s.l.). Some 500 people lived here around the year 1900; the village then covered an area of 236 km^2 (second largest municipality in the country after Prague). Following the post-war transfer of ethnic Germans, the locality became part of military training area and served as target for artillery fire. It ceased to exist in 1952. Nowadays the area is part of Šumava National Park. *Photo* Ivan Bičík

Fig. 3.11 A group of second homes have developed on the south bank of Dyje on former sloping agricultural lands. The valley near Znojmo opens to a fertile plain where large amounts of fruit, vegetables, and wine are produced. *Photo* Ivan Bičík

Fig. 3.12 Aerial image of Kobylí and Bořetice (South Moravia) show the most fertile soils where the former Kobylí Lake used to be located. The lake was drained in mid-nineteenth century to provide fertile soil for sugar beet (now mostly cereal crops, fruit, vegetables, and wine). *Photo* http://geoportal.gov.cz/

Fig. 3.13 Farmers around Kobylí, South Moravia, have specialized in wine since ca. 70 years ago. A shallow freshwater lake had existed on the place of the current winery until mid-nineteenth century. *Photo* Leoš Jeleček

Fig. 3.14 Jizerka, one of the highest villages in Czechia (862 m a.s.l.), was founded by hunters and gemstone gatherers. Glass furnaces originated here since early nineteenth century. Fir and beech forests were cleared to provide place for extensive farming (animal husbandry, cabbage, potatoes, logging). More than 420 permanent inhabitants in 42 houses lived here in 1884. *Photo* Ivan Bičík

Fig. 3.15 Large tracts of Norway spruce forests on the slopes of Sněžka (1603 m a.s.l., the highest Czech mountain, the Krkonoše Mts. National park) were damaged by storms. Protected area without any agricultural activity. *Photo* Lucie Kupková

Fig. 3.16 The deep, winding valley of the central stretch of Vltava including beautiful rapids was flooded by the Štěchovice Lake (ca. 30 km south of Prague). In the centre of the photograph, one of the oldest groups of second homes called Ztracenka (Hidden Valley) can be seen. The area is intensively used for leisure time activities. *Photo* Ivan Bičík

Fig. 3.17 Transition zone between intensively farmed Dolní Pomoraví and hilly Protected Landscape Area Bílé Karpaty near the border with Slovakia. Part of the area shows fragmentation resulting from restitution of property after 1990. In the past, the land was even more fragmented. *Photo* http://geoportal.gov.cz/

Fig. 3.18 Agrobrownfields. Following the disintegration of large cooperatives, many former farm buildings and agricultural complexes fell into disuse and neglect (often due to unclear ownership rights). Such buildings keep decaying and gradually become overgrown by shrubs and trees. *Photo* Radim Perlín

Fig. 3.19 Dalešice Water Reservoir flooded the deep, forested valley of the Jihlava River near the protected area Mohelenská hadcová step (*right*). The lake serves the needs of the nearby nuclear power plant. *Photo* Ivan Bičík

Fig. 3.20 The foothills of Krušné hory, Northern Bohemia, were much altered by human activities, namely by open pits where lignite is exploited (environs of Most). *Photo* Ivan Bičík

Fig. 3.21 Former fertile fields had been converted into open pits and after some 50 years the area has been reclaimed to provide space for a large recreation centre that also includes a horse racing track. The modern town Most can be seen in the background. The original mediaeval town used to be located some 2 km to the north; in 1970s it was demolished for the sake of lignite. *Photo* Ivan Bičík

Fig. 3.22 This aerial picture shows the highly urbanized landscape immediately west of Prague (Rudná u Prahy). In the past, intensive farming prevailed here; nowadays much of the area is covered by residential and commercial development

Fig. 3.23 Improper application of EU standards on renewable energy sources plus high state subsidies resulted in a solar boom. Large tracts of agricultural land have been abandoned to make place for solar plants. *Photo* Ivan Bičík

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Chapter 4
Influence of Socio-Economic Conditions on Land Use

Abstract The main focus of this chapter is put on driving forces of land use changes. Authors distinguish among political, economic, social, technological, and cultural driving forces; the importance of different types much depends on how developed the society is. The greatest attention is devoted to social driving forces as these were behind the land use changes over the last 200 years especially in Europe and North America. Different phases of the "Complex Revolution of the Modern Age" are outlined and the spatial diffusion of new technologies are shown. In the nineteenth century Czechia, technological advance in agriculture and farming innovations were crucial and allowed to cultivate land in a more intensive way. Political driving forces of land use changes were especially important in the second half of the twentieth century. After Communists had seized the power in Czechoslovakia (1948), cooperatives and state-owned estates prevailed, private farming was suppressed. Later on, following the collapse of Communism in 1989, rural areas were significantly influenced by economic and social transformation. Socio-economic conditions in Czechia are outlined in brief, with special emphasis on geographical location and transport infrastructure. The concepts of centrality and peripherality are seen as crucial; core areas, neutral, and peripheral (marginal) regions are defined. The steady urban growth meant that most of the decision-making processes moved from rural areas to cities and towns—process that keeps continuing. The effects of transport infrastructure are studied too. The advance of railways seems to have a big influence on land use patterns in the fertile regions especially in the nineteenth century; later on, highways and modern roads became more important.

Keywords Driving forces · Complex revolution of the modern age · Technological diffusion · Social and economic conditions · Core · Periphery

4.1 Basic Dilemma: Structure Versus Actor

Land use changes can be studied from different perspectives where space, time, and institutions are taken into consideration. The institutional scale covers the global level, international organizations, nation states, regions, localities,

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communities, and individuals. When large spatial units (for instance, nation states) are studied, motivations of all actors cannot be identified, of course. Thus, one should focus on the analysis of "driving forces" and social structures. The behaviour of individual actors is difficult to study, especially when such a research spans a long period of time (Bičík et al. 2012, part 1). However, it is the motivation of individual actors behind the land use changes that includes a lot of information (Kolejka 2007).

The past analyses of land use changes have so far focused mostly on economic conditions and related theories differential land rent (von Thünen's intensity theory). Human behaviour, however, includes much more than just economic concepts (homo economicus). Moreover, sustainable land use cannot rely fully on economic relations, but must include also environmental and social aspects (Fanta 2013).

Most research projects that examined factors influencing land use changes in detail (i.e. at smaller scale than nation states) were based on "empirical structuralism" (Kabrda 2004), i.e. on quantitative assessment of selected proximate factors. These factors, however, represent just one part of the decisions made by individuals. Social and cultural aspects have been rarely studied so far—probably because quantitative analyses are difficult to carry out in this case. The high importance of cultural patterns (ideology, faith, social habits, knowledge, etc.) for land use studies was stressed, for instance, by Bürgi et al. (2004). In the Czech context, sociological research studying the relations between different social groups and landscapes was carried out by Librová (1987). It is essential for any detailed research to identify motivations, knowledge, and values of individual actors (Kabrda and Jančák 2007). This kind of knowledge is also important when various policies regarding future land use are formulated (Lipský et al. 2013).

4.2 Driving Forces of Land Use Changes

4.2.1 Types of Driving Forces: Political, Economic, Social, Technological, Cultural

Social driving forces of land use changes (that primarily have economic reasons and consequences) have been studied by a number of scholars. Turner et al. (1995) argues that in some regions driving forces are the main reasons for functional changes.

The concept of driving forces used in this research is described in Sect. 2.4. Bürgi et al. (2004) as well as Ellis (2007) took also natural driving forces into consideration. It has been underlined that "…Landscape is the prime sphere, where the combined effects of society and nature become visible. As societies and nature are dynamic, change is an inherent characteristic of landscapes" (Bürgi et al. 2004, p. 857). Such a holistic approach towards land use/cover driving forces (i.e. natural and social driving forces intertwined) means that "…the forces that cause observed landscape changes. i.e. they are influential processes in the evolutionary trajectory of the landscape" (Bürgi et al. 2004, p. 858).

Brandt et al. (1999 in Bürgi et al. 2004, p. 859) also suggest that natural driving forces are part of the land use/cover driving forces. These authors recognize five types of driving forces: (1) socio-economic; (2) political (socio-economic and political forces are closely interconnected); (3) technological; (4) natural; (5) cultural. They argue that space, time, and institutional framework of the research define the driving forces of land use.

Due to the advance in economic forces, modes of production, technologies, etc., the society was becoming less and less dependent on the nature. Purš (1980) argues that while the so-called "Complex Revolution of Modern Age" had started already in the sixteenth century (i.e. during the Renaissance), humans really became "liberated" from the dependence on the nature as late as during the Industrial Revolution—thus, in Czechia not before the nineteenth century. The fast spread of steam engines meant that manufactories and later factories were no more spatially bound to energy resources (hydro, wind) and deposits of raw materials. Railways and steamers brought new signs of globalization and directly influenced the acreage of arable land as well as the spatial distribution of major crops in Europe and North America. Mather (2006, p. 182) argues that "…Without the railroad and steamship in the nineteenth century, for example neither wheat farming in the Great Plains nor colonial coffee production would have attained their respective scales or significance in terms of land-cover change". Bičík (2004) suggests that in this way, new forms of internal (social) and external (socio-geographical) organization of the society came to existence.

Some social driving forces have far-reaching, almost global effects. Let us mention the differential land rent, Industrial and Agricultural Revolution followed by urbanization, new modes of transport, spread of technological innovation (at present computers, Internet, and genetic modification), global economic and cultural trends, etc. Lambin and Geist (2007) argue that social driving forces include first of all activities of multinational corporations and banks, international organizations (UN, IMF, WB, EU, etc.), environmental organizations, and—last but not least—also wars.

Seen from the Czech (Central/Eastern European) perspective and with respect to the turbulent history of the twentieth century, major underlying driving forces of land use/cover change have developed in this part of the world. Especially in the second half of the twentieth century these were influenced by political changes of 1948 and 1989 (see Sect. 6.2, Table 6.1). Moreover, there are also social driving forces with limited (regional) influence: agrarian reforms, different laws, ownership types, environmental protection, agricultural management, and competition, state investment strategies, etc.

Social driving forces that influenced land use patterns in Czechia have been analysed with attention to detail by this research team already in a number of past studies (Bičík and Jeleček 2005; Bičík et al. 2001; Jeleček 1995, 2002, 2006; Mareš and Štych 2005, etc.). Sections 6.4–6.7 examine the social driving forces in the periods 1845–1900–1948–1990–2010.

4.2.2 General Driving Forces of Landscape Changes in Developed Countries

Social driving forces, together with natural driving forces, have been behind the land use changes over the last 200 years especially in Europe and North America. In the second half of the twentieth century, increasing pressure on the landscape resulted in global environmental crisis. These driving forces are formed and act in a close relation with societal changes in space and time. They are spread by diffusion and develop fully first in the core areas. The rate of diffusion (the term "revolution" is sometimes used) usually slows down in regions distant from the core area. In this context, using the term "revolution" (Agricultural, Industrial, Demographic Revolutions, etc.) means fundamental changes of the past trends, qualitative changes of the content, innovation, and speed of elapsing time.

The most dynamic land use changes over the past 170 years have been recorded in the period of the so-called Industrial-Scientific Revolution (Purš 1973b, 1980; Jeleček 1985, 2006; Bičík et al. 2010). Purš argues that it was the last phase of the so-called Complex Revolution of Modern Era. The profound changes that had begun during the revolutionary years 1848–1849 gave birth to a new economic and social system.

Box 4.1 Complex Revolution of Modern Age

"The structure and dynamics of this general revolution were determined by the interaction of series of partial revolutions affecting asynchronously different areas of the development of society, e.g. the scientific and philosophical revolution, the social revolution, as well as the technological, communication, agricultural, demographic revolutions, and finally the three phases of the industrial and scientific revolution (industrial, technological and scientific, and scientific and technological). If the superior term of industrial and scientific revolution has been used here for the three phases of the summary term, it was in an effort to express right the principal trends of this historical process from the lower forms to the higher, from industry to technology and science, from industry as manufacturing (making) via technology to industry as an applied science. The fundamental feature (of that revolution) was the gradual penetration of the dynamic principle into the main areas of the intellectual and social development of the European civilization and its diffusion into the areas of other civilizations."
Source: Purš 1980, pp. 135–136.

Geographical aspects of the so-called Industrial-Scientific Revolution are evident. Purš (1980, p. 365) describes that "…the Industrial-Scientific Revolution had three phases that overlapped in various countries… and reflected the uneven rate of diffusion, which was delayed in peripheral developing countries…". The

Table 4.1 Time delay measured by the performance of steam engines in industry (in hp) in 1900 per 1000 inhabitants

Countries time delay behind Great Britain	Retardation index		
	Asynchronous t = years	Synchronous r = hp/1000 inhabitants	a = Synthetic coefficient of retardation
Russia/Great Britain	86	156.2	13.43
Austria (Cisleithania) /Great Britain	41	134.6	5.52
France/Great Britain	27	118.2	3.19
Czechia/Great Britain	24	108.2	2.60
Germany/Great Britain	11	90.6	1.0

Explanations t = approximate delay behind Great Britain measured by combined performance of steam engines per 1000 inhabitants; r = difference between combined performance of steam engines per 1000 inhabitants; a = (r × t)/1000. *Source* Purš 1973a, b, p. 477

same was true for other modernization processes, namely in the case of Industrial Revolution. Purš used the uneven spread of innovation during the Industrial Revolution in selected European countries (including Czechia) to construct a simple "retardation index" (see Table 4.1). This index is based on the combined performance of steam engines (in horsepower) in industrial enterprises per 1,000 inhabitants in different countries. In this way, Purš identified how individual countries lagged behind Great Britain, the cradle of Industrial Revolution, and proved that at least some historical processes can be measured rather exactly. Importantly, the territory of present-day Czechia ranked second on this list—fact that confirms its position as the "factory" of Austria-Hungary.

According to Purš (1973b), the Industrial-Scientific Revolution was composed of three phases. The Industrial Revolution (also called First Industrial Revolution by some Western historians) was the most important of all modernization processes and became the catalyst of further two phases: the so-called Technical-Scientific Revolution (Second Industrial Revolution), and finally Scientific-Technical Revolution (Third Industrial Revolution).

In Czechia, however, it was the Agricultural Revolution that influenced land use and landscape changes most. Contrary to the so-called English Agricultural Revolution (Kerridge 1968; Chambers and Mingay 1966), the former was based on the transition from ley farming towards crop rotation system (Jeleček 1995, 2006). Consequently, fallow land as a factor of natural fertility became gradually non-existent. Forage crops (clover, alfalfa) and legumes expanded significantly as did potatoes and sugar beet. These changes allowed intensive animal farming; consequently, animal husbandry as a whole rose significantly (including milk production). Arable land could be cultivated in a more intensive way (deeper tillage, more manure), and also the extent of arable land expanded through "invading" the former meadows and pastures that were no longer needed.

Fertilizers were gradually introduced (guano and potassium chloride at the beginning, industrial fertilizers later) as were better tools, machines, and new technologies based on scientific research. These innovations were first applied on large estates. The Agricultural Revolution in Czechia started in the second half of the eighteenth century, intensified in 1850s and 1860s, and finally peaked in 1880s when the innovations reached most agricultural businesses including small farms.

The territorial expansion of agricultural land reached maximum in 1860s and 1870s; in this period, less than 5 % of arable land lay fallow. Differential land rent I kept increasing: regional differences of land fertility rose as did the importance of geographical location (urbanization, transport).

Industrial Revolution is usually defined as transition from hand production methods to machines and factories. It included introduction of new chemical technologies (in Czechia 1820s and 1830s) and especially introduction of steam engines, the true "engines of the Industrial Revolution". The latter was accomplished between 1850s and 1870s. In the same time, the Industrial Revolution was more or less completed also in Czechia: modern factories were already prevailing in all key industrial sectors, including food industry (Purš 1973b, 1980). This modernization was fuelled by expansion of railways that connected industrial centres with coalfields and deposits of other raw materials.

As serfdom has been abolished in 1848–1849 and agricultural productivity kept increasing, more and more farmers were becoming jobless. Several rural regions were relatively overpopulated (Fialová et al. 1996). New industrial enterprises were springing up in cities and towns where workforce was available; this change initiated the large-scale migration from rural regions to urban areas—process that has been in effect till present. General modernization and the influence of Technical-Scientific Revolution (so-called second Industrial revolution; Purš 1980, pp. 140–141) led to a special type of Technical-Scientific Agricultural Revolution (compare Jeleček 1985, 1995, 2002, 2006—pp. 588–590).

The above-mentioned modernization secured enough food for the growing non-agricultural population. With the exception of railways, steam engines could not compete with other types of energy including electricity (transferred at long distances) and combustion engines (in lorries, tractors). Production in general (also agricultural production) was becoming more effective; the costs of production, however, kept rising as well. The advancement of chemical industry brought increased production and thus use of fertilizers; new factories (often located in the fertile regions) produced modern agricultural machinery. This phase of Industrial-Scientific Revolution started in 1870s and came to an end in 1945.

Box 4.2 The definition of technical-scientific revolution

"At the time the final phase of the Industrial Revolution was underway in the most industrial countries of West and Middle continental Europe, a new, technological and scientific revolution, began to develop, characterized by

the use of electric power to drive machines, by combustion engines, by the development of heavy chemistry, introduction of improved machines and technological chemical processes in a number of the main industries, by the beginning of formation, production of belt systems and a more extensive use of scientific knowledge in production practice, for the purpose of which companies began to expand their specialized laboratories and research departments. The new development of economic forces was based on entrepreneur organization in an increasing number of limited companies and could be no longer controlled within the narrow limits of individual private business of the period of free competition capitalism. The beginnings of the technological and scientific revolutions, associated closely with the results of the Industrial Revolution, became, among other things, the material base for the transition from free-competition capitalism into the monopolistic stage of capitalism."
Source: Purš 1980, p. 140–141.

The Technical-Scientific Revolution in Czech agriculture has two different phases. The first one was taking place in 1880s and 1890s. Crop rotation was typical; more advanced machines (ploughs powered by steam engines, seed drills, harvesters, etc.) were being introduced as were fertilizers. Drainage systems helped to improve productivity in large areas, scientific findings enabled new breeding programmes. Electricity and combustion engines, however, were so far used exclusively on large estates. It was the period of transition towards more effective farming, based on differential land rent II. In many areas, forests were being cut and lakes drained to provide space for new fields; fallow land became virtually non-existent (Jeleček 1986, 1995, 2002, 2006—pp. 588–590).

The second phase of Technical-Scientific Revolution lasted from the turn of the twentieth century till the end of 1940s. All the improvements and technological innovations described above were increasingly used also by small farmers. The use of fertilizers and machinery was essential and increased the natural fertility of soils. Pesticides were being gradually introduced. The spread of electricity allowed night work, encouraged factory farming (large stables), processing forage and other products within the farms.

The introduction of combustion engines and electricity brought fundamental changes to agriculture. Tractor as a universal farming vehicle delivering high tractive effort was equally important for farmers as was steam engine in industry. Tractors and electricity triggered mass use of machinery in agriculture since the end of the nineteenth century, and especially in early twentieth century (Jeleček 1995, 2006—pp. 588–590).

As new technologies and farming innovations required a lot of funds, the importance of the so-called intensification of differential land rent II has increased more than differential land rent I (see Sect. 4.3). As a result, much of the capital was invested into fertile regions where profits were realistic in short term. Thus,

regional differences among the so-called agricultural production areas (Novák et al. 1925; Purš 1965, map 21b) were rising. Also the economic and social gaps between great landowners and small farmers were widening. Many small farmers were heavily indebted; of some help was the advance of cooperatives since the end of nineteenth century that included—apart from classical cooperatives—also sugar factories, milk factories, breweries, distilleries, slaughterhouses, etc. All these businesses were abolished under Communism (1948–1989) and only few re-established after 1990 as the privatization laws applied only to individuals.

The third phase of Industrial-Scientific Revolution is called "Scientific-Technical Revolution" by Purš (1973b, 1980). It was based on advanced technologies that in many cases had originally been developed for the war industry and included nuclear energy, mass spread of automation in industry (especially heavy industry), expansion of plastic and new types of fuel, etc. This third phase started in the end of World War II when scientific findings and inventions were gradually applied to practical life (Purš 1973b, p. 369).

In the post-war Czechia (Czechoslovakia), the Scientific-Technical Revolution was in progress under the conditions of Communist regime and Soviet domination. Since early 1990s, Czechia has experienced fast, largely uncontrolled economic and social transformation that naturally influenced also rural areas. Cooperatives and state-owned estates that had become consolidated during the last phase of Communist regime, were transformed into large profit-oriented enterprises and usually took the form of limited companies. Any kind of return towards small-scale farming did not materialize and the landscape patterns (typically with vast fields) have not changed much either. The high proportion of cereals has even increased since 1990; maize and rapeseed expanded significantly, including highlands. Peripheral regions have become even more peripheral (Havlíček et al. 2008). Farming as a whole faces stiff international competition including subsidized products from other EU countries.

4.3 Basic Overview of Socio-Economic Conditions in Czechia

The influence of social systems on landscapes and environmental changes keeps rising. Some scholars argue that new geological era has already started: Anthropocene, period in which humans form the main driving force. Consequently, the role of social factors is more and more important when processes of landscape changes are studied. This chapter deals with the role of selected social and economic conditions on land use patterns in Czechia with special emphasis on geographical location and transport infrastructure.

The core-periphery relations have been studied by a number of researchers in the past; a whole array of approaches have been adopted. The dual, uncomplicated concept "core versus periphery" has been altered by introduction of the term "semi-periphery" (Wallerstein 1979), and later also by the continuous idea

of "pyramid of power". In the latter concept, the terms "core" and "periphery" are substituted with varying degree of centrality (Schuler et al. 1983). Havlíček et al. (2005) have discussed in detail different approaches towards "centrality" as part of the research focused on peripheral areas.

Regarding centrality and peripherality, the ideas of Hampl et al. (1987) are followed in this publication. Centrality/peripherality of a region is understood as their geographical location combined with the relative importance within the whole social-geographical system. The degree of centrality/peripherality has been defined in terms of:

1. distance from major cities and towns;
2. size and importance of the respective regions;
3. population density in the environs.

The "macro" factors, i.e. the location of major core areas and axes that form the backbone of the whole system, play the most important role (Hampl et al. 1987).

Centrality and/or peripherality are typically linked to other parameters that may influence land use patterns. Centrally located areas are the most attractive ones, with the highest degree of human activities. The so-called metropolitan areas (in Czechia currently all regional capitals and environs minus Jihlava) play the key role (Hampl 2005). At present, especially the outlying parts of cities (urban–rural fringe) are witnessing conflicts among different spatial functions due to unprecedented suburbanization, commercial development, and construction of new roads. These processes influence deeply the existing land use structure.

Further away from cities, the fertile rural areas show much lower rate of land use changes. Such landscapes remain rather stable, with a high proportion of arable land. Apart from the natural conditions, also the distance and accessibility of markets (i.e. the second component of differential rent I) play an important role.

On the contrary, peripheral regions are characterized by low population density and rather traditional economic structure. Ongoing depopulation and high unemployment are common; elderly and less educated people tend to live in such areas. It should be distinguished between "classic" peripheral regions (sparsely populated frontier) and the so-called inner periphery (Musil 1988). The latter is found namely near the regional boundaries. The lack of jobs in industry and service sector in such areas results in higher-than-average proportion of farmers. With respect to usually poor natural conditions, the peripheral regions usually show higher proportion of arable land than expected (see the Vysočina example—Kabrda 2004).

The so-called marginal regions form part of a different concept of space. Andreoli et al. (1989) distinguishes among core, periphery, and marginal regions; the latter are integrated into the existing system only at a very limited scale. Military training areas, to a certain extent also national parks, and the former border zone (that existed under Communism along the Iron Curtain) can be labelled as "marginal regions" in Czechia. Land use research in these areas, however, is difficult due to methodological problems (too big Stable Territorial Units, large proportion of "remaining areas").

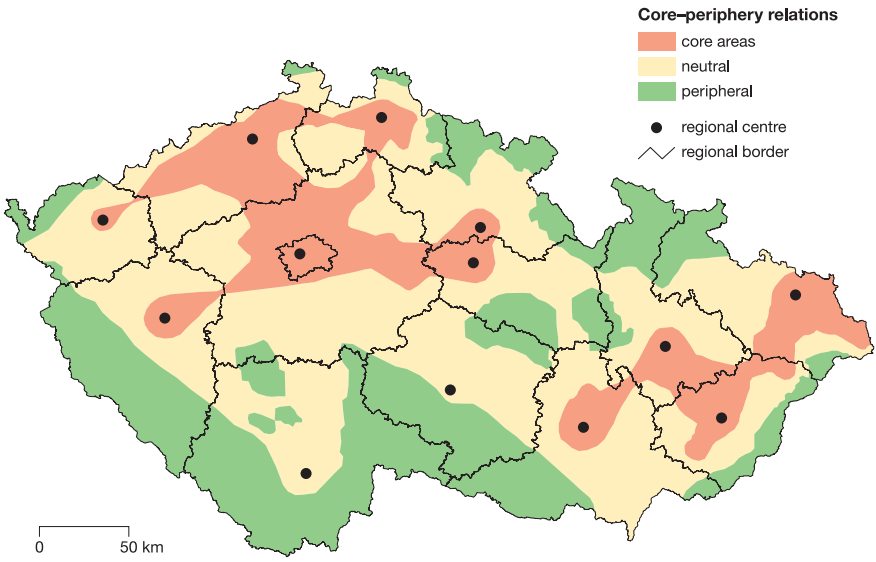

Fig. 4.1 Core-periphery relations in Czechia. *Source* Hampl et al. (1987), simplified. *Note* Core-periphery relations as of 1980; administrative boundaries as of 2013

Changing land use patterns with relation to centrality/peripherality was studied by Mareš and Štych (2005). Regions were sorted into three main classes: (1) core areas, (2) neutral, and (3) peripheral (Fig. 4.1). This classification is based on the 1980 data; however, conditions in different regions have been changing over the whole period 1845–2010.

4.3.1 Changes of Core-Periphery Relations in the Framework of the Settlement System

Hampl (2005) and Hampl et al. (1987) define three main phases of the history of Czech settlement system. The pre-industrial society was characterized by a very low proportion of urban population and urban economy—vast majority of people lived in rural areas and worked as farmers. Urban centres kept expanding and shrinking without any clear tendency. Industrialization brought significant growth of urban regions, hierarchically organized system of settlement structure came to existence. Within the Industrial Age, Hampl (2005) distinguishes four basic trends that led towards bigger and more important differences among urban areas (including creation of metropolitan areas). Though the urban growth (in terms of population) has slowed down or even stopped during the Post-Industrial Era, concentration of decision-making processes into the biggest cities continues. Such a shift reflects the more general transition from (physical) concentration towards concentration of relations that is typical for the current period (Hampl 2005).

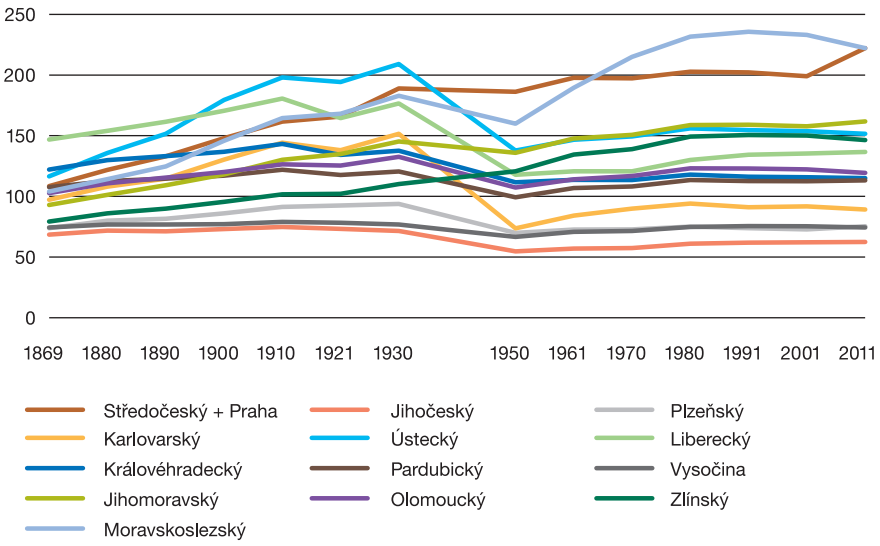

Fig. 4.2 Changes of population density in Czech regions 1869–2011 (inhabitants per km^2). *Sources* ČSÚ (2006), ArcČR 500 (2013)

The above-mentioned trends of settlement patterns have influenced also the core-periphery relations in various Czech regions. The post-war transfer of Czech Germans to Germany and Austria, namely from the border areas, was the single most important event that affected the spatial structure of core-periphery relations. Many villages and small towns in the frontier perished (Kučera 2007) and newcomers were few. Consequently, the centrally located Czech regions became more important in terms of population. This fact is well seen in the chart showing changes of population density in different regions (Fig. 4.2). Karlovarský, Ústecký, and Liberecký kraj (region) suffered badly from depopulation after World War II. (For the overview of present administrative divisions of Czechia see Fig. 4.3). On the contrary, the Ostrava region—with a lot of heavy industry encouraged by the Communist regime—has experienced a significant population boom during the period 1950–1975. In some regions, no major population changes have been recorded (Vysočina, part of the inner periphery). In general, interregional differences increased over the time as the regional division of labour gradually grew.

The above-mentioned concentration of power and decision-making also influenced the way of landscape utilization, as "…already the oldest written accounts bring convincing proofs: the real 'landscape makers' have always been members of the political, economic, and intellectual elite" (Matoušek 2010, p. 315). As the influence and power of urban/industrial population were steadily rising during the so-called Second Industrial Revolution, decision-making processes ultimately moved from rural areas to cities and towns (Matoušek 2010). Technological and scientific innovations then spread into peripheral regions through diffusion. Hägerstrand (1967) explained in detail the phenomenon of spatial diffusion in one of his classic works "Innovation diffusion as a spatial process".

Fig. 4.3 Administrative division of Czechia. *Source* Authors

Globalization, foreign investments, and cross-border trade (including trade with farming land) moved the decision-making processes to a higher hierarchical level and to global economic centres. Consequently, changing land use patterns in a certain region may be affected by social and economic activities in another, rather distant region. Such effects are called *land use teleconnections* (see for example Haberl et al. 2009) and make land use studies even more complex. These *teleconnections* were made possible by cheap long-distance transport in the twentieth and twenty-first centuries that allows easy transfer of various products on global scale.

4.3.2 The Effects of Transport Infrastructure on Land Use

The direct effects of the fixed installations like roads, railways, dams, terminals, etc. on land use in general are rather small in terms of area—one can talk about local changes only. Major roads, railways, etc., however, often bring new economic activities into the given area and these may influence the land use structure profoundly. It is not just a one-sided process: any boom of new economic activities sooner or later requires new transport networks—see Matoušek (2010). Though the advance of railways in England was pushed by the needs of booming industry, in Bohemia and Moravia railways were ahead of industrial development during the first three decades (after the revolution of 1848/9). Such types of land use changes are more important in terms of size (warehouses, depots, or commercial centres are typical examples at present). From the land use perspective, it is an important problem especially in the suburban zones in developed and developing countries as the land in the environs of big cities is often of high quality—it is the same land which sustained the urban population till recently. The above-mentioned processes in the environs of Prague have been analysed by Spilková and Šefrna (2010).

Railways and roads have gradually reached almost every single corner of the country and have facilitated important changes of rural landscapes (and changes of the whole primary sector). Local natural resources became linked to economic core areas more intensively (Matoušek 2010). The opening of local energy and material cycles of the pre-industrial agriculture together with concentration/separation of different land use types on higher levels have been studied by the Austrian school of social metabolism (Krausmann et al. 2003 and other authors; in Czechia see Grešlová-Kušková 2013). It has been proved that increasing specialization and division of labour results in more homogeneous land use structure in small regions, and—on the contrary—in higher differentiation in the framework of large regions.

4.3.3 The Progress of Transport Infrastructure

Historically, the story of railways in Czechia can be divided into four phases (see Fig. 6.7). Though the first part of horse-drawn railway connecting České

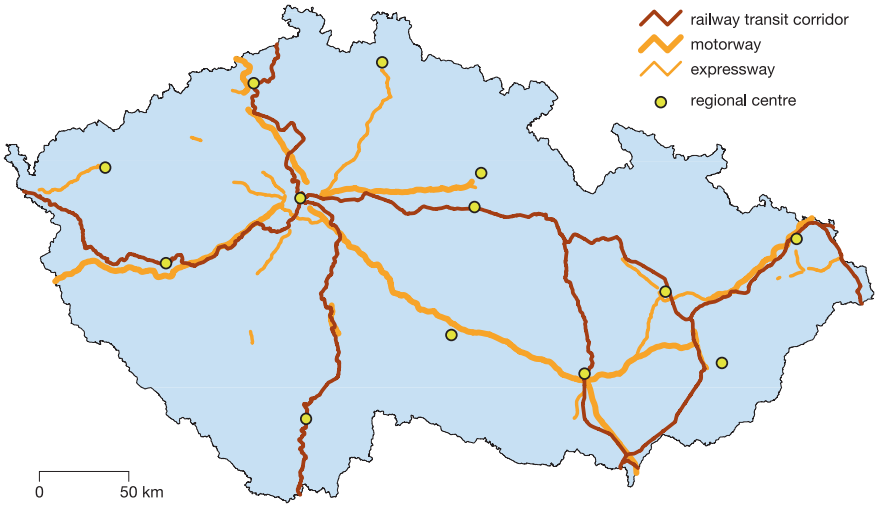

Fig. 4.4 Network of major railways and roads (2013). *Sources* Database ArcČR 500 (2013); SŽDC (2013). *Note* In the case of railways, the figure shows the would-be state—many sections have not been modernized yet

Budějovice and Linz had been opened already in 1827, the really important changes came later with the steam locomotives. The first modern railway line on the Czech territory was opened in 1839, connecting Vienna and Břeclav. All major cities became interconnected by railways by 1854. The basic rail network was finished in 1880. Later on, mostly short local and regional railways were built including private narrow-gauged railways for special purposes (mines, forests, sugar factories—see Fig. 6.8). A few more passenger railways were put into operation after World War I, especially in peripheral regions.

A number of railways have been electrified under the Communist regime; in spite of that, the rail network was very outdated and pretty neglected in late 1980s. Modernization of railways have become one of the important tasks since early 1990s. The government has defined four key lines (Fig. 4.4) to be modernized; the work started in 1993. Constant lack of money caused delays; moreover, economic priority is currently given to highways and trunk roads. Railways receive only 37.8 % of the available transport funds (SFDI 2014).

The advance of modern roads in Czechia was much slower in comparison with other economically developed countries. The basic network in early twentieth century consisted largely of untarred roads that had been built before 1850. The boom of tarred roads came only in 1930s. In the same period, the first plans to build a major highway through the whole of Czechoslovakia were made. The work had begun in 1939 and due to World War II it was suspended soon (1942). The idea of a motorway linking Prague and Brno was renewed much later; it was finally put into operation in November 1980 (Čihák et al. 2013). Since 1990, the network of motorways has expanded from 335 to 776 km; in the case of expressways it was

from 209 to 458 km (Čihák et al. 2013—Fig. 4.4). Compared to the western countries, the network of motorways remains inadequate.

The restoration of democracy and civil rights after 1989 brought real chances to defend citizens' rights also with respect of land use. A number of conflicting interests among different functions in the landscape (especially tensions between highway builders and conservationists) resulted in a number of long-term court cases: the best known example is the—still unfinished—motorway between Prague and Dresden across Central Bohemian Uplands.

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Chapter 5
Data Sources and Research Methods

Abstract Historical and current data sources and research methods in land use studies are described in this chapter. Regarding historical data sources, the Land Registry is mentioned as a primary source. Its long tradition spans almost 1000 years; from the second half of the eighteenth century Land Registry includes maps also. The so-called Stable Cadastre (data collected in the first half of the eighteenth century) presents an especially important source of historical land use data. Military Land Survey was a series of detailed land surveying covering the whole Austria-Hungary in three phases (eighteenth and nineteenth centuries). Maps produced by Military Land Survey had high quality and were often used during the following decades. Commencing mid-twentieth century, aerial photography brought new qualities and new possibilities into land use studies. Multispectral satellite images have been in use since 1970s. Creation and structure of the "LUCC Czechia Database: Database of long-term land use changes in Czechia 1845–2010" are described in detail. This database forms the main information source used by the research team. It includes cadastral data from 1845, 1896, 1948, 1990, 2000, and 2010. As the structure of land use data collected was slightly different in each of the above-mentioned years, compatibility of data must be secured in order to allow historical comparisons. Methods of land use change analyses are outlined, including various indices (development index, saturation index, index of change, ecological coefficients, etc.), typologies, and other quantitative methods. In selected model areas, detailed land use changes were studied. To do so, GIS technology was applied. Results include quantitative data as well as detailed spatial information.

Keywords Land registry · Military land survey · Aerial photography · Land use classes · LUCC Czechia Database 1845–2010 · GIS

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5.1 The Land Registry as the Basic Source of Statistical and Spatial Land Use Data

The research of long-term land use changes in Czechia and especially the search for social driving forces at the national level in this publication are based on statistical analyses of historic and current data from the Land Registry (see Sects. 5.3 and 5.4). To examine land use changes within the cadastral areas, maps and other cartographic sources are used (see Sects. 5.2, 5.5, and Chap. 7).

Compared to other methods (remote sensing, analyses of historical maps, satellite and aerial images), the use of historic and current data from the Land Registry has a number of advantages. First, it allows the examination of quite a long period of time (ca. 170 years) which can be divided into shorter sections (with different character and intensity of social driving forces) by the most important historic events. Second, researchers can take advantage of rather precise and comparable numerical data from different years related to small, stable areas (so-called Stable Territorial Units—STUs; for definition, see Sect. 5.3.3). Last but not least, numerical land use data by STUs can be correlated with other types of geographical information (landscape features, soils, population, economic data, etc.).

The English expression *cadastre* has evolved from the Latin root *capitastrum* (*caput* = head; *tastrum* = document, record). Thus, *capitastrum* corresponds to a written account sorted by "heads" or other units (Bumba 2007, p. 10). In broader sense, *cadastre* indicates methodically sorted files (in written or cartographic form) that include description and inventory of real estate (plots, buildings) plus legal rights, type of use, areal extent, ownership, financial profits, etc. Such data allow to set the value of plots and serve as a base for taxation and the so-called official land price (Kain and Baigent 1992; Jeleček 2006b; Mašek 1948; Bumba 2007).

During the last phase of feudalism, the agricultural land tax formed the base of taxation system and was one of the main sources of state revenues. However, modernization of state government and military affairs and shift towards a more rational public administration required more and more money—and in the pre-industrial society land was the main source of wealth. Therefore, it became essential to get precise information on land use structure (including areal extent and profits). However, the nobles' land was exempted from tax until 1848/1849 (Jeleček 2006b).

The remarkable publication, The Cadastral Map in the Service of the State. A History of Property Mapping written by Kain and Baigent (1992, pp. 175–204) offers a unique insight into land surveys and cadastral maps since 1526 on the whole territory of Habsburg Monarchy, also some European countries (including Czechia) such as England, France, Germany, etc.

Land Registry has a long tradition in Bohemia and Moravia. Bumba (2007) argues that such registers and files including land tax can be traced back almost 1000 years. From the eleventh century until the second half of the eighteenth century there were only numerical files with approximate figures, without maps. Land Registry including precise maps started in the end of the eighteenth century.

First documents that include notes on land tax date back to 1022. Since early fourteenth century, the land ownership rights were recorded in the so-called *Zemské desky* (literally "Land Tables"). Polyptychs (*urbář* in Czech) were detailing the land ownership, rights, and obligations of peasants before 1650 (Mašek 1948).

The term "cadastre" was first used in 1654 when the Royal Council of Bohemian Kingdom (Mašek 1948) established the First Land Registry (*První rustikální katastr* or *první berní rula* in Czech). It included, however, peasants' land only (*Catastrum rollare*) and was sorted by basic taxation units, i.e. by estates/farms. Such units covered 11.2–22 ha and depended on the fertility and profitability of soils. Three classes of arable land were identified: good, average, and poor. The Second Land Registry (*druhá berní rula* in Czech) came to existence in 1684 and was in use until 1748 (Bumba 2007).

It was the update of population and economic conditions in Czechia, devastated by the Thirty Years' War, that necessitated creation of the Second Land Registry. Population declined by one-third at least during the war, a number of regions became virtually deserted, many rural settlements (especially in areas with poor soils) ceased to exist. People who had survived the war were moving to more fertile, better accessible areas. The economic recovery was hindered by lack of finances. The land tax formed the base of taxation system: apart from peasants, also "ordinary tax payers" (urban middle class, vicars, millers, etc.) were subject to this tax.

The first land registry in Bohemia and Moravia that included peasants' land as well as nobles' land was created in mid-eighteenth century and bore the name of Empress Maria Theresa: *Theresian Land Registry* (Mašek 1948; Bumba 2007).

The survey results were kept in the so-called *fasí* books (peasants' land was recorded by villages; these were called *berní rolla* in Czech). The fourth *berní rolla*, finished in 1757, was valid until 1848. The survey of nobles' land came to existence in 1713 and was sorted by estates. This first survey of nobles' land, so-called *exaequatorium*, served as a basic source for taxation. Data on individual plots included location, description, name, owner, topographic number, and areal extent (in morgens; 1 morgen = 0.5756 ha).

It was Emperor Joseph who introduced quite radical modernizing reforms. These included the *Land Registry of Joseph II* (*Josefský katastr* in Czech) that came to existence on the base of imperial decree on land tax and surveying (1785). "The principle which Joseph II wanted to establish was that one tax (land tax) to be paid by all" (Kain and Baigent 1992, p. 192). This land registry was more advanced in terms of quality. Originally, it had aimed to survey all agricultural land in the period 1785–1789 (peasants' and nobles' land). This idea, however, had to be abandoned in 1792 due to strong opposition from the nobility. Land Registry of Joseph II did not include maps. The decree stipulated that the ownership rights to peasants' and nobles' land were legally equal.

The Land Registry of Joseph II formed the network of "cadastral municipalities" ("cadastral areas" at present), i.e. clearly defined areal and taxation units. The registry also defined the so-called "sections" that included houses and farms

in numerical order. Cadastral municipalities formed the first step towards future administrative units, i.e. municipalities, villages, and hamlets. Unlike the previous Land Registries where estates formed the basic units, in this case plots were measured and recorded.

In Moravia, the surveying lasted longer (until 1748) and the method was different, based on the so-called *lánský rejstřík*. Taxes were set by the Moravian Land Council (for details, see Mašek 1948).

The "Franciscan Cadaster" (also called Stable Cadaster) is the most valuable source of landscape data from mid-nineteenth century (Stabilní 1979). It is unique in the world context and also used in our analyses as the oldest data source (Fig. 5.1 shows sample map). The Franciscan Cadaster was established by the decree issued by Emperor Francis II in December 1817. The name "Stable Cadaster" is an unofficial one and reflects the presumption that the cadaster should remain unchanged in the future.

The Franciscan Cadaster, as well as other European cadasters, was modelled on the Milan Cadaster (Censimento Milanese) that was executed in Lombardy in 1718 and put into effect in 1780. It is used to present times. The Milan Cadaster was the first one that included precise location of plots; the areal extent of plots was defined from cadastral maps. The Franciscan Cadaster covered the whole Austrian Empire except Hungary, Transylvania, Croatia, Slavonia, Vojvodina, and Banat. Surveying started already in 1817 in Lower Austria; Cisleithania (including Czechia) was fully covered in 1861 with Tyrol as the last part. The surveying

Fig. 5.1 Stable cadaster—sample map. *Source* COSMC—Czech office for surveying, mapping and cadastre (Ústřední archiv zeměměřictví a katastru)

was based on a dense network of triangulation stations that secured high precision. Mašek (1948) describes in detail the surveying methods including mapping, depiction, and description of all plots; the scale of maps was 1:2,880. Plots were sorted by types of use and land cover. Agricultural plots also included net profits based on the fertility of soil and were accordingly sorted into different classes. The land tax was based on the above-mentioned net profits. In Bohemia the surveying was carried out between 1826 and 1843, in Moravia between 1824 and 1836 (see Box 5.1). Most cadastral maps in Czechia are still derived from the survey made for Stable Cadaster (Mašek 1948).

The Stable Cadaster includes maps (*měřický operát* in Czech), written accounts (*písemný operát* in Czech), and evaluations (*vceňovací operát* in Czech). The written accounts include the list of plots and owners plus more details about the owners, land cover, soil quality, and net profit. Evaluations consist of a broad array of data that served as a base for financial evaluation of plots.

Box 5.1 Surveying the Stable Cadastre

In Bohemia, surveying lasted 12 years (1826–1830, 1837–1843). In total, 8967 cadastral municipalities were surveyed, the total area was 51,953 km^2 with 9,321,064 plots. In Moravia and Silesia, surveying lasted 11 years (1824–1830, 1833–1836); in total, 3724 cadastral municipalities were surveyed, the total area was 27,375 km^2 with 6,038,454 plots. According to the survey, the area of the present-day Czechia covered 79,328 sqkm (ČÚZK 2013; Bumba 2007). Original maps of Stable Cadaster were produced; these were used by public administration and often reproduced. One of the copies, the so-called *imperial copy*, was in colours and kept in the archives. In total, 11,372 cadastral maps were produced (8444 in Bohemia, 3288 in Moravia and Silesia) covering 46,732 map sheets (31,209 in Bohemia, 15,523 in Moravia and Silesia). The basic size of maps was 60 × 71.5 cm.
Sources: Mašek 1948; ČÚZK 2013.

The Stable Cadaster constitutes a comprehensive piece of work, a very precise one (many of the maps are still in use). It includes a lot of information on soils, land cover, and economic conditions (Kain and Baigent 1992). The Stable Cadaster covers the whole Czech territory (Bohemia, Moravia, and Czech Silesia; see Fig. 4.3). It reflects very well the landscape features of early nineteenth century, i.e. in the period of early Industrial Revolution and Agricultural Revolution. As the maps of Stable Cadaster are of detailed scale and high accuracy, they can easily be digitized in GIS and compared with the current maps. Of great importance is the very detailed classification: the legend contains 52 classes (see Fig. 5.2). Also the information included in the written accounts and evaluations is a valuable source for landscape, agricultural, and economic studies.

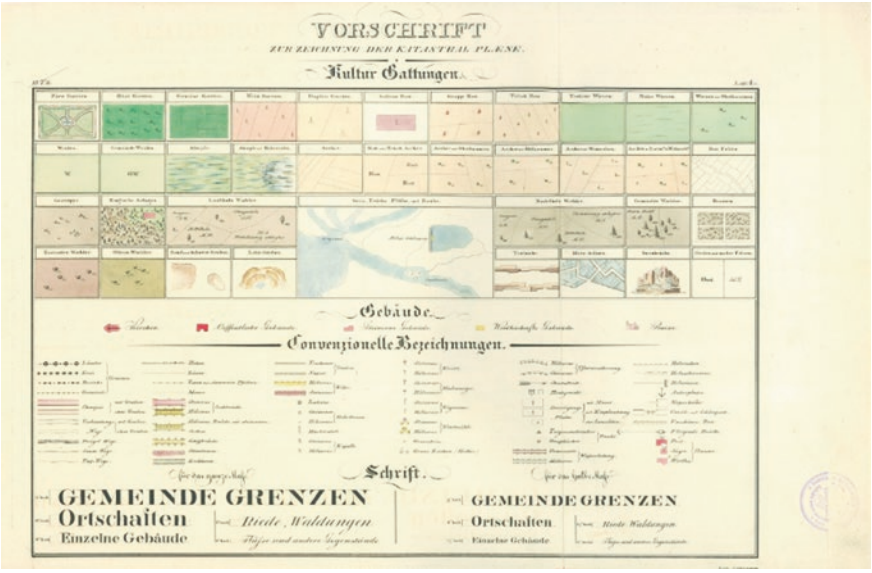


Fig. 5.2 Map from stable cadaster—legend. *Source* COSMC—Czech office for surveying, mapping and cadastre (Ústřední archiv zeměměřictví a katastru)

Soon after Czechoslovakia had gained independence (1918), a more detailed cadastral survey was carried out (*pozemkový katastr* in Czech, since 1927). Especially in urban areas the old maps were updated and made more accurate, resulting in scales 1:1000 and 1:2000. Bumba (2007, p. 90) states that "… the new cadastral maps were executed in the national coordinate system, the so-called Unified Triangulation Cadastral Network (S-JTSK)…". The information on each plot included the ownership, dimensions, cultivation, quality (nine classes), and value (ČÚZK 2013).

After the Communist coup-d'état (1948) the interest in surveying declined, especially when it came to ownership rights. The socialist-style economy was based on rigid central planning; what really counted was who *managed* the land—not who *owned* the land. Changes of ownership were in many cases no longer recorded. The governmental decree, issued in 1956, called for the Unified Land Records (*Jednotná evidence půdy* in Czech) (Bumba 2007; ČÚZK 2013). Launched in 1964, the so-called Real Estate Record (*Evidence nemovitostí* in Czech) included ownership rights, but the information was incomplete and more focused on the data needed for central planning and especially agricultural planning (Bumba 2007; ČÚZK 2013). Thus, there was a big difference between the ownership and real use of farmland and this discrepancy remains till nowadays: cadastral files include the owners while the Land Parcel Identification System (LPIS; *Veřejný registr půdy* in Czech) records the users (more information in Sect. 6.7).

The Statistical Yearbooks of Agriculture (*Statistická ročenka půdního fondu* in Czech) published by Czech Office for Surveying, Mapping, and Cadastre since

1960, shows information on the so-called types of plots. Eleven land use classes sorted by districts were recognized: arable land, hop gardens, vineyards, gardens, orchards, meadows, pastures, forests, bodies of water, built-up areas, and remaining areas. Since 2010, these yearbooks have been published under the title "General Survey of Land Use from the Real Estate Cadaster" (*Souhrnné přehledy o půdním fondu z údajů katastru nemovitostí České republiky* in Czech) and include information on type and number of plots sorted by districts and regions. The above-mentioned publications and also the relevant databases are accessible at the Czech Office for Surveying, Mapping, and Cadastre. In this research, land use data of 1990, 2000, and 2010 come from this source.

The new political climate after 1989 brought privatization, denationalization, and restitution of property. Since 1993, all changes of ownership have been recorded in the Real Estate Cadaster of the Czech Republic (*Katastr nemovitostí České republiky* in Czech) which combines the functions of former land records and cadastral surveys. By law, the Real Estate Cadaster is managed by Cadastral Offices (Bumba 2007; ČÚZK 2013). At present, cadastral maps are being digitized; as of May 2014, the digitized versions of cadastral maps was available for 80 % of all cadastral areas (ČÚZK 2014).

5.2 Further Data Sources

Maps that resulted from military surveys rank among the most important cartographic sources that can be used in land use research. Since 1930s, the character of landscape has been well documented in aerial images. An extensive archive of aerial images is available in Czechia. Satellite images from multispectral scanners have been in use since 1980s. About 10 years ago, hyperspectral imagery was introduced. The latter provides land use/cover data as well as information on landscape condition (Laboratoř Geoinformatiky FŽP UJEP (2001–2010) and others).

5.2.1 The First Military Land Survey (Josephinian)

After Austria had been defeated in the Seven Years' War (1756–1763), Empress Maria Theresa ordered detailed land surveying the whole Austria-Hungary. As this survey was finished under the reign of Joseph II, it is often referred to as *Josephinian Survey*. It was based on the older Müller's Map (in Bohemia from 1720, in Moravia from 1716, scale 1:132,000) which was magnified to the scale 1:28,800. The survey was rather inaccurate as it lacked any network of triangulation stations. Data were "collected" by military personnel that criss-crossed the landscape on horses and observed the landscape features. More precise methods were used only on a limited scale. In the end of the thing, large inaccuracies prevented the creation of a general map of the Empire—map sheets were distorted and did not match each other (Mikšovský and Zimová 2006; Cajthaml and Krejčí 2008).

Brůna and Křováková (2005, p. 25) argue that "…the first Military Land Survey was a detailed one and included extensive written accounts. It reflects the landscapes of Bohemia, Moravia, and Silesia before the eve of Industrial Revolution, in the heyday of Baroque cultural landscape and its diversity…". Seen from the land use perspective, it is important that the first Military Land Survey shows all important land use classes (arable land, pastures, vineyards, swamps, forests, different types of built-up areas, etc.). Maps included colours so that different land use classes could be easily recognized. For strategic reasons, all roads were drawn with great care, sorted into different types. The same applied for water courses (rivers, creeks, artificial waterways) (Brůna and Křováková 2005).

5.2.2 The Second Military Land Survey (Franciscan)

The form and contents of the second Military Land Survey are very similar to the first Military Survey (Brůna and Křováková 2005). The most important difference is that military triangulation stations had been established just before the second survey started. Mapping was carried out between 1836 and 1852 and the scale was 1:28,800. According to Mikšovský and Zimová (2006), the second Military Land Survey was much more accurate. One of the good reasons was that surveyors were using the already existing precise maps of Stable Cadaster in the scale 1:2880 (see above). Thus, surveyors just corrected the changes that had appeared since the time of cadastral mapping (Mikšovský and Zimová 2006). These maps reflect the period when Industrial Revolution and agricultural intensification just started.

5.2.3 The Third Military Land Survey (Franciscan-Josephinian)

As demand for accurate maps was increasing also among non-military companies (e.g. in construction), in 1870s it was decided in Austria-Hungary to carry out one more detailed land survey (Mikšovský and Zimová 2006). This was done between 1876 and 1880 and was again based on cadastral maps. Accuracy remained high, and elevation data were much improved: the maps included hatches, contour lines, and spot heights. The importance of these maps is proved by the fact that they were used in World War I and World War II and till 1953 these were the only maps covering the whole Czechoslovak territory (Cajthaml and Krejčí 2008).

The outcomes of military surveys in Czechia were often used in landscape studies namely during the first decade of the twenty-first century. In this period, the maps have been scanned and made accessible at the website of Czech Office for Surveying, Mapping, and Cadastre. Brůna and Křováková (2006a), for instance,

were using these maps while assessing the history of Czech forests. Military maps can show interesting features also in regions where fundamental changes took place; as an example, Brůna and Křováková (2006b) used them when researching landscape changes in the military training area Boletice.

5.2.4 Aerial Photography

The first ever aerial photograph of the Czech territory was made in 1935 (Struha 2009). In that time, aerial photography was controlled by the military. All activities connected to aerial photography (planning, production of images, distribution) was carried out by the second Military Geographical Institute, later by Military Triangulation Institute (at present called Military Geographical and Hydrometeorological Office, or *Vojenský geografický a hydrometeorologický úřad* in Czech) located in Dobruška in north-eastern Bohemia. According to Struha (2009), the latter institute created tens of thousands of different types of aerial photographs annually. The archive in Dobruška contains some 800,000 original aerial photographs and related material (maps largely in the scale 1:50,000, different registers, central database) (Struha 2009). In 1990s, the military lost the monopoly on aerial photographs and now images are created also by specialized private companies.

The aerial photography archive covers a long period of time and it is a valuable source of detailed information on landscape changes. The past images show landscapes that no longer exist (e.g. mining areas, submerged regions, former German villages in the frontier, now abandoned). Many images document well the radical landscape changes that were taking place in 1960s after collectivization: amalgamation of fields into giant units, disappearance of field boundaries, etc. (for more information see Chap. 7, or Struha 2009).

The rather detailed scale (1:27,000–1:10,000 depending on the exact period) and very good quality ensured that aerial photographs could be used in the course of property restitution in 1990s. The images can help to identify former plot boundaries, field margins, water courses, and even the number of trees in orchards. Some were used as proofs in court cases that were assessing compensations for property stolen under Communism (Struha 2009).

Colour orthophotos have been available for the whole Czech territory since 2000. The images are updated every 3–5 years, can be accessed at cartographic web pages (for instance geoportal.cuzk.cz), and provide valuable information on the current state of landscape.

In landscape studies, the aerial photographs are often combined with historical and current maps to carry out detailed analyses (see Kupková 2001; Mareš and Štych 2005; Bičík et al. 2012; Boltižiar et al. 2007; Elznicová et al. 2012 and many more).

5.2.5 *Multispectral and Hyperspectral Imagery (Satellite, Aerial)*

Multispectral satellite images have been in use since 1970s. A number of different satellites are currently being used for the data acquisition. Landsat, operated by NASA (U.S.), ranks among the best known ones; NASA archive contains satellite images since 1972. Data collected by Landsat form the main source for the extensive CORINE database (CoORdination of INformation on the Environment—http://www.eea.europa.eu/data-and-maps/find/global#c12=corine). CORINE provides valuable information on land cover in almost all Europe from 1990, 2000, and 2006. CORINE data were used by authors of this publication for interpretation of land cover changes in Czechia (Kupková et al. 2013). Many other scholars have been using CORINE data as well (Romportl and Chuman 2012; Feranec et al. 2007).

As Czechia is a small country, spatial resolution of satellite images is always an important issue. In the case of Landsat, one pixel usually equals to 30 × 30 m. Such a resolution can be used for analyses on regional or national levels. To carry out more detailed analyses, however, satellites with higher resolution are needed. As an example, pixels of the SPOT satellite equal 20, 10, or 2.5 m. More and more commercial satellites are used; imaging is programmed according to customer's needs. These satellites (IKONOS, QuickBird, WorldView 2) provide data with 1–2.5 m spatial resolution. For example, Kupková and Ouředníček (2013) used QuickBird data to analyse land cover changes connected with suburbanization in Prague's hinterland after 1990.

Hyperspectral data have similar size of pixels plus they provide a high spectral resolution. Hyperspectral data can be used for tracing land cover changes; moreover, the very detailed spectral resolution supplies detailed information on various landscape features, e.g. on the state of vegetation. As an example, the state of forests can be analysed using the information on the chlorophyll content in the spectral signal from the aerial data provided by hyperspectral (HyMap) sensor (see Kupková et al. 2012).

5.3 Database of Long-Term Land Use Changes in Czechia

5.3.1 *Database Creation and the Importance for Historical-Geographic Research*

Data from cadastral files serve as a basic source for assessment of land use changes over time. Our research team has created the Database of long-term land use changes in Czechia (1845–2010) (in the further text: LUCC Czechia Database) in the period 1994–2013 as part of a number of consecutive projects. Cadastral data from 1845, 1896, 1948, 1990, 2000, and 2010 are used.

The above-mentioned years coincide with some key events of the modern Czech history. The 1845 data reflect the conditions in times of the 1848 revolutionary movement which paved the way towards market economy. Industrial revolution was already in process, serfdom abolished and the society was ready to move towards a more democratic regime.

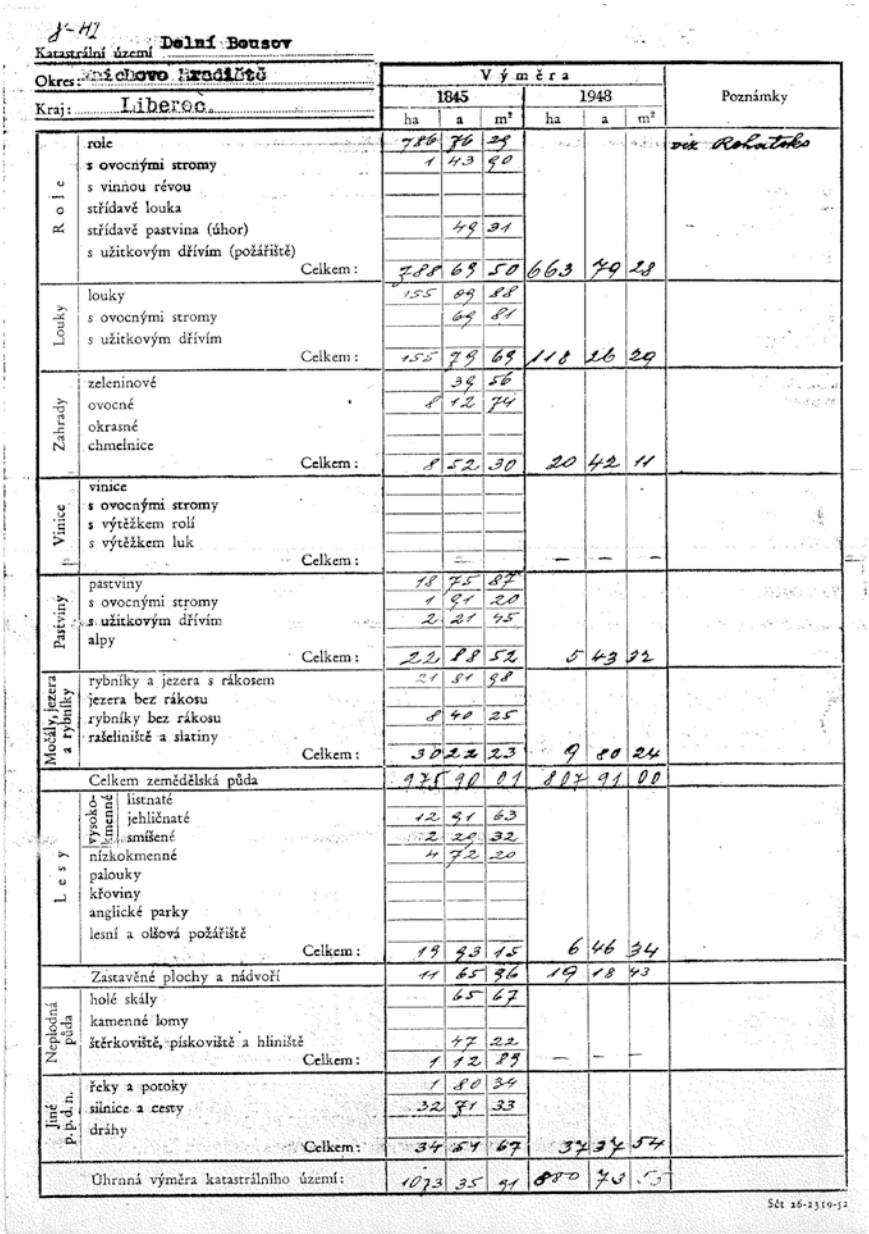
The 1896 data were collected when agriculture was undergoing vast economic and technological changes. Extensive agriculture (including gradual expansion of farmland) had already reached its limits and more intensive measures had to be taken. This period can be seen as a transition from the agricultural revolution towards the first phase of technological-scientific revolution in agriculture. In the same time there was a long-lasting agrarian crisis in 1880s and 1890s.

The 1948 data reflect the final stage of a century-long period when market economy was functioning. In the very same year, Communists seized the power and entirely new political situation emerged. Next, the data of 1990 coincide with the crucial point when centrally planned economy had come to end and market economy was reestablished. Finally, the data of 2000 and 2010 reflect the decade (two decades) of transition that included some stabilization (from 2000 onwards). The post-socialist transition led to a marked downturn in agriculture. Globalization and accession of Czechia to the EU (2004) played an important role in this period too (Bičík and Jančák 2005).

The earliest data are results of the Stable Cadaster mapping that has been carried out on the Czech territory between 1824 and 1843 (see Box 5.1). The written form of these data roughly reflects the situation in 1845 (Mašek 1948; Jeleček 2006a). The files had been first kept in the archives of Ministry of Finance in Prague and later moved to the Central Archive for Surveying and Cadastre. After 1948 separate files were made, one for each cadastral area, and data were transformed from the Austro-Hungarian measurement system to the metric one (1 morgen equalled 5,754.6 m^2). Newly created files were enriched by 1948 land use data in corresponding classification (Fig. 5.3). These data were systematized into 11 land use classes by our research team and digitized. Later, the most recent data were added. The data of 1990, 2000, and 2010 come from the Central Database of Cadastral Office in Prague. Also the 1896 data were added: the main source was the Lexicon from population census in the year 1900 (Gemeindelexikon 1905). In order to secure comparability of data related to six different years, adjustments in terms of territorial unit size and land use classification were necessary.

5.3.2 Compatibility of Land Use Classification

As the land use classification varied year by year and also the number of classes fluctuated (as an example, 52 classes were recognized in 1845, but only 10 in the year 2010), it was inevitable that data should be amalgamated into comparable classes. This comparable classification includes 8 basic land use classes: arable land, permanent cultures (gardens, orchards, hop gardens, vineyards),



Katastrální území: Dolní Bousov
Okres: Mladá Boleslav
Kraj: Liberec

		Výměra 1845 ha	a	m²	Výměra 1948 ha	a	m²	Poznámky
Role	role	786	76	29				viz Rohatsko
	s ovocnými stromy	1	43	90				
	s vinnou révou							
	střídavě louka							
	střídavě pastvina (úhor)		49	31				
	s užitkovým dřívím (požářiště)							
	Celkem:	788	69	50	663	79	28	
Louky	louky	155	89	88				
	s ovocnými stromy		69	81				
	s užitkovým dřívím							
	Celkem:	155	79	69	118	26	29	
Zahrady	zeleninové		39	56				
	ovocné	8	12	74				
	okrasné							
	chmelnice							
	Celkem:	8	52	30	20	42	11	
Vinice	vinice							
	s ovocnými stromy							
	s výtěžkem rolí							
	s výtěžkem luk							
	Celkem:	—	—	—	—	—	—	
Pastviny	pastviny	18	75	87				
	s ovocnými stromy	1	91	20				
	s užitkovým dřívím	2	21	45				
	alpy							
	Celkem:	22	88	52	5	43	72	
Močály, jezera a rybníky	rybníky a jezera s rákosem	21	81	98				
	jezera bez rákosu							
	rybníky bez rákosu	8	40	25				
	rašeliniště a slatiny							
	Celkem:	30	22	23	9	80	24	
	Celkem zemědělská půda	975	90	01	807	91	00	
Lesy	vysokokmenné: listnaté							
	vysokokmenné: jehličnaté	12	91	63				
	vysokokmenné: smíšené	2	29	32				
	nízkokmenné	4	72	20				
	palouky							
	křoviny							
	anglické parky							
	lesní a olšová požářiště							
	Celkem:	19	93	15	6	46	34	
	Zastavěné plochy a nádvoří	11	65	96	19	18	43	
Neplodná půda	holé skály		65	67				
	kamenné lomy							
	štěrkoviště, pískoviště a hliniště		47	22				
	Celkem:	1	12	89	—	—	—	
Jiné p.p.d.n.	řeky a potoky	1	80	34				
	silnice a cesty	32	71	33				
	dráhy							
	Celkem:	34	54	67	37	34	54	
	Úhrnná výměra katastrálního území:	1073	35	91	880	73	53	

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Fig. 5.3 Land register for cadastral unit Dolní Bousov in 1845 and 1948. *Source* COSMC—Czech office for surveying, mapping and cadastre (Ústřední archiv zeměměřictví a katastru)

meadows, pastures, forest areas, water areas, built-up areas, and remaining areas. As meadows and pastures are often difficult to distinguish from each other and the Cadastral Office does not make any difference between them since 2000 either, we amalgamate meadows and pastures into one class—permanent grassland. The "remaining areas" include a number of subclasses—human influenced, half natural, and natural areas—like roads, railways, sports grounds, leisure-time areas, parks, mines, dumps, cemeteries, various kinds of protected areas, unused land, etc.

The above-mentioned structure consisting of eight basic land use classes can be simplified into three aggregate classes: agricultural land (arable land, permanent cultures, and permanent grassland combined), forest areas, and other areas (water, built-up, and remaining areas combined). The 1896 data does not contain basic land use classes of the other areas class. The whole structure of land use classes is outlined in Table 5.1.

Aggregating land use classes certainly brings some simplification—the importance and quality of each land use class change over time (as an example, the permanent cultures of nineteenth century are very different from those at present), plus some "historical" land use classes do not exist any more (multifunctional areas like combination of vineyards and grassland, etc.). That is why care should be taken when it comes to historical comparisons. The early classification, created primarily for tax assessment, allowed more detailed ecological rating.

Table 5.1 Land use classification

Aggregate classes (LUCC Czechia)	Basic classes (LUCC Czechia)	Nature of land use (COSMC 2010)
Agricultural land (AGL)	Arable land (AL)	Arable land
	Permanent cultures (PC)	Hop gardens
		Vineyards
		Gardens
		Orchards
	Meadows (M)[a]	Permanent grassland (PG)[a]
	Pastures (P)[a]	
Forest areas (FA)	Forest areas (FA)	Forest areas
Other areas (OA)	Water areas (WA[b, c])	Water areas[c]
	Built-up areas (BA)[b]	Built-up areas and courtyards
	Remaining areas (RA)[b]	Remaining areas

Explanations [a]Meadows and pastures were recorded separately until 2000; the 2010 data include permanent grassland only (meadows and pastures combined)
[b]In 1896 only data for other areas are available
[c]Bodies of water and water courses
Note COSMC—Czech office for surveying, mapping and cadastre (Ústřední archiv zeměměřictví a katastru)

5.3.3 Territorial Comparability

Historical comparisons require that the territorial units examined should be more or less stable in terms of size. The cadastral system, however, has never been fully stable—the size of some cadastral units varied over time, some units ceased to exist, new ones emerged. In order to ensure comparability, cadastral units have been amalgamated into such units that remained spatially roughly stable over the whole period studied (1845–2010); the maximum fluctuation allowed was 1 %. The year 1990 was chosen as a standard and the rule was that the size of the very same unit (sometimes consisting of a number of cadastral areas) in 1845, 1948, and 2000 should not differ from the size of 1990 by more than 1 %. Later, when the data of 1896 and 2010 were added, a more relaxed 2 % rule was adopted (1896 compared to 1845 and 1990; 2010 compared to 1990 and 2000).

In this way the so-called STU has been created. At the moment there are about 13,000 cadastral units on the national territory (12,696 as of 1845; 13,027 as of 2010) that were amalgamated into 8832 STUs for the research purposes. In some cases one STU consists of two or more amalgamated cadastral units, usually in areas where historically some exchange of administrative territory happened. Almost 80 % of all STUs, however, consist of single one cadastral unit; 10 % consist of 2 cadastral units, 4 % of three, 2 % of four, and the rest (i.e. 3 % of STUs) consists of more than four cadastral units (see Fig. 5.4). Most STUs consisting of two and more cadastral units are found in the core areas (in and around cities and towns), also in mining regions (Northern Bohemia), depopulated border land, and in military areas. On the contrary STUs consisting of just one cadastral unit

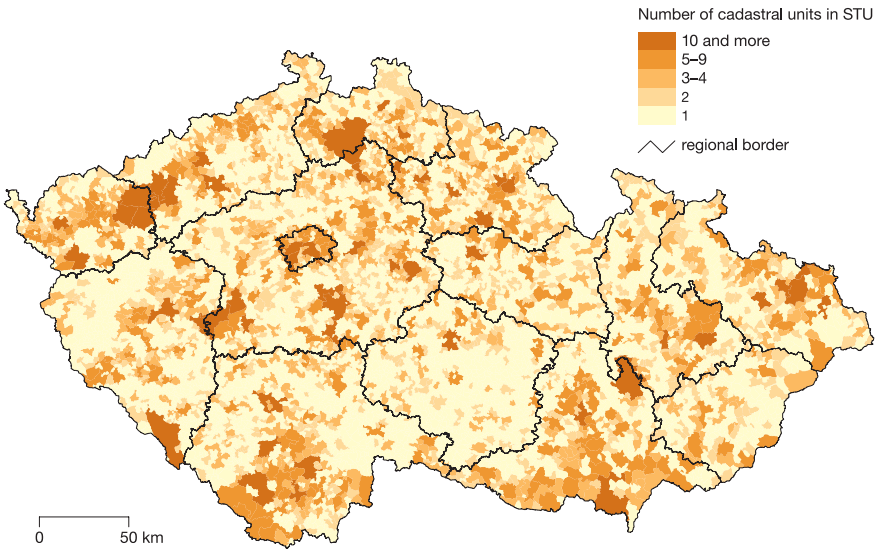

Fig. 5.4 Amalgamation of cadastral units into stable territorial units (STU). *Source* LUCC Czechia Database

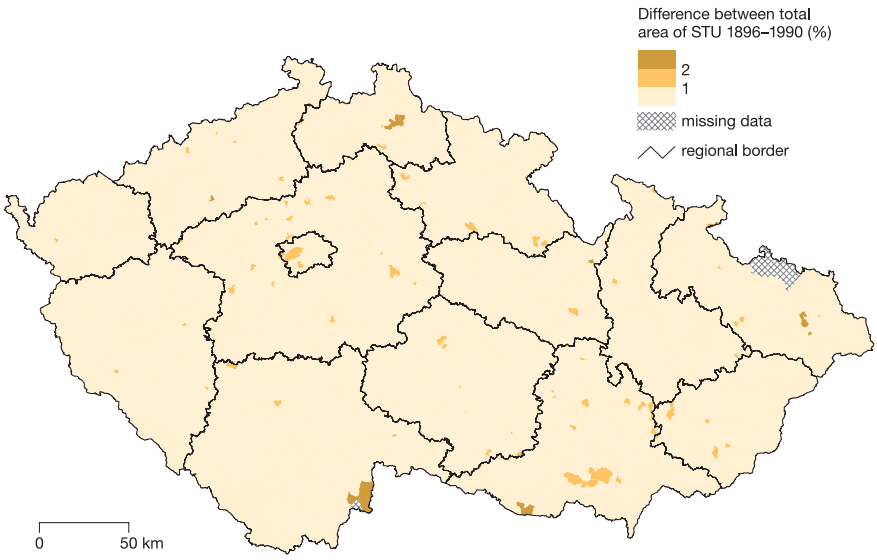

Fig. 5.5 Territorial comparability between 1896 and 1990. *Source* LUCC Czechia Database

are often located in peripheral rural regions (Vysočina, parts of Central Bohemia, etc.). The significantly varying size of STUs should be taken into consideration when statistical analyses are carried out (correlations, etc.). The average size of cadastral unit equals 6.05 km^2, that of STU 8.93 km^2.

It proved to be impossible to comply with the 1 % rule in all cases; however, this criterion is met by 98.2 % of all STUs. The biggest problems of comparability are related to 1845. These data do not include any information from Hlučínsko (Opava District), i.e. 19 STUs are missing. The border changes, though minor ones, that occurred after the establishing of independent Czechoslovakia in 1918 (Valticko, Vitorazsko) also created troubles. Similar problems are related to the year 1896 where data of 20 STUs are missing (see Fig. 5.5). The surveying methods that were becoming more accurate over time also caused minor changes. In general, however, comparison proved to be most difficult in military areas (Ralsko, Hradiště, and more; see Fig. 6.37). In some cases, cadastral units in military areas were being abolished and fully reorganized—as a result, it was necessary to create large and rather heterogeneous STUs.

5.4 Methods of Land Use Change Analysis

This chapter outlines indicators, indices, and quantitative methods used in land use research in Czechia and other countries where comparable data are available (especially Slovenia—see Sect. 5.4.4). Specific use of these methods is discussed in Sect. 5.4.5.

The basic method used in this research is the comparison of land use data by STU related to different years—the areas covered by the same land use class are compared. This approach, however, does not enable to trace land use changes *within* STUs. Section 5.3 explains how the database containing figures by land use classes (Ar_i) in STUs has been compiled; figures were rounded to 1000 m^2 (0.1 ha). These data served as the base for calculation of several indices. The first one equals to the proportion of relevant land use class on the total area of STU (P_i). The formula

$$P_i = 100 \cdot \frac{Ar_i}{Ar_T}$$

relates the area covered by the land use class (Ar_i) to the total size of STU (Ar_T), both in hectares.

5.4.1 Basic Development Indices

The proportions of relevant land use class in different years are used for calculation of the so-called development index (D_{iA-B}). It reflects how the proportion (on total STU area) changed over time. The particular formula is:

$$D_{iA-B} = 100 \cdot \frac{P_{iB}}{P_{iA}},$$

P_{iA} equals the proportion of relevant land use class at the beginning of the examined period; P_{iB} equals the same proportion in the end. The index can range from 0 to ∞; 100 % means no change, more than 100 % indicates an increase, less than 100 % a decrease. Zero would mean that such land use class does not exist any more; ∞ would mean that (in theory) the examined land use class was not present at the beginning.

The development index (D_{iA-B}), however, is not a symmetrical one which poses problems. As an example, an increase from 0.05 to 1 % means that D_{iA-B} would equal 2000 %—in absolute terms, however, such a change would be minimal. As a result, development index should not be used in more sophisticated statistical methods (parametric correlations, regression analysis, etc.). The importance of change is crucial: D_{iA-B} equal to 200 % may indicate increase from 0.5 to 1 %, but also increase from 30 to 60 %! This issue was discussed and analysed by Štěpánek (1996, p. 15) who argued that development indices should be used with great care, recommends "to assess relative changes with regard to absolute extent", and mentioned "dual character of quantitative data".

Štěpánek (1996) also introduced a more precise index labelled "saturation index". The formula reads:

$$S_{iA-B} = 100 \cdot \frac{P_{iB} - P_{iA}}{100 - P_{iA}}.$$

Again, P_{iA} equals the proportion of relevant land use class at the beginning of the examined period and P_{iB} equals the same proportion in the end (in per cent). The saturation index indicates how much of the maximum possible increase really was "filled" over the examined period. Example: in time A the relevant land use class covered 40 % of STU, in time B covered already 70 %; thus one-half (30 %) of the maximum possible increase (60 %) was recorded and the saturation index equals 50 %. Saturation index can range from zero to 100 %; the higher the value, the "more important" the increase. In this way, increases that are very small in absolute terms are eliminated: increase from 0.1 to 2 % results in $D_{iA-B} = 2000$ %, but $S_{iA-B} = 1.9$ %.

Also the saturation index, however, has some imperfections. It can be used only when the proportion of examined land use class increases over time. The index makes no sense in case of decrease and must be altered. The result is a similar index which reflects how much of the maximum possible decrease really was "filled" over the examined period:

$$S_{iA-B} = -100 \cdot \frac{P_{iA} - P_{iB}}{P_{iA}}.$$

When the minus sign is added (as shown above), this index can be combined with the saturation index. It can be used for STUs where decreases have been observed; on the other hand the "real" saturation index can be used for STUs with increases. The "dual character of quantitative data" still remains a problem—for example, increase from 98 to 99 % results in the same S_{iA-B} (50 %) as an increase from 20 to 60 %. By analogy, decrease from 100 to 50 % gives the same result as decrease from 2 to 1 % ($S_{iA-B} = -50$ %).

The relative development index (RD_{iA-B}) is another option (Bičík 1995). In this case, the plain development index is related to development in larger area, for instance in the whole Czechia:

$$RD_{iA-B} = \frac{P_{iB} \cdot C_{iA}}{P_{iA} \cdot C_{iB}},$$

P_{iA} equals the proportion of relevant land use class at the beginning of the examined period and P_{iB} equals the same proportion in the end (in per cent). Similarly, C_{iA} and C_{iB} equal the proportion of relevant land use class at the beginning (end) of the examined period in larger area, for instance on the national territory. $RD_{iA-B} > 1$ indicates that the increase of selected land use class within STU during the examined period was more important (in per cent) than that in Czechia as a whole. On the contrary, $RD_{iA-B} < 1$ indicates more important decrease or less important increase compared with national data. Though in theory also RD_{iA-B} can range from zero to ∞, in reality extreme values are rare which makes the index especially useful. It should be underlined, however, that RD_{iA-B} does *not* reflect increase/decrease of the examined land use class in absolute terms.

In this publication, the proportion change index (PC_{iA-B}) is widely used. It indicates how the proportion of examined land use class changed over the time (in percentage points):

$$PC_{iA-B} = P_{iB} - P_{iA},$$

P_{iA} equals the proportion of relevant land use class at the beginning of the examined period and P_{iB} equals the same proportion in the end (in per cent). PC_{iA-B} ranges from −100 to +100 %; zero indicates no change. Compared to the development index widely used in the past (Bičík et al. 2010), PC_{iA-B} is symmetrical around zero and the maximum value cannot exceed 100 %. Anyway, concerns about the "importance" of changes remain: is the increase from 1 to 6 % equally important as the increase from 61 to 66 %? And, by analogy, is the decrease from 2 to 0 % (i.e. disappearance of the relevant land use class) equally important as the decrease from 82 to 80 %?
The inevitable conclusion is that changes of land use classes over time can be statistically measured by a number of indices, of which none is perfect.

5.4.2 Aggregate Development Indices

The above-mentioned imperfections do not apply to the index of change (Bičík 1995, etc.). This index indicates the intensity of land use changes over a certain period of time; it does not, however, assess the "quality" (structure) of such changes:

$$IC_{A-B} = 100 \cdot \frac{\sum_{i=1}^{n} |P_{iB} - P_{iA}|}{2},$$

IC_{A-B} means index of change between year A and year B; n indicates the number of land use classes; P_{iA} equals the proportion of relevant land use class at the beginning of the examined period; and P_{iB} equals the same proportion in the end. In this publication, five land use classes are taken into consideration ($n = 5$): arable land, permanent cultures, permanent grassland, forest areas, and other areas. Data for these land use classes are available for all examined years. In some earlier publications and articles, calculations included all eight basic land use classes (Bičík 1991; Bičík et al. 2010, etc.).

The higher the index of change, the more intensive the land use change in the area examined. This index ranges from 0 to 100 and—put in a simple way—indicates the proportion of area where *any* land use change occurred, based on the comparison of beginning and end (changes that may occur during the examined period are not reflected). Territorial "shifts" without change of size are ignored, too, though these are relatively frequent, especially in the case of agricultural land. To ensure comparability among periods of different length, the average index of change is calculated (index of change divided by the number of years). Also this index, however, requires caution when it comes to interpretation.

As the index of change is based on the proportions of land use classes, potential changes of STU area over time do not pose a problem (see Sect. 5.3.3). Only changes reflecting the proportions of land use classes are taken into consideration.

The index of change is one of the so-called aggregate indices. In a similar way it is also possible to assess the existing structure of land use, not just changes over time. There are a number of aggregate indices that work with land use classes in order to assess the economic or environmental potential of a selected area. The most important ones are explained in further text.

The coefficient of anthropogenic influence (*CAI*) (Kupková 2002) reflects the degree of human impacts on the landscape. It equals the ratio of the intensively used areas (classes) to the less intensively used ones:

$$CAI = \frac{AL + BA + RA}{PG + FA + WA},$$

AL = arable land; *BA* = built-up areas; *RA* = remaining areas; *PG* = permanent grassland; *FA* = forest areas; *WA* = water areas) (all in per cent). Permanent cultures represent a heterogeneous land use class and are not taken into consideration.

CAI ranges from 0 to ∞; the lower the coefficient, the lower the human impact. Value "1" means that the intensively used areas have the same size as the less intensively used ones.

The so-called coefficient of ecological stability (*CES*) was used quite often in the past (Míchal 1982). *CAI* represents its multiplicative inverse with the exclusion of permanent cultures as stated above. Kupková (2002, p. 141) argues that *CAI* presents a better tool for the assessment of human–nature relations as "…it (*CAI*) reflects the range and intensity of areas that are not natural or that are strongly influenced by human activities rather than 'ecological stability'—vaguely defined ability of the landscape to resist such disturbances".

Slightly different is the coefficient of ecological importance (*CEI*) assessing the complex ecological quality or stability (Miklós 1986). The proportions of land use classes are multiplied by special coefficients that reflect the ecological significance ("quality") of respective classes. Similar approach, with slightly different coefficients, was adopted by Bičík (1995); details in Table 5.2.

$$CEI = \sum_{i=1}^{n} cei_i \cdot P_i,$$

cei_i statistical weight of land use class
P_i proportion of examined land use class on the total area
n number of land use classes

Table 5.2 Weights of land use classes as used in coefficient of ecological importance (*CEI*)

Land use class	*cei*
Arable land	0.14
Permanent cultures	0.34
Permanent grassland	0.64
Forest areas	1.00
Water areas	0.79
Built-up areas	0.00
Remaining areas	0.14

Explanations *cei* = weights used for *CEI*. For other areas, *cei* = 0.30 applies (1896 only) (reflecting the ratio between water areas, built-up areas, and remaining areas). For permanent grassland, *cei* = 0.64 applies (reflecting the ratio between pastures and meadows, roughly 1:2)

CEI ranges from 0 (fully developed land) to 100 (all area covered by forests). The higher the index, the ecologically "more important" the area (more stable, with less human impacts, closer to nature). Similar approach was adopted by Slovenian geographers who developed the "method of arable equivalent" (Gabrovec and Petek 2002, etc.). The proportions of land use classes are multiplied by different coefficients that roughly reflect the amount of energy needed for maintenance (cultivation); energy needed to cultivate arable land is taken as standard.

Comparing the two "ecological" coefficients, Kabrda (2003) prefers the *CEI* to the *CAI* on the grounds that *CEI* better and more precisely reflects the land use structure and changes. For this reason *CEI* is used in further text.

5.4.3 Aggregate Assessment of Land Use Structure

Differences among STUs can also be measured by the structure of land use classes as well as by the proportions of individual classes. Variability (dispersion) is crucial here, measured by variance or standard deviation of proportion of selected land use class in all STUs. Alternatively, coefficient of variation can also be used (Kabrda 2003), calculated as the ratio of standard deviation to average proportion of the selected land use class in all STUs. The coefficient of variation ranges from 0 to ∞ and is indicated in per cent. Zero would mean that the selected land use class has the same proportion in all STUs; the higher the coefficient, the more varied the proportions. The coefficient of variation can also be used for aggregate indices, i.e. for the assessment of changes within complex land use patterns.

Normal (Gaussian) distribution is crucial for successful use of the above methods; in other words, it is expected that "average is typical". Many geographical elements, however, rather show asymmetric (skewed) distribution, more precisely positively skewed (asymmetric) distribution (Hampl 2000) in the sense "many minimal values, few maximal values". In the land use context, skewed distribution is typical for land use classes that are closely related to settlements and urban space (permanent cultures, built-up areas, and remaining areas). In these cases, it is more appropriate to use the rate of heterogeneity (Hampl 2000, 2002, etc.). This indicator shows which proportion of the whole territory (for example, Czechia) is covered by the more dispersed one-half of the selected land use class. Basically, it matches the point on Lorenz curve (constructed by the proportion of selected land use class on the total area of STUs) corresponding to half size of the land use class. The rate of heterogeneity ranges from 50 to 100 %. The higher the rate, the higher the concentration (or less equal spatial distribution) of the examined land use class. The rate of heterogeneity cannot be used for aggregate indices.

5.4.4 Typologies of Land Use Changes

The attempts to assess aggregate changes of land use structure result in a number of typologies. The first method is based on areal increases (decreases) of selected land use classes (Bičík 1995, 1998). The classes that show increase/decrease over the examined period of time are marked "+" or "−"; using combinations of increases and decreases (related to different classes), various types are created.

Also changes of the three aggregate classes (agricultural land, forest areas, and other areas) over time can be compared in this manner. There are naturally different ways how to amalgamate the basic land use classes into aggregate classes. One option reflects the human pressure on land use and distinguishes among (1) agricultural land, (2) forest and water areas) combined (low human impact, often used for leisure-time activities), and (3) built-up and remaining areas combined (much altered by humans through industrialization and urbanization). However, as full-scale data of land use structure are not available for 1896, such analysis cannot be carried out for the whole period examined. Similarly, it is possible to assess the internal structure of agricultural land: arable land, permanent cultures, and permanent grassland.

In this book, the areal extent of individual land use classes (Ar_i) is substituted with the proportion of total STU territory (P_i) which eliminates the varying size of STUs. In this way, STUs can be divided into seven types; the last type (+++) applies only to such STUs where no change was observed (the plus sign includes also stagnation).

When it comes to assessment of agricultural land structure (arable land, permanent cultures, and permanent grassland), eight types (combinations of "+" and "−") can be distinguished. Areal increase/decrease of all three basic classes can appear—depending on the increasing/decreasing extent of agricultural land in the examined STU.

These typologies can be presented in a graphic mode ("typogram") too (Bičík and Kupková 2002). However, one particular type (of land use change) strongly prevailed in each of the periods examined; details will be discussed in further text. As an example, one typical combination was decrease of agricultural land, increase of forests and remaining areas. Decrease of arable land and permanent grassland combined with increase of permanent cultures is another example. To sum it up, this typology is a simple one and indicates directions only, but not any significance of the changes observed.

The method which works with prevailing/dominant land use class is rather similar. Here, STUs are sorted by the basic land use class which is the biggest in size. It somehow reflects the "landscape matrix" (Lipský 1996). In many cases this method does not bring too much new information, however, as especially the dominant importance of arable land or forests is easy to anticipate. In theory, the proportion of 12.5 % of total area (when 8 classes are considered) can be enough to become "prevailing land use class"—as such, this method is often inaccurate. Changes of the prevailing class over time can also be examined.

As the maps derived from the so-called "stable cadastre" covered the whole Cisleithania (present-day Austria, Czechia and Slovenia, plus Galicia, Bukovina, and Dalmatia), similar land use data are currently available also in Austrian and Slovenian archives. Slovenian geographers have developed *typology of landscape changes* (Gabrovec and Kladnik 1997; Gabrovec 1995, etc.) similar to that used by us.

The typology of landscape changes works with five land use classes (partly aggregate) only: (1) arable land and permanent cultures, (2) permanent grassland, (3) forest areas, (4) built-up and remaining areas, and (5) water areas). First, increases/decreases over the examined period of time are calculated. Next, only increases are taken into consideration. STUs are sorted into types according to the land use class which shows the biggest increase. Five types of landscape changes are distinguished: agricultural intensification (highest increase of arable land and permanent cultures), increase of grassland, afforestation, urbanization (highest increase of built-up and remaining areas), and submersion.

Each of the above-mentioned types can be further sorted into subtypes according to the grade of dominance. It is measured by per cent of the "prevailing" increase on all increases combined. Three levels are distinguished: important change (the "prevailing" change accounts for more than 75 % of all changes combines), medium change (50–75 %), and minor change (less than 50 %). Considered the grade of dominance, there are 15 types of change altogether. STUs where any land use change was recorded on less than 1 % of territory are not examined.

The latter method is quite precise and formally accurate, but still not absolutely perfect. It can happen, for example, that in a flat farming region the only land use change would be a slight increase of forest along a creek (say, from 1 to 3 % of total area). Using the typology of landscape changes, however, such change would be labelled as "dominant" in the examined period. Thus, also results of this method should be treated with care and ideally should be combined with some other method reflecting the intensity of land use change (index of change or saturation index—see above).

Bičík (1995, 1998) presents a number of other synthetic approaches to assessment of land use structure and changes like triangle charts or the so-called Wroclaw Dendrit. However, these are relatively complicated methods that bring rather more accurate results than really new information.

5.4.5 Quantitative Methods Used in This Publication

The previous parts of the text deal with the most important indicators and methods that were used in the past research projects dealing with land use changes in Czechia. In this publication the following ones are utilized: proportion of selected land use class in STU, change of this proportion over examined period of time, CEI, index of change, typology of increase/decrease of land use classes, and typology of landscape changes.

The updated version of the LUCC Czechia Database (1896 and 2010 data added) is used in this publication. The data of 2000 were not used as they are very similar to 2010 data. The period between 1990 and 2010 is assessed as one single unit.

The data of 1896 and 2010 are not fully complete as they include less land use classes than the previous version of the LUCC Czechia Database (covering 1845, 1948, 1990, and 2000)—see Table 5.1. This incompleteness had to be reflected when aggregate indices were calculated and typologies constructed. For the sake of comparability, only data of land use classes available in all examined years were used for the calculations of the index of change and *CEI* (see Sect. 5.4.2)—i.e. arable land, permanent cultures, permanent grassland, forest areas, and other areas. The *CEI* coefficients for permanent grassland (0.64) and other areas (0.30) related to the year 1896 had to be constructed too—see Table 5.2.

Similarly, in the typology of landscape changes (see Sect. 5.4.4) only four processes have been distinguished: agricultural intensification (highest increase of arable land and permanent cultures), increase of grassland, afforestation, and other changes (a rather heterogeneous group of STUs with the highest increase of built-up, water, or remaining areas). Especially, the type of "other changes" is questionable. In the past research projects the "urban" type of landscape change (highest increase of built-up areas and remaining areas) was recognized (Gabrovec and Kladnik 1997; Bičík and Jeleček 2009, etc.); however, the results were also inaccurate as remaining areas include rather different subclasses too.

On the other hand STUs where the increase of water areas dominates are quite rare (new artificial lakes). In case when two or more land use classes show the same increase, preference has been given to the class with the smallest proportion at the beginning of the examined period (in other words, with the biggest relative change).

Cartograms and other maps form a good part of this publication. In most cases, legends were created on the base of quantiles (i.e. each class includes the same number of STUs). If the examined index (coefficient) could yield both positive and negative values (or values higher/smaller than 100 %), these important levels were recognized. In such cases, the frequency of STUs is set independently for negative/positive values. STUs with no change were included in the class with the lowest increase. Last, but not least, the number of classes usually ranges between 4 and 6.

5.5 Land Use Changes in Model Areas: Research Methods

Section 5.4 describes research methods that were applied when data for whole cadastral areas were taken into consideration. Apart from that, detailed land use analyses within selected cadastral areas have been carried out; the model areas represent different types of land use changes (see Chap. 7). These detailed analyses enabled to trace landscape changes by plots and to assess structural changes.

Maps from the so-called "stable cadaster" (mid-nineteenth century—see Sect. 5.1), current land use maps (scale 1:5000), and current aerial photographs were used. Land use changes in model areas were detected using GIS. Results show: (1) type of change and (2) exact place where changes took place. Results of this method bring quantitative data as well as spatial information and are more precise than pure quantitative analyses based on numerical data only. In the past, this method was used in a number of studies including Mareš (2000); Štych (2001) and Kupková (2001).

First, compatibility of land use classes must have been secured. Table 5.3 shows all land use classes (subclasses) analysed in all examined years.

In reality, to assign the proper land use class to individual piece of land may pose a problem and the same applies when it comes to exact spatial definition.

Table 5.3 Land use classification

Aggregate land use classes	Basic land use classes	Detailed land use classes
I. Agricultural land (AL)	1. Arable land (AL)	1.1 Arable land
		1.2 Arable land, not cultivated
	2. Permanent cultures (PC)	2.1 Hopyards
		2.2 Vineyards
		2.3 Gardens
		2.4 Second homes with gardens
		2.5 Orchards
	3. Permanent grassland (PG)	3.1 Meadows
		3.2 Pastures
		3.3 Permanent grassland, not used
II. Forest areas (FA)	4. Forest areas (FA)	4.1 Broad-leaved forests
		4.2 Mixed forests
		4.3 Coniferous forests
		4.4 Mountain pine
III. Other areas (OA)	5. Water areas (WA)	5.1 Water areas
	6. Built-up areas (BA)	6.1 Residential housing/yards
		6.2 Second homes/yards
		6.3 Factories, material production/yards
		6.4 Other types of buildings/yards
	7. Remaining areas (RA)	7.1 Field boundaries
		7.2 Swamps
		7.3 Dispersed trees, shrubs
		7.4 Public green space
		7.5 Sport, leisure time
		7.6 Devastated areas
		7.7 Solidified surface
		7.8 Other

Sources LUCC Czechia Database; Vyhláška č. 190/1996 (příloha)

Individual experience of the persons who carried out the mapping may play a certain role too. In order to make the mapping as precise as possible, also aerial photographs were used.

Processing of cartographic data step by step:

- Maps were digitized using a large-scale scanner.
- The digital images were edited (trimming, resolution adjustment, etc.). Maps were transformed into a unified coordinate system. Topol software that includes correctly georeferenced map sheets of "stable cadaster" and maps 1:5000 (field mapping) was used. In some cases, the method of identical points was employed. Cadastral boundaries, major crossings, dykes, corners of important buildings (churches, etc.) were used in order to identify reliable reference points on the source and corrected maps. In such a way, the deviation did not exceed 5 metres.
- Individual patches of land were visually interpreted and vectorized in ArcGIS to ESRI shapefile format. The minimal mapping unit was 4 m^2. Identifiers were attributed according to the legend.
- Areas of land use classes in selected years were calculated.
- Spatial overlay of vectorized layers was made and land use changes were identified.
- Share of areas where a land use change occurred during the examined period of time was calculated and precise position defined.
- Tables and maps documenting the above-mentioned changes were created.

Results of this analysis are presented in Chap. 7. Figures and tables present the extent of stable areas (no land use change) and changing patterns of land use. The spatial distribution of land use classes in the observed years is presented in maps. Thus, time change of land in use in space is well demonstrated.

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Chapter 6
Land Use Changes in Czechia 1845–2010

Abstract The history of land use changes on the Czech territory since the very beginning is outlined; each subchapter deals with one important historical period. The emergence of organized agriculture (Neolithic revolution) is seen as the first period when humans began to influence nature on a certain scale. For thousands of years, however, land use changes were largely limited to inhabited lowlands. The transition from wilderness towards largely agricultural landscape accelerated only during the German plantation (eleventh–fourteenth centuries) when many forests were cleared in the frontier. As a whole, however, changes were rather modest until the eighteenth century. Really important economic and social changes that fundamentally influenced land use patterns have been taking place since the eve of Industrial Revolution. In that time, agricultural society was being gradually transformed into the industrial one at the beginning of the 20th century. The second half of the nineteenth century brought general modernization; agricultural land and arable land expanded to maximum. Since the turn of nineteenth and twentieth centuries, however, reverse trends are recorded: decrease of agricultural land (due to more intensive farming) and gradual expansion of forests. Land use patterns during the twentieth century were much influenced by turbulent political events like Czechoslovak independence (1918), World War II (1939–1945), Communist coup d'état (1948), and restoration of democratic conditions (1989). The Communist legacy included outdated technology and production-oriented agriculture that could not compete on the international markets. The post-Communist period brought restitution of confiscated property (including land) and return to market-oriented conditions. In the most recent period, the accession of Czechia to European Union (2004) has also had profound effects on land use changes.

Keywords Land use changes 1845–2010 · Political and economic changes · Social driving forces · Political and economic transition · Reforms of Czech agriculture

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6.1 Changing Nature of Czech Landscapes: From Neolithic Revolution to Industrial Revolution

The current appearance of Czech landscapes results from thousand years-long human–nature interactions. Ložek (1970) distinguishes three major phases between the Neolithic Era and late nineteenth century: transition from hunters/gatherers to early agriculture and animal husbandry, Agricultural Revolution, and transition from extensive agriculture towards more intensive use of arable land. During the first phase, i.e. before the eve of agriculture, humans were simply part of the nature and human impacts on the nature were comparable to that of big animals.

It was the Neolithic Revolution (emergence of agriculture) that brought fundamental changes into human–nature relations. Some 5000–7000 years ago warm climate reached Central Europe (Ložek 1973) and, as a result, the land could sustain more people. Thus, the existing potential of natural conditions became exhausted; economic and environmental crises followed. The emergence and advance of organized agriculture helped to cope with the first crisis, but contributed to the second one. Hunter-gatherer societies ceased to exist and humans started organized production. People were no more dependent on wild animals and became capable to secure enough food. To do so, much smaller area per capita was needed.

Neolithic agriculture started the second phase of landscape changes. Human–nature relations were already very important (Beranová and Kubačák 2010; Lipský 1995, 1998). This phase lasted until the end of feudalism, i.e. till the turn of eighteenth and nineteenth centuries. Agricultural land gradually expanded; new fields typically emerged on former forest land or permanent grassland. This process, however, was limited just to the most fertile areas labelled by Korčák (1938) as "core population areas" in former Czechoslovakia.

Before the beginning of organized agriculture, much of the land was covered by climax communities. These included first of all forests; forest steppe covered some warm, low-lying areas too. The advance of agriculture caused a permanent decrease of forests, trend that lasted till mid-nineteenth century. In 1000 A. D. some 75 % of Czech territory was covered by forests (Lipský 1998). Due to organized colonization in the High Middle Ages and consequent population increase the forest cover was gradually diminishing. In the end of the eighteenth century forests covered just 25 % of the country; in 1820 the same figure was 29 % and since then forest cover has kept growing in terms of size (Lom 1972, p. 175, Table 11). Nowadays, Czechia has more forests (34 %) than many European countries, and slightly more than Central European countries on average (32.4 %, FAOstat 2014).

The Slavic colonization, focused on fertile lowlands that were still partially covered by forests, took place between the fifth and ninth centuries. Slavs, who moved in from the present-day Ukraine, were mostly farmers, gradually cleared the forests and cultivated the newly acquired areas. They practised the so-called long fallow crop rotation where small fields bordered on wide stripes of grassland

that were occasionally ploughed (Beranová and Kubačák 2010; Lom 1972; Černý 1992). Robinson (2004) uses the terms "bush fallow" (fallow period 5–10 years) and "forest fallow" (more than 10 years).

The lack of population in the early phases of Czech mediaeval state (that had been formed in the tenth century) meant that there were not enough people to colonize the hilly, forested border regions—though conditions were favourable, thanks to rather warm and humid climate that lasted till mid-fourteenth century. Sparse Slavic settlers began to mix with German migrants coming from the west (Jeleček and Boháč 1989; Lom 1972). Consequently, agricultural land expanded also in less favoured regions with poor soils.

To secure enough population, Czech rulers, nobility, and church authorities tried to attract settlers from overpopulated Germany by organizing plantations. In Czechia this happened between the end of 12th century and beginnings of 14th century. The "border forest" has been gradually cleared; in some areas, German settlers advanced even further east to the silver mining regions in central part of Bohemia/Moravia, and also to scarcely forested uplands (Černý 1988, 1992). Agricultural land expanded, hundreds of villages were founded and the agricultural business was organized on the grounds of emphyteusis.

Such plantations were no exception in mediaeval Europe—much of Central and Eastern Europe, also western parts of the British Isles, were colonized in a similar way. Settlers often brought new technologies and more advanced agricultural practices and contributed to development.

The transition from wilderness towards largely agricultural landscape, however, was not a linear, uninterrupted process. Human impacts on the nature were becoming more and more intensive and were enhanced by new technologies and innovations. From thirteenth until sixteenth century, new towns were being founded, lakes created to support fishing, mines opened…. Climatic changes proved to be an important factor too: agricultural production usually decreased during cold periods which sometimes caused famines and population downturn. The character of landscape, of course, was much influenced by social and political factors: these also included frequent wars like Hussite Wars (1415–1431) and Thirty Years' War (1618–1648) (see Box 6.1).

Though cultivated land expanded significantly, still there was a sort of cooperation between man and nature. While new habitats emerged, biological diversity began to decrease (trend that continues till present—see Veverka 1987; Ložek 2007), and human-induced erosion began, the above-mentioned changes were not markedly disturbing the natural balance.

There have been several factors contributing to increased erosion since thirteenth century: deforestation, introduction of more intensive modes of cultivation (crop rotation) and also extensive use of more advanced ploughs. Due to expansion of sugar beet, potatoes, and maize, mass increase of soil erosion has been documented since nineteenth century.

Changes in agriculture, population, transport, crafts, etc., however, were rather slow until the eighteenth century. As a result, from the environmental perspective "…there was no major difference between a Neolitic settlement and an

18th century village" (Ložek 1970, p. 76). Among the reasons were the devastating impacts of Thirty Years' War when the population of Bohemia and Moravia was reduced by one-third. Consequently, a great deal of settlements were abandoned, cultivated land shrank by about 50 %, and much of the land was naturally "invaded" by forests and grassland.

The second phase of development of Czech rural landscape came to its end in late eighteenth century when the effects of Agricultural Revolution started. The agricultural practices changed, crop rotation was gradually substituted by more intensive ways of cultivation. Forage crops, potatoes, and sugar beet became widespread; also animal husbandry grew. Agricultural revolution reached its climax in late nineteenth century (Jeleček 2006, pp. 25–27).

As a result of social and economic changes in that period, agricultural land became very much fragmented; most farms and agricultural businesses were rather small. Thousands of tiny fields and plots were separated by countless grass or bush field bounds/paths, and countryside roads that helped to maintain the environmental stability, to reduce erosion, and contributed to biological diversity (Jeleček 1991, 1995a; Bičík 1988).

The third phase of development of Czech rural landscape started in late nineteenth century and was characterized by advancing capitalism, industrial revolution, industrialization, and population growth. The marked changes Czech landscape has undergone since mid-nineteenth century are examined and discussed in this book. Major findings dealing with the period until the end of the twentieth century were published in Land Use Policy (Bičík et al. 2001).

Hampl (1992, 1994) elaborated the above-mentioned three phases of human–nature interaction defined by Ložek (1973). Hampl talks about (1) nature determination (roughly till the beginning of Modern Era), (2) competition (nineteenth and twentieth centuries), and (3) cooperation (at present). Such a concept brings a lot of inspirations; in our opinion, the third phase (cooperation) has not yet gone beyond its initial part and reflects the regionally uneven "global fight" between the policy makers and free movement of capital. The terms "cooperation" or "dialogue" rather define the measures and tools that contribute to sustainable development.

Box 6.1 Deforestation/Reforestation
Deforestation and consequent expansion of cultivated land have had crucial environmental impacts in the period of intensive colonization in the thirteenth and fourteenth centuries. As an example, in Drahanská Uplands (Western Moravia) some 117 settlements had come into existence till the end of the fourteenth century. This process reduced the percentage of forest cover from 95 % to about 45 %. However, as many settlements ceased to exist after the Thirty Years' War, forests began to expand again and nowadays cover some 62 % of the territory (Černý 1992).

6.2 Basic Overview of the Political and Economic Changes in Czechia in the Period of 1845–2010

Political and economic driving forces form the most important group of societal (social) driving forces that influence land use patterns in space and time. They do so in interaction with natural driving forces (for more information see Sect. 4.2.1). A sound knowledge of these driving forces helps to find the answer "why" exactly the observed changes happened (and not different ones). It also contributes to the prediction of future land use/cover changes (Jeleček 2002, 2007, p. 1159).

Key historical events, changes in modes of production and peoples' lives, technological advance, changing social structure, etc. (i.e. societal driving forces) kept accelerating since the end of the eighteenth century. Purš (1973b, p. 365) argues that the above-mentioned changes cannot be explained just by traditional methods of historical science or by sociological generalizations. In such a way, historical events would lack the context of geographical organization and natural driving forces (compare Purš 1973a, b; see also Worster 1988, p. 293, 1990, p. 1090; Simmons 1993, 2003; Mannion 1995). Historical land use as well as historical geography blend with the modern interdisciplinary science of environmental history, which "…deals with the role and place of nature in human life. It studies all the interactions that societies in the past have had with the non-human world, the world we have not in any primary sense created" (Worster 1990, p. 1089). Thus, they present a synthesis and research of interaction within the system perceived as a complex of human society (including culture, i.e. way of life, thinking, and economy), technology, and nature; in general term, the geographical organization. In other words, we talk about the traditional triad "Nature—Culture—Technology".

Box 6.2 History and space (Historical-geographic holism)
"The significance of the revolutionary changes which have been taking place at an accelerated rate over the past 200 years and which have changed human life, can not be expressed to their full extent by a chronological record, or by a summary of sociological generalizations which segregate the meaning of historical events from their association with the geographic medium and the conditions of the historical relations of the individual phases of evolution. One must draw on as extensive a set of significant facts as possible; however, their relations can only be understood on the background of the network of the fundamental trends of evolution of longer periods of time characterized by the relative unity of the way of life and thinking of the people" (Purš 1980, p. 135).

"The most important trend within the examined period was the growing importance of economic and social factors in the context of rapidly spreading technological and social innovations. Regarding the value of land as a natural resource, in fertile regions the economic aspects prevailed (due to stronger influence of differential rent II on agricultural intensification); in the less fertile areas the environmental aspect was the most important one" (Jeleček 2007, p. 1062; Bičík and Jeleček 2005).

Societal driving forces that influenced most the trends of land use changes in Czechia serve as a base for definition of major periods of land use changes. By chance, the years for which land use data are available coincide with some of the major events of the modern Czech history (for more information see Pánek et al. 2009).

Table 6.1 outlines the most important societal driving forces of land use changes, i.e. includes the major political, social, economic, technological, and cultural events of the period 1845–2010.

6.3 On the Eve of Industrial Revolution

Revolutionary movements of 1840s symbolized the turn of two historical periods. The final phase of transition from feudalism towards capitalism gave way to a number of processes collectively labelled as "Complex Revolution of Modern Era" (Purš 1973a, b, 1980). Industrial revolution formed an important part of it: agricultural society was being gradually transformed into the industrial one and also agriculture moved from pre-industrial phase into the industrial one (Fischer-Kowalski and Haberl 2007).

The land use data of 1845 (Fig. 6.1) show land use structure as a result of centuries-long gradual agricultural use, before industrialization. Data were collected during field mapping between 1826 and 1843. The extent of agricultural land reflected the high population density (85 people per sqkm in mid nineteenth century—ČSÚ 2006) and also relatively high economic level. Extensive farming prevailed, natural conditions were of average quality (mostly uplands and highlands—see Chap. 3). Agricultural land covered two-thirds of the country in 1845 and arable land itself almost one-half; the arable land–permanent grassland ratio was about 1:2.75 (see Fig. 6.1). As in many areas crop rotation was still practiced, part of the arable land lay fallow. In mid-nineteenth century about 500,000–700,000 ha, i.e. ca. 15–20 % of arable land lay fallow on the Czech territory (Jeleček 1991, 1995b; Kušková et al. 2008).

The expansion of farming resulted in gradual diminishing of forests that covered only 29 % of the country in 1845 (see Fig. 6.1). Moreover, most forests were in relatively poor conditions due to excessive logging (fuel, construction) and other economic use; forest regeneration was inadequate (Mather 2002; Gingrich et al. 2007). Built-up areas, water bodies, and other areas covered just a small

Table 6.1 Major societal driving forces of land use changes in Czechia 1845–2010

Political		Social and economic	Technological
International	Domestic		
1845–1896			
Revolution 1848/1849	Revolution 1848/1849	Abolition of serfdom and transfer of peasants' land to farmers (payments required) Market economy Land and workforce became components of the market	Revolutions finalized: 1. Industrial revolution 2. Agricultural revolution 3. Transport revolution 4. Demographic revolution (ca. 1880s and 1890s)
Austria defeated by Prussia in 1866 German unification in 1871	Beginnings of democracy Austro-Hungarian compromise of 1867 (the dual monarchy of Austria-Hungary established) 1867 Constitution—fundament of modern society Beginnings of "monopoly capitalism" 1870s	Tariff-free market in the whole Austria-Hungary Competition of cheap grain imported from the U.S. Financial crises 1873–1879 Agrarian crisis in 1880s, 1890s	New farming methods—no more land lies fallow (1890s) Mechanization, introduction of fertilizers and pesticides (big estates only) Agricultural tariffs imposed
1896–1948			
World War I (1914–1918) Disintegration of Austria-Hungary (1918) Czechoslovakia gains independence (28 October 1918) Close political and economic ties with western countries	Democracy Universal suffrage (1907)	Agricultural boom (1905–1912) First Agrarian Reform (1919–1938) Agricultural tariffs still in effect Great depression 1929–1933	The effects of differential land rent II keep rising Spread of mechanization, extensive use of fertilizers and pesticides Cereal crops retain dominance

(continued)

Table 6.1 (continued)

Political		Social and economic	Technological
World War II 1939–1945 Transfer of ethnic Germans from Czechoslovakia 1945–1947	About one-third of Czech territory annexed by Nazi Germany (1938) Protectorate of Bohemia and Moravia (1939–1945)	War economy Ration stamps in effect Resettlement schemes in the frontier largely unsuccessful (1945–1989)	Economic restructuring, focus on arms production
1948–1990			
The "Iron Curtain" Cold War 1948–1989	25 February 1948: Communist coup d'état, Czechoslovakia part of the Soviet sphere of influence Introduction of centrally planned economy, nationalization	Major changes of social and economic conditions (1948–1960s) Collectivization, large cooperatives and state-owned estates come to existence (1948–1960), often on nationalized and confiscated land	Amalgamation of fields, large drainage schemes
Global bipolarity (U.S. vs. Soviet Union)	Unsuccessful attempt to reform the socialist system in late 1960s (Prague Spring)	High military expenditures	Advanced harvesters and other machinery introduced
COMECON (1949) and Warsaw Pact (1955) founded	Czechoslovakia occupied by Soviet troops (1968–1991)	Economic and financial crisis in 1960s, beginning of agricultural intensification Collectivization reached climax	Fertilizers and pesticides used at large scale Further amalgamation of fields and cooperatives (since 1970) Agricultural land protection act passed (1976)
European economic community created (1957)	Oppressive regime; political freedom and human rights severely restricted Massive emigration to the West		"Special conditions" in effect in regions close to the Iron Curtain

(continued)

Table 6.1 (continued)

Political		Social and economic	Technological
1990–2010			
Collapse of Communist regimes in Central/Eastern Europe, end of Soviet dominance Accession to NATO (1999) Accession to the European Union (2004) Czechia reestablishes close ties with Western countries Multipolar world system	"Velvet Revolution" (November 1989) Collapse of Communist system Democracy, civil and human rights reintroduced Fundamental social and economic transformation Laws on agricultural land protection passed	Privatization of "national property" (big, small privatization) Restitution of property seized by the Communists including land and real estate (nobility and church also partly eligible) Cooperatives and state-owned estates transformed into capitalist-style businesses Suburbanization Construction boom at city margins and in suburban zones	
	Disintegration of Czechoslovakia; independent Czech Republic (Czechia) and Slovak Republic (Slovakia) come to existence (1 January 1993)	Foreign nationals eligible to acquire land in Czechia (2013)	

Note: Czechoslovakia has split into Czech Republic and Slovak Republic. These are official names; short geographical names used in both countries are Czechia and Slovakia

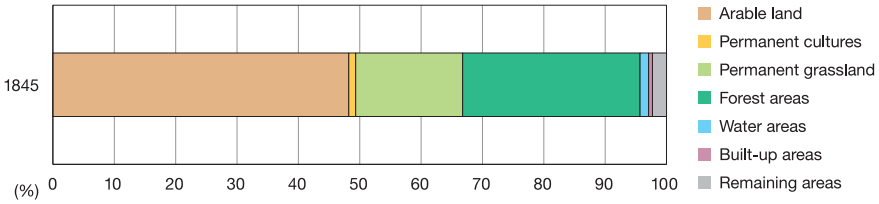

Fig. 6.1 Land use in Czechia 1845. *Source* LUCC Czechia Database

portion of the country—less than 4.5 % combined in 1845 (Fig. 6.1). Such a land use structure clearly shows the attempt to maximize agricultural use in conditions of low yields and growing demand for food by urban population (Fischer-Kowalski and Haberl 2007). Most fertile plots were ploughed and the rest (sloping land, wet, stony, or remote plots) was used at least for grazing or hay making.

The regional land use patterns of mid-nineteenth century were influenced by differential land rent II, i.e. reflected natural conditions and location. Most of arable land (Fig. 6.2) was found in lowlands and low-lying uplands; much of permanent grassland (Fig. 6.3) occurred in highlands and in the mountains, especially in the southern half of the country. Similarly, forests (Fig. 6.4) were mostly found in higher altitudes, in the borderland and also in deep valleys and highlands (South Moravia, Central Bohemia). Built-up areas (Fig. 6.5) concentrated in lowlands and also in industrial regions at the foot of mountainous areas (Northern Bohemia). Built-up areas, however, were rather evenly spread in these regions (about one-half of built-up areas occurred in 35 % of STUs and not yet concentrated around cities and towns or along major transportation routes). The contrast between the more

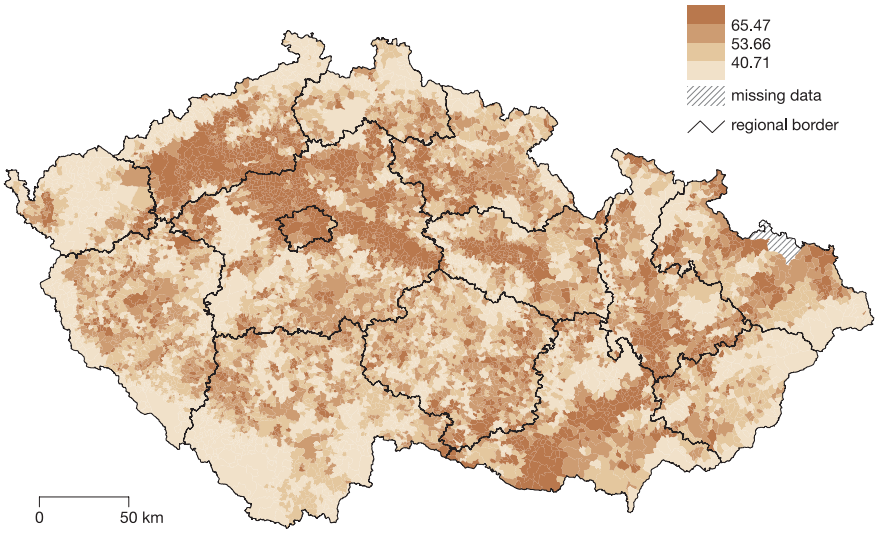

Fig. 6.2 Proportion of arable land in 1845 (% of STU area). *Source* LUCC Czechia Database

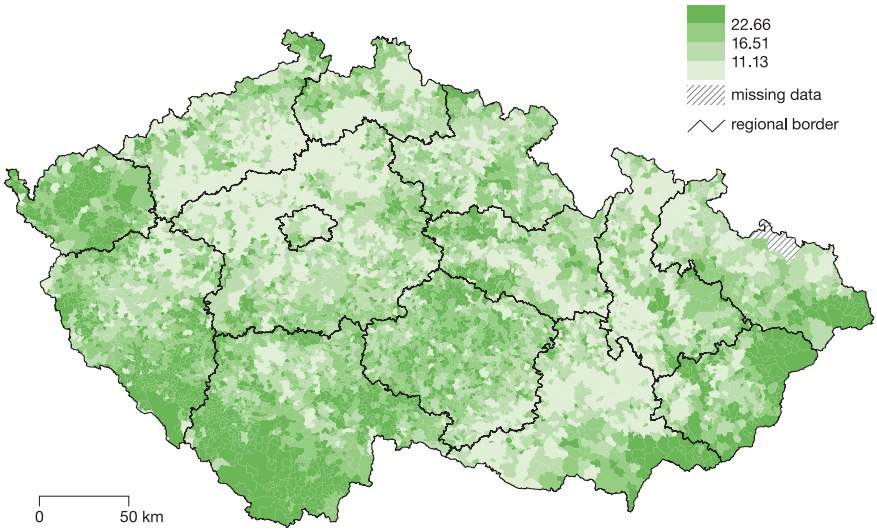

Fig. 6.3 Proportion of permanent grassland in 1845 (% of STU area). *Source* LUCC Czechia Database

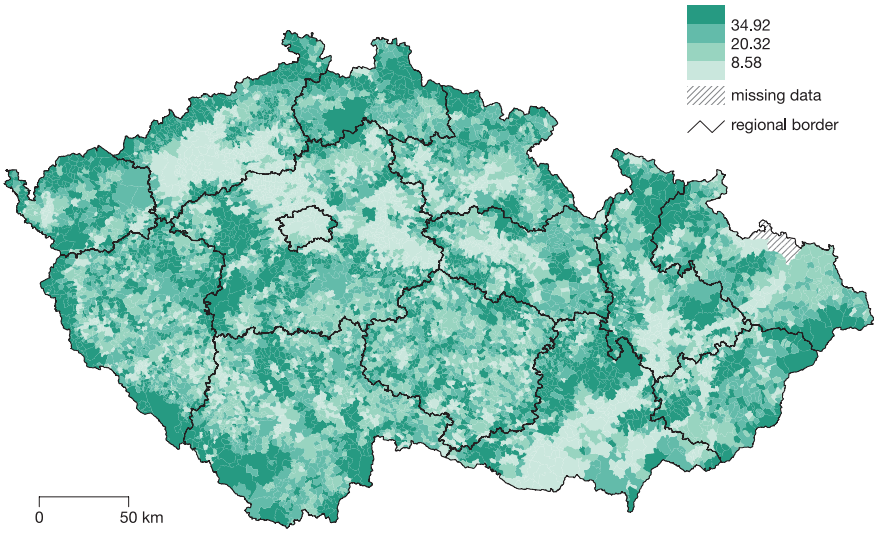

Fig. 6.4 Proportion of forest areas in 1845 (% of STU area). *Source* LUCC Czechia Database

populated northern half of Bohemia and the sparsely populated southern half was striking—fact mentioned by Korčák (1938) or Hampl et al. (1987). In Moravia, most built-up areas were found in the lowlands of South and Central Moravia (Fig. 6.5).

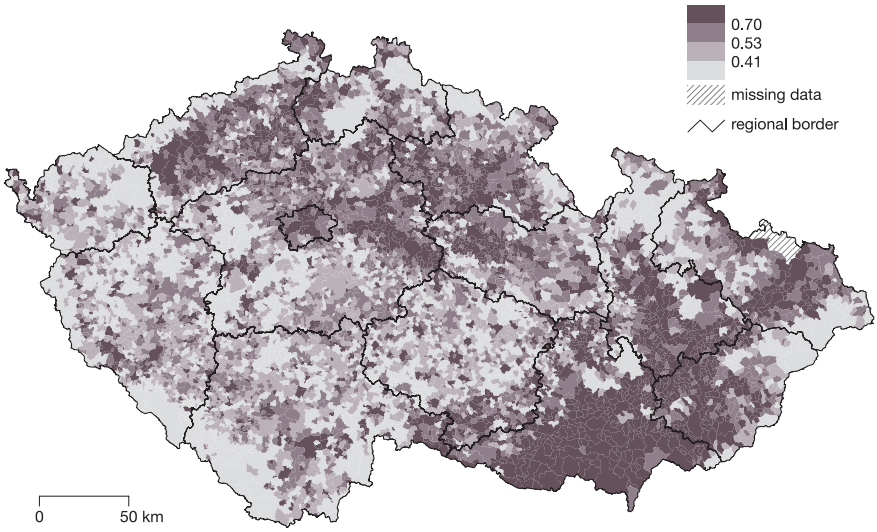

Fig. 6.5 Proportion of built-up areas in 1845 (% of STU area). *Source* LUCC Czechia Database

In general, regional differences of land use structure were rather small, especially as regards arable land and permanent grassland. In one-half of all STUs arable land covered 40–65 % of the area, permanent grassland 10–20 %, forests 10–35 %, and built-up areas 0.4–0.7 % (LUCC Czechia Database). Typically, Czech landscape was covered by a mixture of fields, meadows, pastures, and forests (see Chap. 7). Land use patterns were rather heterogeneous on local level—and, on the contrary, relatively homogeneous on national level.

Economic and technological limits of the pre-industrial production mode were behind the relatively low regional differences. Transport remained slow and costly (see Sect. 2.3), long-distance trade and competition limited. Most products were consumed locally, spatial division of labour and specialization remained weak (Hampl 2000). Most of material goods, energy, etc. circulated within a limited space only (farm, village, manor) and relations with the surrounding environment were weak—with few exceptions like exports of agricultural surpluses to the nearest town (Gingrich et al. 2013). Consequently, different land use types had to be spatially interconnected. Everywhere, including mountainous regions (see Fig. 3.1), it was essential to possess enough arable land (to provide food), grassland (for livestock), and forests (to provide fuel and construction material) (Krausmann et al. 2003). This system secured environmental balance as well as local balance of biophysical transfers of chemical elements and nutrients (Krausmann et al. 2003; Gingrich et al. 2013).

The Coefficient of Ecological Importance (CEI) reflects well the general land use patterns. Higher values of CEI indicate low human impact on the environment. The importance of differential land rent in mid-nineteenth century was undeniable—human impact decreased from lowlands towards higher, sloping grounds

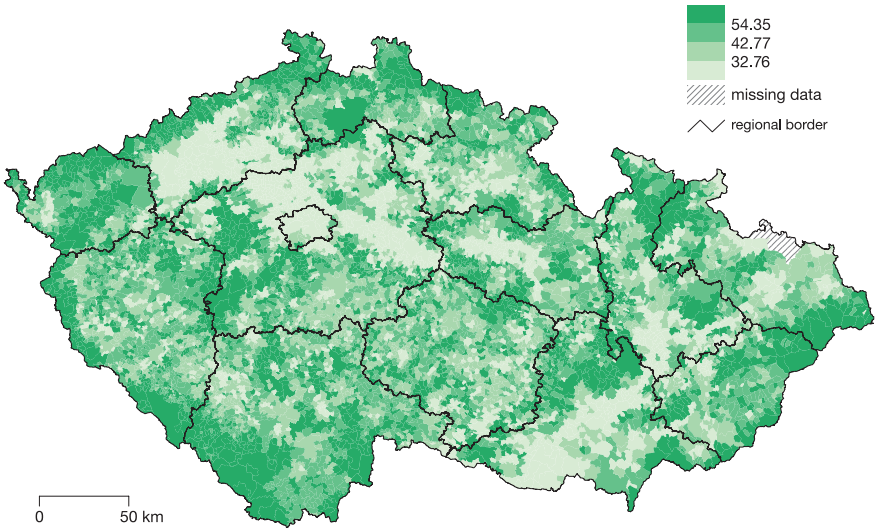

Fig. 6.6 Coefficient of ecological importance in 1845 (in %). *Source* LUCC Czechia Database

(Fig. 6.6). These differences, however, were not huge. About 50 % of STUs showed levels of CEI between 30 and 55 %; less than 20 % or more than 80 % was detected just in about one-tenth of STUs (LUCC Czechia Database). Also these figures prove that regional differences of land use patterns were rather small on the eve of Industrial Revolution.

6.4 Extensive Farming at the Peak: 1845–1896

The territory of the present-day Czechia as well as other European countries experienced fast modernization in the second half of the nineteenth century. The revolutionary movements of 1848–1849 brought the end of feudalism: serfdom was abolished, industrial revolution accomplished, and the path towards new social and economic organization, free market capitalism, was open. Democratic processes within the society began and the social movements in general became faster.

6.4.1 Driving Forces of Land Use Changes

Industrial revolution was the most important single aspect within the broader modernization processes of the second half of the nineteenth century (Jeleček 2006, pp. 302–303). In the course of few decades, Bohemia and Moravia combined

became an important industrial power. This territory accounted for just 20 % of the total population of Austria-Hungary, but generated 60–70 % of its industrial production (Semotanová et al. 2014).

Box 6.3 Industrial Revolution in Bohemia and Moravia
The territory of the present-day Czech Republic was among the most developed parts of Austro-Hungarian Empire already before the revolutionary years 1848–1849. Textile industry, production of glass and ceramics were among the key branches. Workshops manufacturing various goods were widespread in the whole northern frontier, Bohemian-Moravian Highlands, and the Jeseníky Mountains already in the second half of the eighteenth century. Similarly, a lot of production was concentrated in the growing cities and towns including Prague, Pilsen, Ústí nad Labem, Liberec, Brno, and Ostrava (see Fig. 4.1). The mode of production gradually shifted from manufactures towards larger factories. Steam engines became widely used in metallurgy since 1840s, especially in the coal mining areas (Ostrava, Kladno, north-western Bohemia), in cities and towns. Large industrial companies were founded (ČKD Praha, Škoda Plzeň etc.), comparable to those already existing abroad. Food industry, especially sugar refineries, developed in the fertile lowlands, as did production of agricultural machines. Distilleries and starch factories became abundant in the higher regions; these were often linked to other industrial enterprises by local railways (see Fig. 6.8). Railways were supported by the state and contributed a lot to economic development. There were 5.9 km of railways per 100 km^2 in 1875; in 1905 the same figure was 10.7 km (see Fig. 6.7).
Sources: Purš 1960, 1965, Hlavačka 1990, Semotanová et al. 2014

Box 6.4 The level of industrialization of Czechia in late nineteenth century
Bohemia and Moravia were highly industrialized already in the end of the nineteenth century. In 1890, some 43 % of the workforce was employed in industry and mining. Agricultural population stagnated, but its share declined: there were 3.6 million farmers (60 % of the population) in 1850, and 3.7 million farmers (just 45 % of the population) in 1890. At the turn of the twentieth century Bohemia and Moravia became an industrial country. Marked regional inequalities existed, however. The northern half of the country was more industrialized and urbanized; on the contrary, the regions in the south remained rather rural—difference which can be seen even nowadays. Cities and towns grew in the north, metallurgy, chemical industry, and production of machines developed (Purš 1960; Jakubec et al. 2007; Hampl et al. 1987).

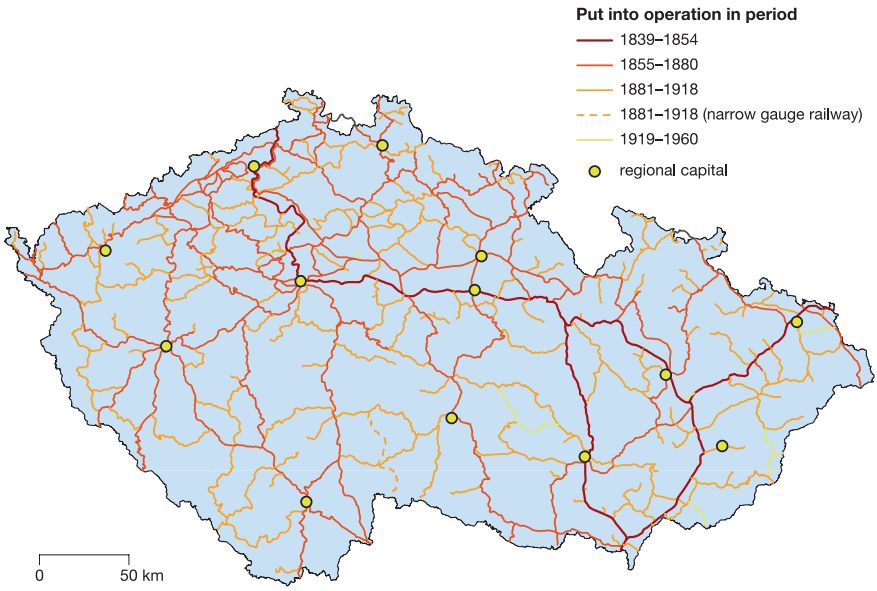

Fig. 6.7 The advance of railways in Czechia. *Sources* Purš (1965); Hlavačka (1990); Bičík et al. (2010)

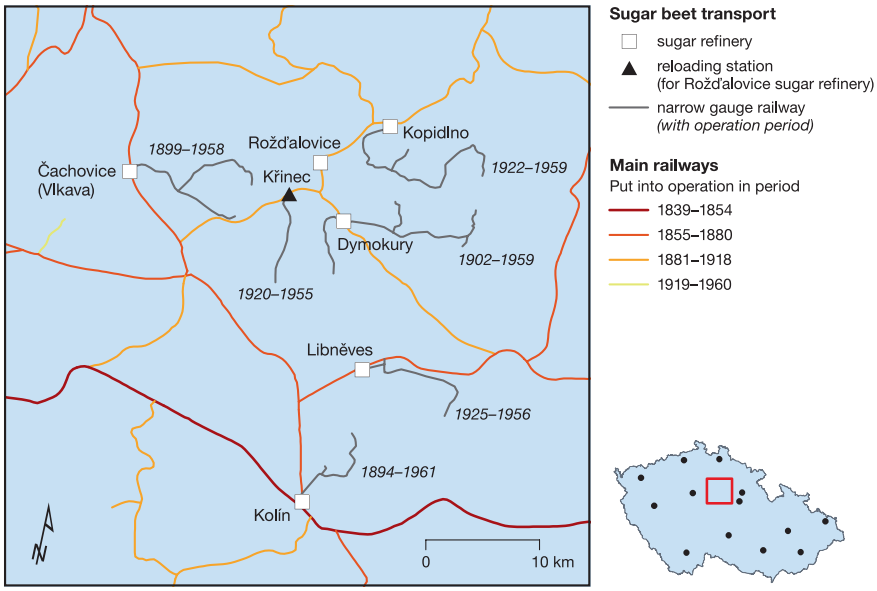

Fig. 6.8 Sugar refineries and "sugar railways" in the central Elbe Plain north of Kolín. *Sources* Vyskočil (2010), Purš (1965), Hlavačka (1990), Bičík et al. (2010), Strnad (2010), Bauer (2003). *Note:* The map shows sugar refineries that could be accessed by narrow gauge railways (sugar beet for the refinery in Rožďalovice was reloaded in Křinec) plus the major railway lines. Starting and closing years are indicated

Modernization processes were ongoing in the economy as well as in the society. Population rose quickly, from 7.7 million (1869) to 10.5 million (2010). Even more important, the population patterns changed. The proportion of urban population grew from 20 % (1850) to 50 % (1900) (Fialová et al. 1996). Most urban dwellers, however, lived in small towns: in 1910, just 25 % of the population lived in towns that had more than 10,000 inhabitants (Hampl et al. 1987). Rural depopulation was taking place especially in remote areas with poor natural conditions, far from the market centres. The relative decline of farmers was balanced by technological advance.

6.4.2 Political and Institutional Reforms in Agriculture

Institutional reforms had important effects on agriculture and land use in the second half of the nineteenth century. Land tenure changed as did the use of agricultural and forest land. Until the revolutionary years 1848–1849 most small farmers did not own the land they actually cultivated. The system was based on a long-term lease which increased the costs of production; the land was owned by nobility or by the church. Typically, within a village the land was fragmented into large segments that corresponded to crop rotation; farmer had at least one plot in each segment. Within the segments just spring plants or winter cereals, or the whole segment lay fallow. Some parts of the agricultural land, often pastures, were managed on the communal base.

After the revolutionary years 1848–1849 much of the land that had previously been owned (and rented out) by landlords became property of small farmers. The former owners, however, were partly compensated by the farmers (two-thirds of the value) and also by the state (one-third). Consequently, many farmers became heavily indebted; on the other hand, the finances received allowed the landlords to invest money into modernization.

Even after the above-mentioned reforms there were still a number of restrictions, especially when it came to plots fragmentation. The size of farms usually could not be smaller than 3–6 ha and could be inherited by one heir only. Heirs had to compensate financially other potential heirs which led to debts. These restrictions were abolished only in 1866–1869 when new Land Act was passed; since then, farmers were allowed to manage their land freely and the capital could easily circulate.

The land use patterns became more or less stabilized in 1880s and 1890s, following a long-term increase of arable land. The acreage of arable land, however, started to decline in terms of size afterwards as on some plots the costs of production were too high to meet the differential land rent II. On the national level, the proportion of arable land has been gradually declining until the present time; on the contrary, forests have been expanding.

The differences between large estates and small farmers remained striking. The proportion of small farmers on the agricultural land rose slowly: in Bohemia from

58 % (1839) to 62 % (1896). In the same period the proportion of land owned by big landlords declined from 42 to 38 %. In 1896 farmers who owned less than 20 ha managed just 38 % of agricultural and forest land (of this, 12 % of farms were smaller than 5 ha), but accounted for more than 80 % of all agricultural businesses. Middle-sized estates (20–100 ha), the core of rural middle class, cultivated just 24 % of the total agricultural land. On the contrary, the largest estates (2000 + ha) that numbered just 150 owned 25 % of agricultural and forest land (for more details see Jeleček 1985; data collected from Lom 1939 and Říha 1949).

In many cases even the land owned by small farmers within a single village was much fragmented. Such a situation resulted from the liberal laws as well as from the long-lasting crop rotation system. The state sponsored attempts to amalgamate land were largely unsuccessful.

The Austro-Hungarian agricultural policy included high tariffs and state monopoly on import of cereals. Even more strict tariffs were being imposed since 1880s. Hungary benefited most from this policy, as did large estates in Cisleithania and partly also middle-sized farms. Farmers in Cisleithania (including Czechia) on the one hand benefited from the large Austro-Hungarian market; on the other hand they were facing competition from Hungary where natural conditions for agricultural production were better.

6.4.3 Agricultural Revolution in Czechia

The agricultural revolution that culminated in 1880s and 1890s was part of the broader "complex revolution of the Modern Era" (Jeleček 2002, 2006, p. 352). It included transition between two phases:

1. Extensive farming came to a climax in 1870s; until then, the rise of agricultural production was secured by expansion of land under cultivation.
2. Further territorial expansion of agricultural land was no longer possible since 1880s. This fact, aided by scientific and technological advance as well as by capital investments, enabled the gradual transition towards more intensive farming. Since then, increase of production has been secured by higher yields on the existing (or slightly declining) extent of agricultural land.

The agrarian crisis of 1880s and 1890s was much influenced by cheap agricultural imports, especially grain, from Midwestern United States. As a result, agricultural patterns in Western Europe changed. The import of U.S. grain accelerated after the transcontinental railway had been finished and steamers introduced on the transatlantic sea routes. The European agrarian crises, however, was also influenced by the financial failures in Vienna (1872) that resulted in the so-called Panic of 1873. It was the first crisis of overproduction in Austria-Hungary.

As the access to funds was unequal, differences between large estates and small farmers regarding the available technologies grew. The transition from crop rotation system (that combined cereals production and fallow land) towards a more

advanced organization was essential for the introduction of intensive farming. The Norfolk four-course system was the most important one. It had been used in Czechia at a limited scale already since early nineteenth century and prevailed since 1850s. It was characterized by the absence of fallow year and by an emphasis on new fodder crops and root crops (mainly potatoes and sugar beet) together with a slight decrease of cereals. For details, see Sect. 4.2.2.

The Norfolk four-course system was widely used until mid-twentieth century. Its basic form included rotation of four crops: winter cereal (wheat) → potatoes or sugar beet → spring cereal (barley) → fodder crop (clover). Yields increased substantially and the system was sustainable, with minimal energy inputs (Fischer-Kowalski and Haberl 2007).

Compared to other European countries, the proportion of cereals remained high—in total, cereals were grown on more than 60 % of arable land (see Table 6.2). Much of the general increase of agricultural production should be attributed to the decrease of fallow land which became virtually non-existent since 1870s; yields increased in most regions too.

Animal husbandry experienced even more radical modernization during the second half of the nineteenth century (see Table 6.3). In most cases, the number of farm animals almost doubled. Sheep farming was the only exception; sheep became gradually confined to the mountainous areas and the production faced severe competition of imported wool and cotton. Animal husbandry also became more intensive, the average weight of cattle increased by 40 % (Lom 1972). Milk and meat production rose even faster (up to three times), fact that reflects better organization of breeding and more advanced specialization.

The agricultural revolution of the second half of the nineteenth century brought higher yields, more intensive animal husbandry, increased labour productivity, and increased total production. Enough food for the growing population was secured and part of the farming workforce moved to new industrial plants. In Bohemia, i.e.

Table 6.2 Selected crops in Bohemia in the second half of the nineteenth century

	Proportion of arable land in Bohemia (%)			Average yields (100 kg/ha)		
	1845–55	1870–79	1894–1903	1848	1871–80	1891–1900
Wheat	7.1	9.7	8.6	10.8	12.0	14.0
Barley	9.3	11.0	15.6	9.6	10.7	13.9
Rye	26.3	23.2	18.8	9.5	10.6	11.5
Oat	20.3	17.1	18.5	8.1	9.0	10.5
Sugar beet	0.2	4.7	5.6	120.0	170.0	224.0
Potatoes	8.2	12.7	13.3	65.0	70.0	78.0
Fodder crops combined	10.5	12.7	13.8	X	X	X
Fallow land	14.2	5.5	1.6	X	X	X

Note Figures refer to Bohemia only (Moravia and Silesia not included)
Sources Lom (1972), Jeleček (1985, Tables 7, 13)

Table 6.3 Animal husbandry in Bohemia in the second half of the nineteenth century

Indicator	Amount	1846	1869	1900
Horses	1000	160	190	230
Cattle	1000	1050	1600	2260
Pigs	1000	240	320	690
Goats	1000	100	190	320
Beef	1000 of tonnes	33.6	59.3	94.9
Pork	1000 of tonnes	10.3	14.8	34.4
Milk	1,000,000 of litres	743.3	927.1	1784.6

Note: Figures refer to Bohemia only (Moravia and Silesia not included)
Sources Lom (1939), Jeleček (1985)

western part of Czechia, the ratio between non-agricultural population and farmers rose from 2.8 to 4.8 in the period 1869–1896. In 1869 there were 2.6 ha per farmer in average compared to 2.2 ha in 1896. In the same period, the share of agricultural population declined from 64 to 36 % (Lom 1972).

6.4.4 Major Changes of Land Use Patterns in the Second Half of the Nineteenth Century

Given the radical social and economic changes in the second half of the nineteenth century, the land use changes were more modest than one would expect (see Fig. 6.9).

The extent of agricultural land was expanding over the centuries; in most cases new fields emerged on former forest land. Even during the first half of the nineteenth century, agricultural land increased by some 10 % (Bičík et al. 2001). In the second half of the same century, however, there was no more room for further expansion. Over 50 years the agricultural land covered about 66 % of the territory without major changes (see Fig. 6.9). However, the agricultural revolution resulted in a more intensive structure of agricultural land: arable land expanded by some 250,000 ha and permanent grassland decreased. Lakes were drained in order to get

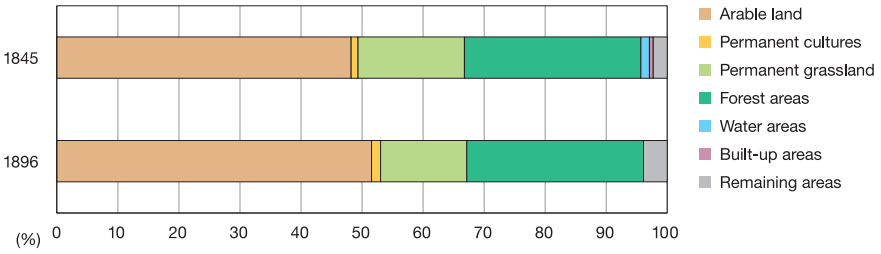

Fig. 6.9 Land use in Czechia between 1845 and 1896 (%). *Source* LUCC Czechia Database

high-quality arable land: in this way new space for sugar beet (in lowlands) and potatoes (in highlands) was acquired.

The proportion of land covered by arable land reached a climax in 1896 (52 %) though the natural conditions for farming are rather average than excellent. The proportion of permanent grassland decreased from 17 to 14 % in the period 1845–1896. Meadows remained more or less stable, but pastures declined significantly (more than by 30 %) as more and more animals were kept in sheds and stalls. The ratio between arable land and permanent grassland increased significantly from 2.8:1 to 3.7:1 (see Fig. 6.9).

The above-mentioned processes meant that large tracts of the land became prone to erosion. The increased number of potato fields on sloping land also contributed to this risk.

Agricultural land expanded by 0.7 % in the period 1845–1882, arable land by 7.1 %. It was also the time when extensive agriculture came to an end and intensification processes were taking place. As a result, in the following period both agricultural and arable land remained stable in terms of size and later became to shrink. The agrarian crises of 1880s and 1890s which resulted in agricultural stagnation also contributed to this process. Within the short period of 1882–1896 agricultural land declined by 0.2 % and arable land by 1.8 % (Jeleček 1995b; Bičík et al. 2001). Thus, the final phase of the nineteenth century in Bohemia and Moravia can be seen as the beginning of the "forest transition". More intensive farming methods meant that there was no more need for new fields and gradual expansion of forests could start (Table 6.4).

The above-mentioned processes were recorded also in other developed countries of Central, Western, and Northern Europe and can be seen as the result of economic and technological modernization. The "forest transition" in Austria and Germany appeared roughly in the same time as in Czechia. The minor differences between Czechia, Austria, and Germany should be attributed to diverse natural conditions.

Table 6.4 Changing land use patterns in the nineteenth century in Czechia, Austria, and Germany: proportions of land use classes on the national territory (%)

	Czechia		Austria		Germany	
	1845	1896	1830	1880	1800	1900
Agricultural land	66.8	67.2	41.8	39.7	55.5	64.8
–Arable land	48.2	51.6	22.3	23.8	33.3	47.6
–Permanent cultures	1.2	1.5			1.0	1.2
–Permanent grassland	17.4	14.1	19.5	15.9	21.2	16.0
Forest land	28.9	29.0	38.8	40.2	25.0	25.9
Other areas	4.3	3.8	19.4	20.1	19.5	9.3
–Alpine pastures			11.0	12.3		
–Other			8.4	7.8		
Total	100.0	100.0	100.0	100.0	100.0	100.0

Note: "Czechia" refers to the present-day Czech Republic; "Austria" refers to the present-day Austria less Burgenland; "Germany" refers to Germany as of 1913
Sources LUCC Czechia Database; Jeleček (1995b), Krausmann (2001)

6.4.5 Changing Land Use Patterns in the Second Half of the Nineteenth Century: Regional Differentiation

Land use patterns of the second half of the nineteenth century were much influenced by the differential land rent II (DLR II, see Chaps. 2, 4). DLR I dominated until 1870s; as a result, land use changes to a great extent reflected the local natural conditions and geographical position.

The intensification of farming that started in 1880s accentuated the importance of DLR II, i.e. capital investments (fertilizers, mechanization, drainage) into existing plots. Most money was naturally invested into areas with higher DLR I that were more fertile and easily accessible (Jeleček 2002). This synergy between DLR II and DLR I increased the regional inequalities of land use patterns, but the local natural conditions and geographical position still played an important role.

Box 6.5 Changing land use patterns and railways
The influence of major transportation routes on land use patterns was very important in the second half of the nineteenth century—probably more important than at present. Railways were crucial as transport in areas with no railways were significantly higher. Consequently, land use changes in the areas near railway lines were faster than elsewhere: built-up areas mushroomed, permanent cultures expanded, and arable land was intensively cultivated. Railways secured long-distance transportation of agricultural and industrial products. In many cases, remote areas became linked to the national economic system through railways. Railways also contributed to competition among regions, division of labour, and specialization.
Sources: Hampl (2000), Jeleček et al. (2003), Kabrda (2004)

The agricultural intensification in the second half of the nineteenth century was to a great extent concentrated into areas with favourable natural conditions and to the economic core areas (Bičík et al. 2001). Increase of arable land and decrease of permanent grassland were recorded in more than 75 % of stable territorial units (STU) in the period 1845–1896. Biggest changes were taking place in the fertile lowlands: the transition from permanent grassland into arable land was recorded on more than 4 % of the total territory. However, important increase of arable land can also be seen in the vicinity of major cities (Prague, Ostrava) and along the important transportation routes (for example, to the north, south, and west from Prague)—another proof that geographical position played a big role. Increase of arable land and meadows combined with decrease of pastures was typical in the high regions in the frontier (Šumava/Bohemian Forest, Krušné hory/Ore

Mountains, Krkonoše/Giant Mountains)—see Fig. 3.1. In these areas it was mostly subsistence farming that secured food for the growing number of local workforce (Bičík and Kabrda 2007).

Surprisingly, a good deal of grassland was converted into arable land (and into forests) also in Southern Bohemia where natural conditions are average at most. The explanation could be that in this traditionally rural region, little affected by urbanization and industrialization, jobs outside agriculture were scarce so the growing population still needed more land to cultivate.

STUs with arable land decrease and permanent grassland increase are scarce and can be found mostly in peripheral regions with poor natural conditions: in the mountains of north-western Bohemia, near the border with Slovakia, in Bohemian-Moravian Highlands, and in south-western Bohemia (see Figs. 6.10 and 6.11). This can be seen as the beginning of less intensive land use (transition from arable land to permanent grassland), process that became much more common later.

Forest areas did not show any radical changes. Afforestation (deforestation) that would afflict more than 4 % of the examined territory was recorded only in 15 % of STUs. There was some deforestation in ca. one-half of all STUs (Fig. 6.12), typically in fertile regions of Central and Northern Bohemia and also in Southern Moravia. In some areas forests were cut to make place for new industrial plants. On the contrary, forests tended to expand in peripheral regions, especially in the highlands and mountains of the southern, less developed half of Bohemia: this is where the "forest transition" was rather intensive in the end of the nineteenth century.

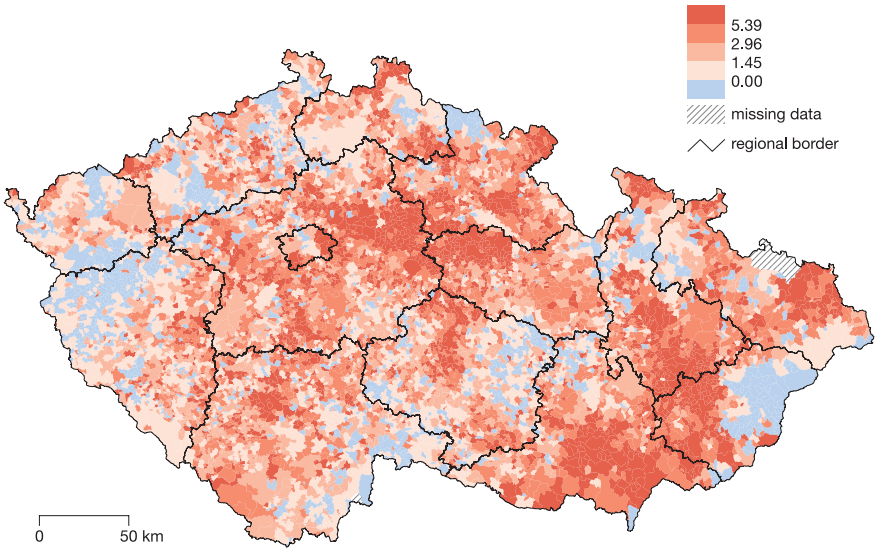

Fig. 6.10 Change of arable land proportion by STUs between 1845 and 1896 (percentage points). *Source* LUCC Czechia Database

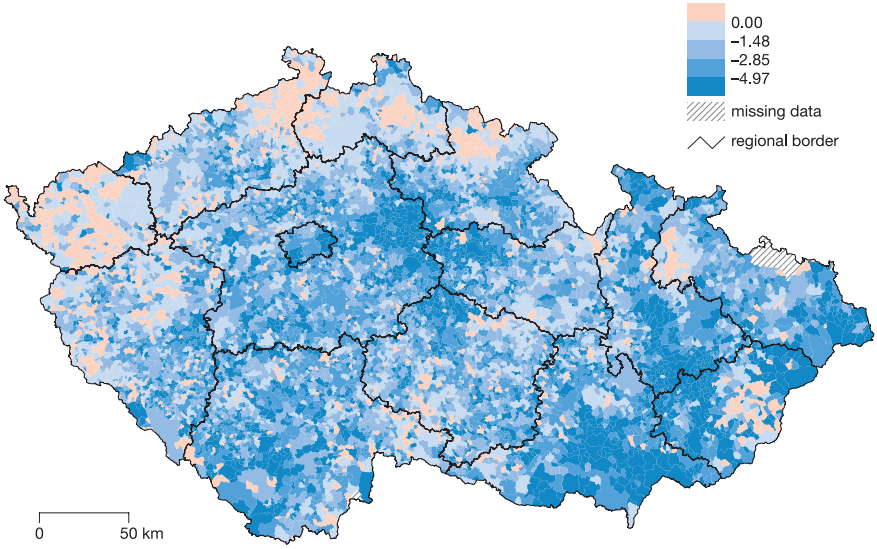

Fig. 6.11 Change of permanent grassland proportion by STUs between 1845 and 1896 (percentage points). *Source* LUCC Czechia Database

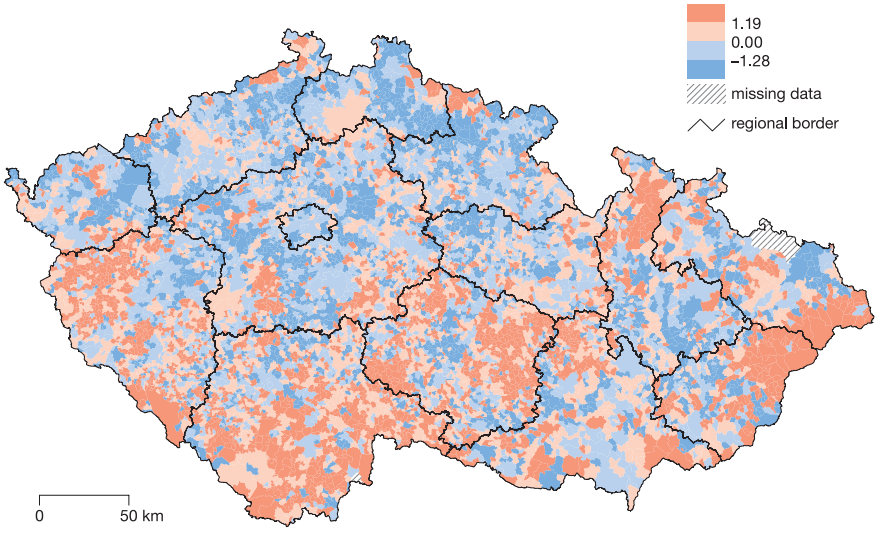

Fig. 6.12 Change of forest area proportion by STUs between 1845 and 1896 (percentage points). *Source* LUCC Czechia Database

The regional inequalities of land use patterns accentuated during the second half of the nineteenth century. A clear shift towards a more intensive use (especially, expansion of arable land and decline of permanent grassland) was recorded in most parts of Czechia, especially in the fertile lowlands. On the contrary, some

peripheral regions with less favourable natural conditions where afforestation was taking place and permanent grassland increased, showing signs of less intensive land use.

6.4.6 *Land Use Changes in the Second Half of the Nineteenth Century: Summary*

Relative political stability was typical for the second half of the nineteenth century in Czechia, especially the period of "Belle Époque" (1880–1910). As a result, land use changes were driven mainly by economic factors. Austria-Hungary was defeated by Prussia in 1866 and since then the Monarchy was on the way towards gradual disintegration which finally happened in the end of World War I.

The effects of differential land rent contributed to increased regional inequalities of land use patterns. The differences between fertile lowlands that were intensively cultivated on the one hand and peripheral highlands and mountains on the other hand became very distinctive.

Increased regional inequalities of land use patterns in the second half of the nineteenth century can be clearly seen in Figs. 6.13 and 6.14. Compared to the twentieth century, however, changes were rather modest due to the existence of free market economy and relative political stability. Only 40 % of STUs show any kind of land use change on more than 5 % of the examined territory and just 10 % of STUs show changes on more than 10 % of the area.

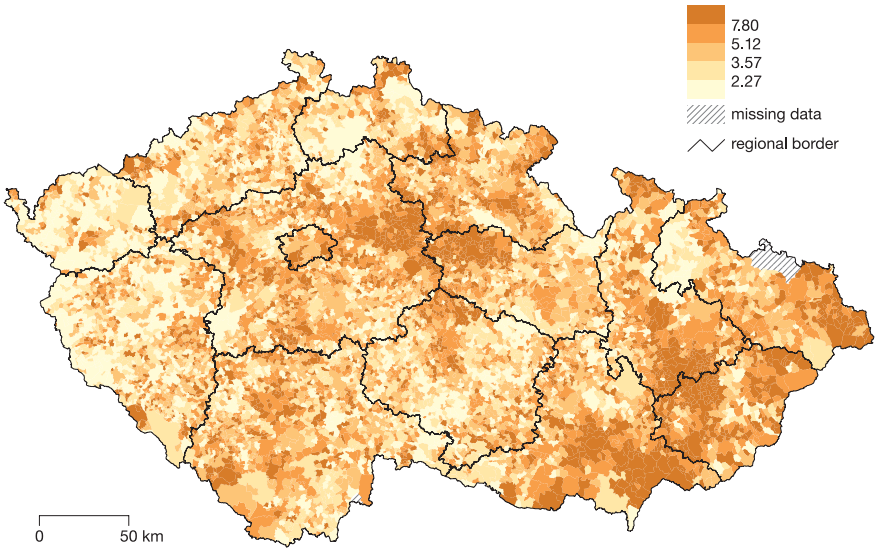

Fig. 6.13 Index of change by STUs between 1845 and 1896 (%). *Source* LUCC Czechia Database

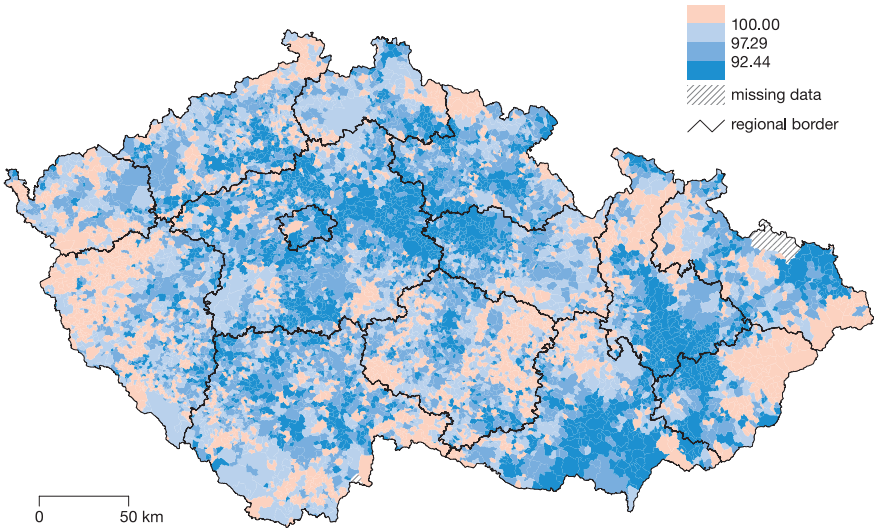

Fig. 6.14 Coefficient of ecological importance change by STUs between 1845 and 1896 (%). *Source* LUCC Czechia Database

The better the natural conditions, the more intensive the land use changes—fact that can be partly attributed to the effects of differential land rent. The coefficient of ecological importance has decreased in some 75 % STUs in the most fertile regions (see Fig. 6.14). Negative environmental impacts that resulted from the high proportion of arable land (increased erosion, loss of biodiversity), however, were balanced by high fragmentation of the plots. Small fields that were separated from each other by distinctive field boundaries, by trees, shrubs, or agricultural roads prevailed.

Trends towards a less intensive land use, i.e. afforestation or transition of arable land towards permanent grassland, remained marginal. Such changes were typically taking place in some mountainous areas in the frontier and also in the Bohemian-Moravian Highlands (Fig. 6.14). In most cases, however, these changes were of modest rate, with the exception of Eastern Moravia. The above-mentioned regions also show increased coefficient of ecological importance. Thus, the majority of peripheral regions remained rather stable and the land use changes were minimal (Fig. 6.13).

The period 1845–1896 includes an important turning point in the history of land use changes (Jeleček 1995b, 2002; Bičík et al. 2010). The third quarter of the nineteenth century was the last period when the practices of extensive farming resulted in an increase of land under cultivation. The technological and scientific advances of the late nineteenth century secured higher yields in all branches of farming and consequently the extent of cultivated land began to decrease. This trend accelerated in the twentieth century and continues also at the present time.

6.5 Agricultural Intensification in Market Economy and Turbulent Political Development: 1896–1948

6.5.1 Driving Forces of Land Use Changes

The Czech history during the 50 years long period between 1896 and 1948 was full of turbulent events, including a lot of chaos and economic, political, social, and ethnic unrest. In most cases the main impetus for change came from the outside world, especially from Central Europe. At the beginning, the territory of Czechia was part of multinational state (Austro-Hungarian Empire) that competed with Germany and Russia for the dominance in Central Europe. The first phase of capitalism peaked in 1880s with a big crisis. One decade later, fast technological and scientific progress started the second phase. Intensification, an entirely new model of social and economic order, was advancing.

New fundamentally different modes of production were being introduced around end of 19th century and basically different after communist overthrow in 1948. In the end of the nineteenth century, fresh phase of market economy (monopolist capitalism) started. In 1948 Communist Party seized the power in Czechoslovakia and consequently the country began to intensify ties with Soviet Union, not with the more developed West. In Central Europe, the period 1896–1948 included five key political and economic stages:

1. 1896–1914: Time of economic prosperity and political détente in Europe (Belle Époque) that followed the crisis of 1870–1880s.
2. 1914–1918: World War I, economic production was primarily focused on the war industry. Growing discontent among the population resulted in fundamental changes and new political order in Central and Southeastern Europe.
3. 1918–1938: Czechoslovakia was among the newly emerged nation states. Despite impact of world Great depression, economic restructuring and ethnic tensions Czechoslovakia formed an “island of democracy” in Central Europe.
4. The Munich Agreement (1938) and subsequent German annexation of the Czechoslovak border regions followed until May 1945 by so-called Protectorate Bohemia and Moravia and its war economy, started the period of violence with far-reaching political, economic, social, and ethnic consequences.
5. 1945–1948: Short period of “limited democracy”; struggle for future political orientation of Czechoslovakia influenced by the fact that most of the Czechoslovak territory had been liberated by the Soviet Army. Transfer of Czechoslovak Germans (ca. 3 million persons; Kosinski 1970).

The population of the present-day Czechia counted 9.373 million in the year 1900. In 1921 the figure was 10 million, in 1940 it is estimated 11.1 million. In the 1950 census (after World War II and the German exodus) only 9.7 million people were counted.

Many scholars agree on that the outstanding economic position of Bohemia and Moravia within Cisleithania and whole Austria-Hungary was crucial for the Czech political emancipation and indirectly paved the way towards independent

Czechoslovakia. Purš (1960) mentions that in 1860s Bohemia ranked third or fourth among the most economically developed regions in Europe (measured by the combined performance of steam engines per 100 km^2). Beranová and Kubačák (2010, p. 303) argue that "…A number of inventions and scientific discoveries enabled a great progress in agriculture during the last 25 years of the 19th century. It included mechanization, extensive use of fertilizers, improvements in selective breeding and animal husbandry. Due to improved roads and railways farmers enjoyed better access to the markets".

Box 6.6 Czechia—economic core area of Cisleithania

(I) Proportion of the Cisleithania production: hard coal 86.7 %, lignite 84 %, steel 53.7 %, sugar 95.3 %, beer 56.6 %, ethanol 53.2 %; Proportion of the Cisleithania production (estimate, no accurate data available): wool 75 %, glass 92 %, paper 65 %, chemical substances 75 %;
(II) 59.3 % of all steam engines in Cisleithania;
(III) 53.4 % of industrial workers in Cisleithania (34.3 % of total workforce).

Textile industry 77.5 %, mining and metallurgy 66.7 %, food production 51.3 %, machinery 46.9 %, chemical industry 45.9 %.
Czechia accounted for 26.4 % of Cisleithania' territory. However, it accounted for 38.5 % of arable land and for 35.5 % of population. But in Czechia, 46.6 % of land value tax and 42.2 % of all taxes were collected.
Source: Přehled československých dějin (1960, p. 830)

Crop yields almost doubled over the period 1870–1914 in the case of major grains. The animal husbandry rose correspondingly and it became necessary to secure enough fodder for the animals. Most of the large estates were owned by the nobility and large-scale farming was very much market-oriented. These estates were utilizing cheap labour force at the beginning; they also pioneered mechanization of farm work.

The progress of modern farming methods and the focus on cash crops required the availability of funds. Credit unions ("Kampelička") came to existence and provided different types of credits including those available for small farmers. The Agrarian Bank was established in 1911 to secure large credits; it belonged among the most important banks over the following 50 years (Kubačák 1995).

In the early twentieth century, almost one-half of the farmers cultivated less than 2 ha of farmland (Kubačák 1995, p. 307). They were mostly subsistence farmers; in order to survive, many had to rent additional land. Arable land formed the major part of farmland. In 1896, 82 % of farms were smaller than 5 ha; these small farms combined, however, covered only 12.5 % of agricultural and forest land in Czechia.

In the Czech part of Silesia, large estates (more than 100 ha) managed 41 % of agricultural and forest land combined at the end of the nineteenth century; corresponding figures were 37.6 % in Bohemia, and 34.1 % in Moravia. In the case of Silesia perhaps this was due to the strong Prussian agrarian traditions that included very large estates owned by the so-called Junkers (local landlords). Peasants who worked on these estates enjoyed only limited civil rights. Small farmers (less than 5 ha) formed the vast majority of rural population (85 % in Bohemia, 86 % in Moravia, and almost 80 % in Silesia), but were in possession of relatively small proportion of total agricultural and forest land.

Such a structure of land tenure (see Table 6.5) and farms was one of the main reasons why capitalist-style agriculture has been developing fast since mid-nineteenth century. Ironically, the Communist government (1948–1989) was striving to achieve a similar goal, i.e. to form a network of large estates (cooperatives) and to increase the agricultural production. Communist regime, however, did not hesitate in 1950s to use brutal political instruments including forced collectivization.

As hundreds of thousands of men had to serve in the army during World War I (1914–1918), agriculture suffered from lack of workforce. It was common that women had to secure jobs normally reserved for men. Agricultural intensity declined, much arable land lay fallow and also forestry was limited. Horses, machinery, and even food were often confiscated to meet army demands. Consequently, the food production declined as did husbandry in general; also the quality deteriorated. In the same time, food prices were rising constantly.

In the period 1918–1938 the Czech economy underwent a transition towards a more cost-effective system. In 1918, the industrial production was down by one-fourth and agriculture even more when compared to the pre-war state. Efforts were made to sell agricultural products at new markets, other than Germany and Austria; success was modest, however. Czechoslovak government channelled a lot of money into the eastern part of the country, i.e. into Slovakia and Carpathian Ruthenia to boost development; in economic terms, these regions were lagging behind by some 30 years.

Table 6.5 Land tenure (including its ownership) of agricultural land, and forests in historical lands of Czechia in 1896

		Holdings by size (hectares)				
		0–5	5.1–20	20.1–100	100+	Total %
Bohemia	Proportion of tenants (%)	81.0	14.3	4.5	0.2	100.0
	Proportion of land tenure area (%)	12.5	26.2	23.7	37.6	100.0
Moravia	Proportion of tenants (%)	85.8	11.5	2.5	0.2	100.0
	Proportion of land tenure area (%)	16.6	29.7	19.7	34.1	100.0
Silesia	Proportion of tenants (%)	78.8	16.5	4.5	0.1	100.0
	Proportion of land tenure area (%)	13.8	24.8	20.4	41.0	100.0
CZECHIA	Proportion of tenants (%)	81.9	14.1	3.8	0.2	100.0
	Proportion of land tenure area (%)	14.3	26.9	21.3	37.6	100.0

For the location of historical lands of Czechia see Fig. 4.1
Source Přehled československých dějin (1960, p. 545)

The structure of Czech (Czechoslovak) agriculture changed significantly after independence. The total production amounted ca. 40 million tonnes in 1920. About 25 % of crops were processed in nearby plants, some 60 % were used as fodder, 4 % were used as seed, and 3 % were utilized at farms. In other words, just 10 % of all crops were sold at distant markets. As an example, much of the agricultural production of Southern Moravia had been sold in Vienna until World War I.; after the war, however, this "export" came to an end. Agricultural intensity varied significantly: in financial terms, the net yield in Bohemia was 1035 Czechoslovak koruna per hectare; in Moravia and Silesia only 763 koruna. The pre-war level of production was surpassed only in 1925. By 1930, higher yields helped to increase the total agricultural production by some 25 %. Still, imported agricultural products accounted for some 5–10 % of the total production. The external trade, however, later declined due to the effects of Great Depression. (Přehled československých dějin 1960).

The Agrarian Party which enjoyed high popularity in rural areas was advocating land reform. The Land Reform Act had been passed in 1919 and transfers of land started in 1920 when the so-called Rationing Act was approved. The reform was intensively implemented between 1920 and 1926 and brought important changes into land ownership and land tenure (Table 6.6). Much of the population perceived the land reform as a symbol which broke the ties with Austro-Hungarian traditions. The new laws stipulated that landowners could possess a maximum of 150 ha of agricultural land or 250 ha of all land. The excess land was paid for by the state; only the property of the House of Habsburg, aristocratic foundations, and that of people alien to Czechoslovakia possessing foreign citizenship, was confiscated. The purpose of this reform, inter alia, was to strengthen the political position of the Agrarian Party in the countryside and, in particular, among the peasants. However, the reform was never fully completed because the state did not have enough money for financial compensations. In the end of 1920s the land reform was terminated; in late 1930s about 60 % of the land that had been subject to the reform (ca. 2.4 million of hectares) was returned to the original owners (tenants), in theory for 20–30 years. The remaining land subject to the land reform, i.e. about 800,000 ha, was distributed to small farmers (payments were required).

Potential applicants were usually entitled to buy 6–15 ha of farmland from the state. Most of them, however, did not have enough money to do so. The remaining

Table 6.6 Structural changes of agricultural businesses in Bohemia, Moravia, and Silesia in 1921 and 1930

Land tenure size	Bohemia		Moravia and Silesia	
Farm size (%)	1921	1930	1921	1930
Less than 1 ha	32.9	28.0	39.3	37.2
1–5 ha	41.0	41.6	39.5	40.0
5–10 ha	11.9	14.6	10.5	11.7
10–30 ha	12.1	13.3	9.5	9.7
30–100 ha	1.7	2.1	1.0	1.1

Source Reich (1934, p. 92)

Table 6.7 Land reform in numbers (as of 1932)

Extent of redistributed land and number of new owners (%)	Bohemia	Moravia and Silesia
Subject to agrarian reform (ha)	546,937	212,713
Sold to applicants (ha)	378,628	133,689
Returned to original owners (ha)	138,130	76,154
%	25	36
Yet to be sold (1932) (hectares)	30,179	2870
%	6	1
Remaining large estates	1268	369
Combined size of estate land (ha)	99,329	30,539
Average size of remaining large estates (ha)	78	94
Average size of farmland acquired by new owners (ha)	1.07	0.74

Source Reich (1934, p. 94)

large estates that could not be fragmented any more covered on average 78 ha in Bohemia, 83 ha in Moravia and Silesia. In total, 1637 of these estates were sold. Forest land was part of the agrarian reform only in the case of largest farms (more than 250 ha); some continuously forested areas (Brdy) were forwarded to the army and have been changed in the large military training area near Prague (see Fig. 6.37) (Table 6.7).

The land subject to land reform accounted for 30.7 % of the whole Czech territory. 64.6 % of this land was distributed to new owners; 30.2 % was retained by the original owners. 254,310 new small landowners emerged in the period 1921–1930; in the same time, however, the number of agrarian businesses declined by 29,727. In other words, though the big estates were being fragmented into small patches of land, amalgamation of plots into large units was also under way. Especially in the less fertile regions small farms were being gradually abandoned.

Subject to the agrarian reform were also industrial distilleries (698), breweries (310), sugar factories (72), sawmills (473), mills (593), brickworks (545), milk factories (67), spas (30), and some 188 more properties (Kubačák 1995, p. 42). Of the employees at large estates, some 25 % of them could buy farmland, the rest were offered a new job or financially compensated.

The land reform of the 1920s fundamentally changed the land ownership patterns and tenure in rural areas. In the past, the large estates in general had been focused on cash crops. On the contrary, most new landowners were forced to become subsistence farmers and had to labour intensively in the fields. That is why arable land slightly increased and permanent grassland decreased in terms of size in mid-1920s.

The reform was supported by the majority of people and the psychological effects—especially for the future—were important too. The ownership rights were breached and way was paved for future ownership changes, often brutal ones. Some 500,000 of farms were affected by the Great Depression, about 20 % of them went bankrupt. Many manufacturing businesses ceased to exist too.

Distances between farms and processing units were much shorter (ideal in a sense) than nowadays.

During World War II, the estate land was reclaimed by previous owners in many cases. After the war, property of the German speaking population was confiscated and people were forcibly transferred en masse just with a handful of belongings. Much large-scale confiscations took place soon after the Communists seized the power in 1948.

The Nazi annexation of the predominantly German speaking areas in the frontier in 1938 had brutal effects on the Czechoslovak economy. People were depressed due to Allies' betrayal after Munich "agreement" (signed in September 30, 1938). The territory of Czechia's border regions, the so-called Sudetenland (the region at borders with Slovakia was not its part), had been reduced by about 29,000 km^2. In it lived about 3 million of Czech Germans. Some 600,000 of Czechs were de facto forced to leave their homes in the border areas. Only a small number of them remained. Already after half a year, in 15 March 1939, Germany occupied the remaining territory of Czechia, and reshaped it in the so-called "Protectorate Bohemia and Moravia". On the contrary, Germany allowed Slovakia the emergence of the so-called "Slovak State". Since then, the well-developed former Czechoslovak economy, heavy industry, notably engineering, especially military one, began to serve German war needs.

Many people lost their lives on the former Czechoslovak territory under the German occupation (1939–1945), many German-speaking citizens were killed on the battlefields elsewhere, hundreds of thousands of Czechs were moved to Germany for forced labour. Tens of thousands of prisoners of war and many young Czechs had to labour hard in industry and agriculture. The agrarian reform was denounced as a whole and part of the redistributed land was returned to the original owners.

Food supply was a problem during wartime. Ration stamps were in effect and prices on the black market skyrocketed. In the end of World War II the lack of food became critical especially among the urban population. The agricultural intensity declined significantly between 1938 and 1945, there was a lack of machines and fuel and much of the agricultural production "disappeared" on the black market.

Czechoslovakia was liberated from Nazi Germany in 1944–1945. In the end of the war an interim reconstruction plan (Košický programme) was adopted. The orderly transfer of Czechoslovak Germans to Germany and Austria started after its approval by the Conference of winning powers leaders, i.e. Soviet Union, United States, and United Kingdom in Potsdam (July–August 1945).

The growing power of Communist Party resulted in the creation of the so-called National Front (union of some non-communist political parties, societal, civic, and interest groups established in 1945 and supervised by Communist Party) which aimed at economic and social recovery of the country. Second land reform came into effect already in June 1945 (see Sect. 6.6), chief banks and industrial enterprises were nationalized. The 2-year reconstruction plan was adopted in 1946–1947. Though industry as a whole achieved the pre-war level of production in 1949, the agricultural recovery took a longer time. As regards crops it took until

1953 (when ration stamps were abolished), in animal husbandry the pre-war level was exceeded only in 1960.

Political parties struggled fiercely for power. In 1945 Communists rejected the Marshall Plan and their influence kept rising: in the 1946 elections the Communist Party won more than 40 % of votes. Non-Communist ministers resigned in February 1948 and within days a new political system, de facto governed from Moscow, was installed.

6.5.2 Analysis of Land Use Changes: 1896–1948

The 50 years between 1896 and 1948 were full of very important changes that influenced economic performance, social structure, and also land use patterns. Compared to the earlier period, decrease of agricultural land and increase of forests and remaining areas were typical. More than 72 % of all STUs show this trend; on the contrary, between 1845 and 1896 it was only 16.5 %. Increase of agricultural land was recorded in more than one-half of STUs in the second half of the nineteenth century; the corresponding figure for the period 1896–1948, however, was just 7.2 % (agricultural land was declining in terms of size in more than 92 % of STUs).

The above-mentioned figures reflect the important changes that started in the end of the nineteenth century when the differential land rent II came into major effect. Capital investments into quality land in good locations became more profitable, agricultural production became more effective. On the contrary, farming on poor soils and in harsh climate was more and more problematic. Arable land was often being converted into permanent grassland and forests (in peripheral regions) or into built-up and remaining areas (in core regions and in low altitudes). These trends even intensified after World War II; in that period, just 0.1 % of STUs showed increase or stagnation of agricultural land.

The driving forces that were influencing economy and society have undergone substantial changes too. Agriculture, forestry, and fishing were less and less important for the composition of GDP creation; industry and partially also services became the leading sectors. These trends are reflected in the changing composition/structure of workforce by sectors. Residential and industrial developments were booming, especially in the urban areas. Consequently, built-up and remaining areas were on increase. However, this was a regionally imbalanced process influenced by different phases of urbanization (Musil 1977; Hampl et al. 1987).

Figure 6.15 shows the changing land use patterns on the Czech territory between 1896 and 1948. Arable land declined a little bit and, on the contrary, increase of forests and other areas is observed. The 1896 data do not allow to distinguish among built-up, water, and remaining areas. Permanent grassland was on decrease, especially when it came to pastures. Basic figures are shown in Table 6.8.

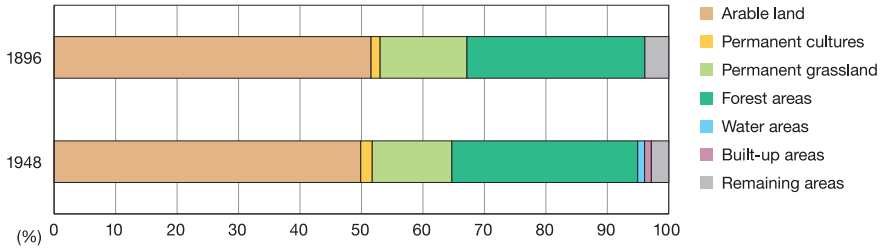

Fig. 6.15 Land use structure in Czechia between 1896 and 1948. *Source* LUCC Czechia Database. *Note* In 1896 water, built-up, and remaining areas are put together

Table 6.8 Proportion of land use classes in 1896 and 1948 (%)

Year	Arable land	Permanent cultures	Permanent grassland	Forest areas	Other areas	Total
1896	51.6	1.5	14.2	28.9	3.8	100.0
1948	49.9	1.9	12.9	30.2	5.1	100.0

Source Lom (1972)

The total area of arable land declined by more than 3 % between 1896 and 1948, permanent grassland by almost 8 %. More animals were kept in stables and many pastures lost previous importance. Other land use classes increased in terms of size: other areas (built-up, water, and remaining areas combined) by 34 %, permanent cultures by 27 %. Also forest areas expanded, which can be attributed to the lower amount of wood used in the construction and for heating and to increased environmental protection that prevented excessive logging.

6.5.3 Regional Patterns of Land Use in Czechia: 1896–1948

The effects of differential land rent I combined with varying natural conditions have resulted in marked regional disparities of land use patterns since 1880s. Differential land rent II was becoming important: capital investments into fertile soils were bringing higher profits and better economic results. Thus, areas with best natural conditions and in favourable locations experienced agricultural intensification; on the other hand, peripheral areas with worse natural conditions suffered from downturn in agricultural business.

In comparison with the previous period (1845–1896), most farmland was lost in the core industrial regions in lowland areas. Also in the chief coal mining regions, namely in north-western Bohemia, much agricultural land shifted to a different use.

Arable land as the most important part of agricultural land usually accounts for the largest proportion (51.6 % in 1896, 49.9 % in 1948). However, there were marked regional differences regarding changes and proportion of arable land between 1896 and 1948 (see Fig. 6.16). The most important decline of arable land

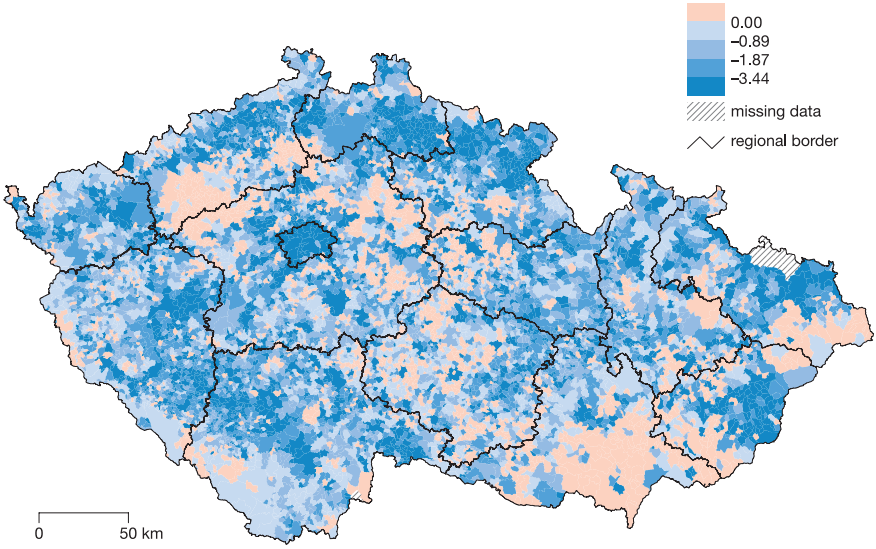

Fig. 6.16 Change of arable land proportion between 1896 and 1948 (percentage points). *Source* LUCC Czechia Database

was observed in the same areas where most agricultural land in total was lost. Decrease of arable land by more than 3.44 % points was observed in the regions of Ostrava and Zlín (both in Moravia), in parts of south-western Bohemia between České Budějovice and Plzeň, and also in the brown coal basins of north-western Bohemia (see Fig. 4.1). In the latter case arable land was declining due to mining, industrial activities, and ongoing urbanization. Significant decline of arable land was also recorded in Northern Bohemia, probably due to the industrial development that required more and more workforce (textile and glass industry, mechanical engineering and coal mining in underground mines), which at that time prevailed.

On the other hand, the most fertile regions focused on cash crops were rather stable as regards arable land. Surprisingly, no major changes were observed in Bohemian-Moravian Highlands and also in the mountainous frontier of south-western and Western Bohemia. Compared to Northern Bohemia, jobs outside farming were scarce in the latter region and subsistence farming prevailed in high altitudes.

The changes of permanent grassland had opposite effects compared to arable land in most Czech regions. The transition from arable land to permanent grassland was quite common in the past, especially in less fertile areas. The total area of permanent grassland did not change much on the national level between 1896 and 1948; however, regional differences existed (see Fig. 6.17).

Permanent grassland showed a marked stability in the northern part of Czechia. This stability may have been influenced by a relatively high industrialization of these areas—arable land had probably been abandoned already in the previous

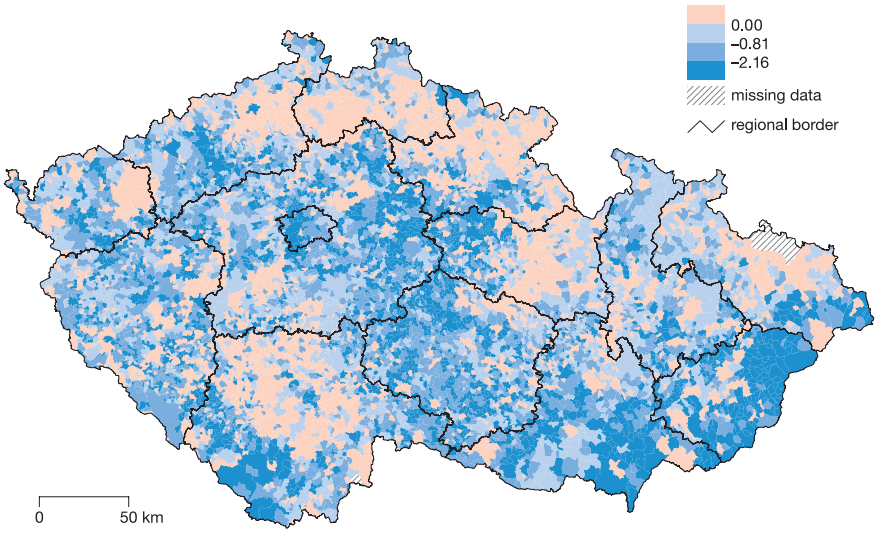

Fig. 6.17 Change of permanent grassland proportion between 1896 and 1948 (percentage points). *Source* LUCC Czechia Database

periods. Meadows and pastures were rather used for dairy farming and cattle breeding, thus replacing crops on sloping, infertile land.

The most important decrease of permanent grassland was recorded in south-eastern Moravia. Traditional sheep grazing and cattle breeding were much influenced by the fast industrial progress in the regions of Ostrava and Zlín (see Fig. 4.1). Some meadows and pastures in South Moravia were converted into arable land for better profits; similar process was observed also in the central part of the Elbe lowland. Furthermore, it was the result of a gradual shift of cattle and sheep grazing from lowland and fertile areas into the foothills and mountainous regions, which began already after 1848. This occurred especially in order to obtain more arable land for intensive lowlands farming.

Forest areas kept slowly expanding during the period 1896–1948. This ongoing increase, however, had started much earlier: forests covered only 25 % of the national territory in mid-eighteenth century compared to 34 % in early twenty-first century. Forest ownership was rather unstable between 1850 and 2010 which influenced the profitability and partly also the extent of forests. Forests declined first of all in fertile plains between 1896 and 1948; in most cases, however, the disappearing forests were very small (see Fig. 6.18). Limited decrease of forest areas was recorded also in Lužické and Jizerské Mountains as well as in Krušné hory (Ore Mountains) in the frontier, i.e. in areas where forests were dominating the land use structure anyway. The above-mentioned regions, however, were a sort of an exception; in most other areas slight increase of forest land was observed. Marked increase of forests can be seen in Eastern Moravia near the Slovakian border where mountain pastures were being abandoned.

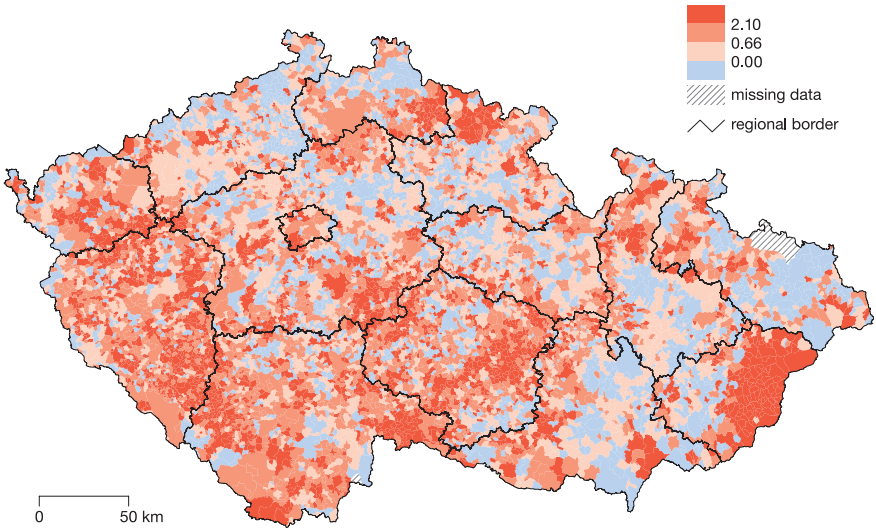

Fig. 6.18 Change of forest area proportion between 1896 and 1948 (percentage points). *Source* LUCC Czechia Database

6.5.4 Synthesis of Results

Apart from numerous analyses of land use classes, attention was also given to general trends in land use changes. In other words, efforts were made to analyse the effects of transition towards a modern industrial society (1896–1948). In this period, crucial structural changes of the national economy took place and urbanization kept advancing. These driving forces also changed the whole regional organization of the society: from processes at local and microregional levels that dominated in the past towards a highly structured organization on the national level. Specialization became inevitable and was also reflected in land use patterns: in fertile rural lowlands, in growing cities as well as in mountainous regions.

The index of change 1896–1948 (Fig. 6.19) shows the varying intensity of landscape changes region by region. The highest values of this index are recorded in urban and industrial areas (Prague, Plzeň, Brno, Ostrava and environs, Liberec–Jablonec, coal basins in north-western Bohemia; see Figs. 3.1 and 4.1). Ironically in a sense, important landscape changes were observed also in the regions where economy was on downturn, especially where agricultural and arable lands were being gradually abandoned. On the contrary, the landscape remained rather stable (i.e. the index of change is low) in border and also inner peripheral regions located far from the core economic areas and mostly typical of their less fertile soils.

Figure 6.20 shows regional changes of coefficient ecological importance between 1896 and 1948. This coefficient directly reflects changing *quality* of the landscape (index of change shows changes of quantity only). Positive shifts were recorded in the majority of regions; deteriorating ecological significance was

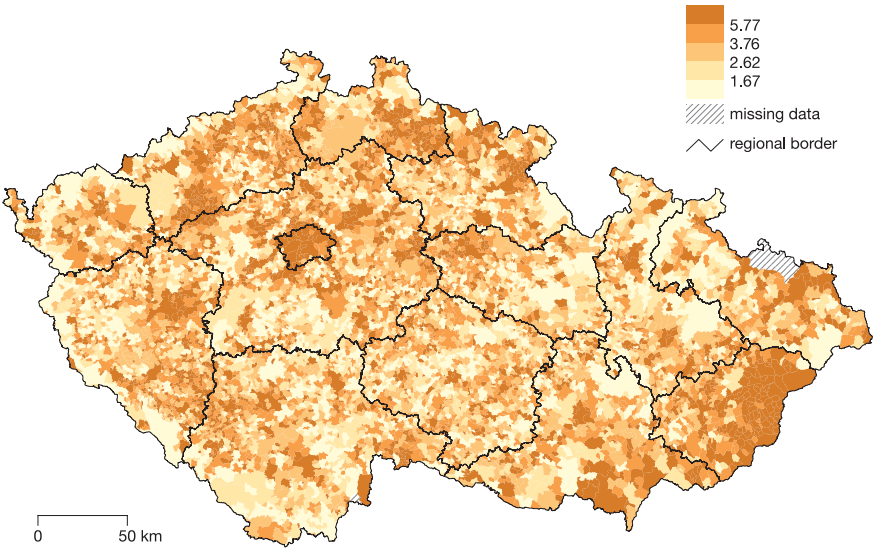

Fig. 6.19 Index of change between 1896 and 1948 (%). *Source* LUCC Czechia Database

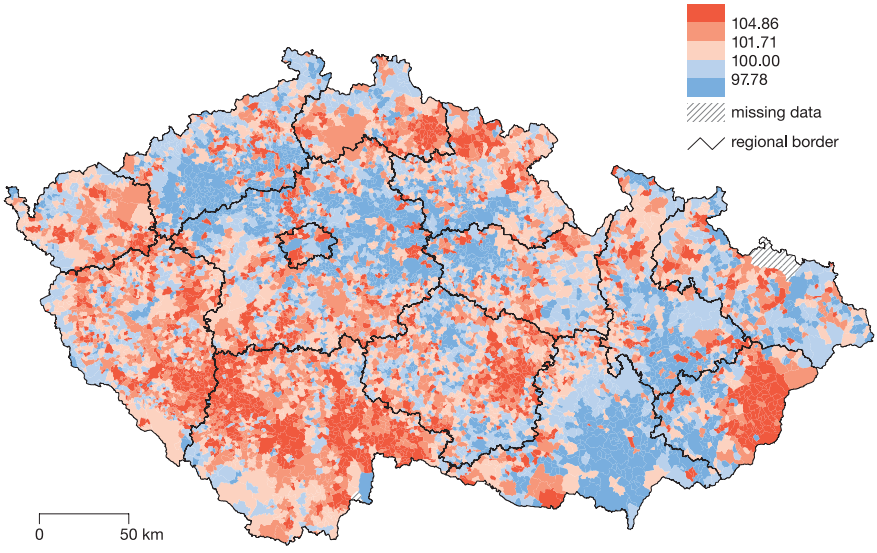

Fig. 6.20 Coefficient of ecological importance change between 1896 and 1948 (%). *Source* LUCC Czechia Database

observed only in the intensively used lowlands where most economic activities are concentrated. The coefficient rose significantly in areas with expansion of forests and permanent grassland. One should be careful, however, when interpreting the results: the coefficient reflects only the *recorded* land use changes; minor shifts within the Stable Territorial Units are not taken into consideration.

6.6 Communist Regime with Centrally Planned Economy: 1948–1990

6.6.1 Driving Forces of Land Use Changes: 1948–1990

In the period 1948–1990 Czechoslovakia was ruled by Communists. It is important to understand that all crucial decisions were de facto made by the Central Committee of Czechoslovak Communist Party (then subsequently and formally by the government whose members were almost exclusively only the communists)—fact that influences the social and economic conditions, including land use patterns, even in the twenty-first century.

The most important land use changes within the whole period of the last 170 years took place between 1948 and 1960. This was the time of major economic and social changes that included the effects of transfer of Czech or Czechoslovak Germans, new political and geopolitical orientation, economic system, large-scale industrialization, introduction of collective farming, emergence of other military training areas, and depopulation of rural areas (Bičík and Jeleček 2005).

The structure of national economy changed profoundly. Czechoslovakia became dependent on raw materials imported from the USSR; on the other hand, a good deal of products were exported to other COMECON countries. Czechoslovak communists encouraged heavy industry and a number of new plants were established in Slovakia and East Moravia as part of the Cold War strategy. In other words, the geographical median of industrial employment moved towards east (Häufler et al. 1960), away from the "unsafe" western frontier. The real importance of new technologically advanced branches was not understood in that time. The incompetent Communist governments relied on outdated, inefficient, energy and raw materials, very demanding industrial structure that could not compete with advanced Western European countries—fact that became astonishingly evident after 1990.

The western frontier, i.e. the regions adjoining the border with West Germany and Austria, underwent especially difficult transformation. After transfer of Czechoslovak Germans, subsequent largely unsuccessful resettlement schemes had devastating effects on the economic situation and settlement structure. These landscape changes were studied in a number of publications (see Štěpánek 1992; Bičík and Štěpánek 1994; Kolejka et al. 2011; Mikšíček et al. 2004—publications and webpage of civic education initiative named Antikomplex; Bičík and Kabrda 2007; Kupková et al. 2013; Kučera and Kučerová 2012, etc.). It took several years,

however, till the effects of such destiny of people and landscapes of border regions after WW II were reflected in land use structure and recorded in cadastral files.

Shortly after the Communist coup d'état (February 1948) the iron curtain was installed along the western border, large tracts of land became inaccessible and in many cases new settlers had to move back. In this case the effects on land use patterns were great and almost immediate.

Farming was severely restricted in the areas along the iron curtain (only state-owned farms were allowed) and often completely forbidden. Much of the western frontier is situated in rather high altitudes (25 % of border regions are over 700 m a.s.l.); in spite of that the German speaking population formerly intensively cultivated these regions (Häufler 1955). The population in the border regions has been slightly declining since 1890, but only after the transfer of German population of 1945–1947 hundreds of villages and towns (up to 1200) ceased to exist and much of the arable land became completely abandoned. Resettlement schemes faced many problems and especially small villages were not attractive for the settlers; on average the population reached just one-third of the pre-war state (Häufler et al. 1960; Mikšíček et al. 2004; Hampl 1998, etc.).

Farming became less intensive in the iron curtain border region. On the one hand the agricultural potential of the landscape has not been utilized; on the other hand such a change had positive environmental and economic consequences. The re-emergence of wilderness which had been happening till 1989 enabled to establish new National Parks in former cultural landscapes in 1990s (Šumava, Podyjí etc.). Before 1990 there was only one NP in Czechia: Krkonoše NP (Giant Mountains NP, founded 1963).

Due to the effects of differential land rent I, farming was comparatively costly and less effective in these high regions in the past, thus generating less profits than in the lowlands (Bičík and Štěpánek 1994; Kupková et al. 2013).

Socialist-style reforms of Czechoslovak agriculture were carried out in three stages (Häufler et al. 1960, p. 330). First, the land previously owned by Germans and Nazi sympathizers was confiscated. In this stage some 1,500,000 ha of farmland (ca. 30 % of the total) and 1,250,000 ha of forest areas (ca. 50 %) were confiscated by 1946. Revision of the first landreform (1919) was followed in 1947 and 1948 when mostly forests were nationalized. Finally, the new land reform which started in March 1948 confiscated all properties over 50 ha; also the landowners who did not cultivate their fields by themselves lost the land. In this last stage some 250,000 ha (5 % of the total) of farmland was nationalized.

Even after these dramatic shifts some 60 % of farmland was still owned by private farmers—until the rise of cooperatives. As a result, "…the land was double fragmented—first, into thousands of miniature farms, and, second, into a myriad of plots within each farm" (Lom 1972, p. 203). There were some 1,500,000 of agricultural farms of varying size on the Czech territory in 1949 (Table 6.9).

The production of crops reached the pre-war level already in 1949; when it comes to animal husbandry, however, this was achieved only in 1963. Ration stamps were in effect in Czechoslovakia until 1953—a system similar to that during the World War II. Rural areas were greatly affected by socialist-style reforms

Table 6.9 Agricultural businesses in 1949 by size (hectares)

Farm size (ha)	less than 1	2	5	10	20	50	100+
Proportion (%)	32.4	13.7	23.3	16.9	10.6	2.3	0.8

Source Lom (1972)

that started already in 1949. Cooperative farms were being founded en masse as were state-owned farms; the latter were coming to existence mostly on confiscated farmland. Private farmers were encouraged, often violently, to join cooperatives and state farms—process that happened virtually in every single village. Later, cooperatives were gradually amalgamated into large units. Collectivization was fast in early 1950s, slowed down after 1955/1956 and came to an end in 1960.

Box 6.7 Agricultural cooperative types

The first and second cooperative types were simply based on collective work of cooperative members. In the third and fourth type incomes were distributed largely according to the amount of work done (the acreage or animals brought by members were not reflected). Häufler et al. (1960, p. 331) defined the third and fourth cooperative types as follows: "Collective farming has been introduced both in crop production and animal husbandry. Profits are distributed especially according to the amount of work; the size of land brought by members plays just a minor role. The 4th cooperative type does not reflect any kind of land rent, it is a fully socialist cooperative". There were only 28 cooperatives of the third and fourth type in 1950 (i.e. just 0.2 % of the total). Later on, however, changes were fast and in 1959 these "more advanced" cooperatives already numbered 12,140 and existed in some 80 % of villages. In the end of 1980s cooperatives and state farms managed 98.5 % of all agricultural land.

Cooperatives and state farms gradually introduced large-scale agricultural production on amalgamated fields. In 1949 decision was made to create a network of mechanization units that were intended to fight the chronic shortage of agricultural machines. Due to collectivization and introduction of better machines most field borders were abolished (in the past these accounted for 5–7 % of arable land!) and vast fields were created. Amalgamated fields, however, often did not fit the natural conditions. The new mechanization units were mostly utilized by cooperatives and state farms with the intention to use the most of modern machinery. Animal husbandry has been modernized since early 1960s when large cowsheds were being built.

Agriculture has gone through a period of fundamental changes: more advanced technologies were introduced as well as better management. Also state subsidies became more important since early 1970s. Large machines were given priority which led to more dense soils. The changes are also demonstrated in Table 6.10.

Table 6.10 Czechoslovak agriculture in 1950, 1970, and 1989—selected indicators (prices as of 1970)

	1950	1970	1989	Index 1970/1950	Index 1989/1970
GAP (in millions of Czechoslovak koruna, prices as of 1989)	65,272	79,451	108,633	121.7	136.7
GAP per hectare of agricultural land (Czechoslovak koruna)	14,237	17,962	25,564	126.1	142.3
Agricultural land (ha)	4678	4465	4296	95.4	96.2
Arable land (ha)	3362	3315	3232	98.6	97.5
Yields per hectare (kg):					
Grains	1850	2770	4690	149.7	169.3
Potatoes	13,900	16,910	21,700	121.7	128.3
Sugar beet	30,020	36,580	35,520	121.9	96.2
Milk yields (litres per cow per year)	1630	2447	3982	151.9	160.8
Netto nutrients (NPK) thousands of tonnes	115.4	782.3	994.6	677.9	127.1
Netto nutrients (NPK) (kg per hectare of agricultural land)	25.2	182.8	242.0	725.3	132.7

Explanation GAP Gross agricultural product
Note: Index: 1970/1950 × 100; 1989/1970 × 100
Sources SNTL (1985), ČSÚ (1992)

The new organization of Czechoslovak agriculture since 1960s helped to create a sort of social equality in the rural regions. Living standards in villages became comparable to those of urban areas. In the past, many farms were family businesses and farmers had to perform a number of different jobs, from planning to hard job in the fields. Conditions became very different, however, in large socialist cooperatives and state farms: division of labour became much more developed, but quality control often lacked. Consequently, the responsibility for production and results disappeared and also soil quality and environmental protection deteriorated. Long-term prospects were seldom taken into consideration (Table 6.11).

Settlement patterns have changed fundamentally after World War II and the state reacted by introduction of a new official settlement network. Since early 1970 it has been attempted to concentrate the dispersed population into the so-called central settlements. These were nominally cores of very small areas and were ranked into three groups: regional, subregional, and local centres. Permanent residency and basic services were supported in these villages and small towns. On the contrary, no major development was planned in the case of the remaining ("non-central") settlements that were labelled either primarily agricultural or residential villages.

The introduction of such a settlement network plus increasing intensity of agriculture had large consequences on land use patterns. Agriculture as a whole became more centralized, huge agricultural processing centres were built. The distances among cooperatives, state farms, and processing plants grew over the time

Table 6.11 Agricultural land farmed in Czechia (January 1990)

	Arable land		Agricultural land	
	Thousands of ha	%	Thousands of ha	%
Companies managed by the Ministry of Agriculture	140	4.3	166	3.8
Other centrally managed companies	90	2.7	183	4.2
State farms	1032	31.9	1439	33.4
Cooperatives	2152	66.5	2637	61.4
"Socialist" companies combined	3184	98.5	4076	94.8
Private farmers	44	1.3	168	3.9
Other	4	0.2	52	1.3
Czechia total	3232	100	4296	100

Source Jančák and Götz (1997, p. 21)

as the whole system was based on fixed prices (including transport costs) rather than on market prices.

Large-scale industrialization and intensive exploitation of raw materials were among the most important driving forces of landscape changes between 1948 and 1990. The major changes took place in north-western Bohemia and north-eastern Moravia (Ostrava and surroundings); the big industrial centres (Prague, Brno, Pilsen, etc.) were affected too. Large residential projects, usually prefabricated blocks of flats, were built in mining and industrial regions to provide accommodation for the workforce migrating mostly from rural areas. These new massive urban developments appeared almost exclusively on greenfields. Family housing programmes were not encouraged; consequently, suburbanization—typical for Western European countries—remained weak. On the contrary, second homes that were used especially on weekends were mushrooming (1991 almost 400,000 s homes).

The Communist period saw major changes in the landscape structure. The majority of these changes, some 70 %, took place in the period 1948–1961 when many regions underwent crucial structural transitions. New industrial plants, residential projects, roads, and dams were built, mines and quarries were opened. The traditional rural society ceased to exist. The intensity of land use changes reached its peak and regional landscape patterns were irreversibly changed.

6.6.2 Overview of Major Land Use Changes

There were three major trends of land use changes between 1948 and 1990 (Fig. 6.21). First, the proportion of arable land decreased from 50 % (1948) to 41 % (1990). In other words, 18 % of all arable land (700,000 ha) disappeared over 40 years. Agricultural land decreased almost by one-fifth (from 65 % down to 55 %). Also the proportion of permanent grassland shrank, from 13 to 10.5 %. The latter change was due to changes in animal husbandry; up to 90 % of livestock was kept in cowsheds permanently throughout the year.

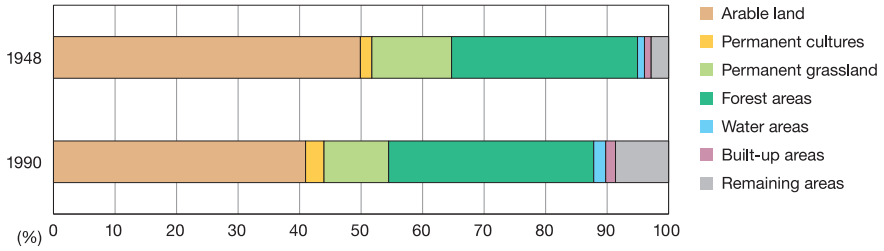

Fig. 6.21 Land use structure in Czechia between 1948 and 1990. *Source* LUCC Czechia Database

The diminishing size of permanent grassland and field amalgamation which included reduction of field boundaries made the landscape more prone to erosion. This had catastrophic consequences in many areas as flash floods became much more frequent than in the past (Lipský 2001; Lipský and Romportl 2007; Kliment and Matoušková 2005, etc.).

The increase of forest areas by some 250,000 ha can be seen as the second major change. The proportion of forest areas rose from 29 % (1948) to 33 % (1990). Such a change is similar to what has happened in most economically developed European countries and what Mather (2002) defined as "forest transition".

Third, urban areas expanded significantly under communist government. This shift reflects the increasing human pressure on the landscape. Built-up areas expanded by 40,000 ha (proportion rose from 1.1 to 1.6 %). The highest increase, however, was recorded in the case of remaining areas that expanded almost by 500,000 ha (proportion rose from 2.9 to 8.6 %). These new remaining areas include industrial compounds, roads and highways, mines and open pits, warehouses, etc. and reflect new functions brought by the advancing industrial society.

More than 95 % of stable territorial units (STU) show decrease of agricultural land in the period 1948–1990. However, this trend differs from earlier losses of agricultural (arable) land in the nineteenth and early twentieth centuries. In the past the extent of agricultural/arable land also fluctuated, but these changes were rather modest and different region by region (more fertile vs. less fertile areas). The rapid industrialization and urbanization plus gradual afforestation that took place after World War II has swallowed infertile agricultural land in remote areas as well as high quality land in fertile plains, especially near cities and towns. In the latter case new residential projects and industrial plants were often built on former agricultural land.

6.6.3 Regional Patterns of Land Use Changes in Czechia

The above-mentioned land use changes between 1948 and 1990 were concentrated into selected areas, at least to some extent. These regional inequalities were influenced by ongoing modernization as well as by varied natural conditions. Though

the centrally planned economy strove to reduce regional differences, it was only partly successful. Comparisons with Austria (Krausmann et al. 2003; Haberl et al. 2003) and Sweden (Sporrong et al. 1996) show similar processes as in Czechia. In other words, land use changes can be seen as one part of transition of social-geographical structures—changes that were slower than the other ones (for details see Sect. 8.1).

The Communist government tried hard to secure enough food from domestic sources and to minimize imports which led to a rather high intensity of agricultural production, at least compared to other "socialist" countries. To do so, Communists developed an intricate system of agricultural subsidies intended chiefly to support cooperatives and state farms in less favourable natural conditions and remote locations. In other words, agricultural companies in fertile regions were charged a special fee that partially covered the subsidies for the "less fortunate ones" (Table 6.12).

Under Communist regime, there has been a decrease of arable land (see Fig. 6.22) in most STUs (86.5 %). This process was especially intense in the mountainous frontier—in some areas arable land wholly disappeared due to depopulation and poor natural conditions. It happened in spite of the generous subsidies that were channelled to less favourable areas. On the contrary, high proportion of arable land remained in the traditional farming regions in the plains.

The total area of permanent grassland decreased between 1948 and 1990. It was much influenced by the shift from free range towards factory farming. Thus, many meadows and pastures were no longer needed; however, there were striking regional differences. Permanent grassland practically disappeared in fertile areas with intensive farming and close to cities and towns (Fig. 6.23). In some cases meadows and pastures (including sloping grounds) were converted into arable land which made the landscape prone to erosion (Jeleček et al. 2012).

Table 6.12 Land value tax and subsidies by production-economic classes (PEC, valid until 1991)

PEC	Land value tax	PEC	Subsidy
	Czechoslovak koruna per hectare		Czechoslovak koruna per 100 Czechoslovak koruna of revenues
1–5	3000	22–26	20
6–10	2400	27–31	210
11–16	1500	32–36	460
17–20	600	37–41	710
21	150	42	920

Explanations PEC production-economic conditions. Classes 1–21 = areas where agricultural companies were subjected to tax related to the quality of natural conditions (classes 1–5 = highest taxes). Classes 22–42 = areas eligible for agricultural subsidies (less-than-average natural conditions). The taxes collected amounted less than the subsidies paid
Source Jančák and Götz (1997, p. 18)

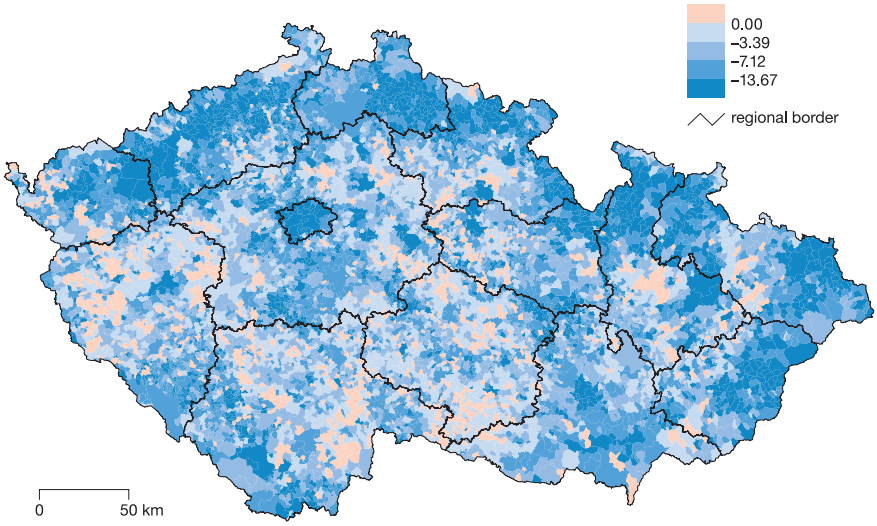

Fig. 6.22 Changes of arable land proportion between 1948 and 1990 (percentage points). *Source* LUCC Czechia Database

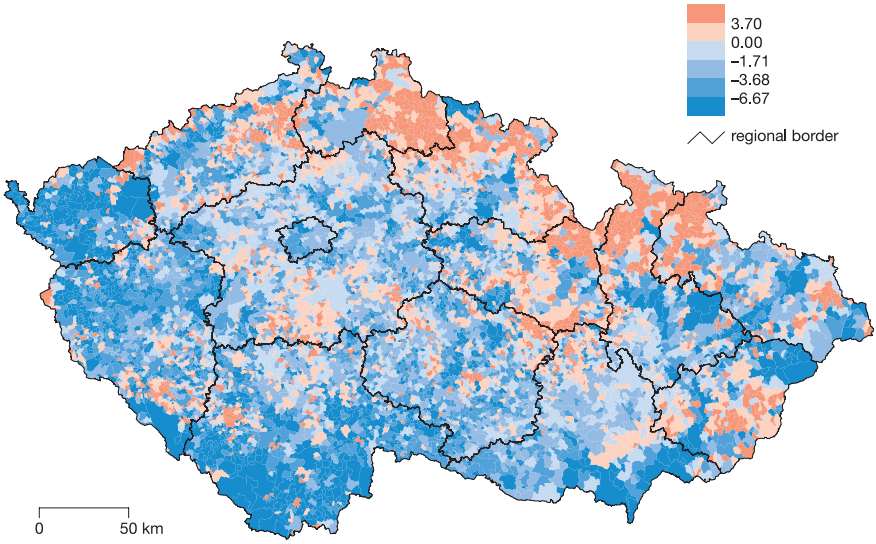

Fig. 6.23 Changes of permanent grassland proportion between 1948 and 1990 (percentage points). *Source* LUCC Czechia Database

In south-western Bohemia much grassland was gradually changed into forests. An entirely different process has been recorded in the northern frontier where permanent grassland remained stable or even increased in size. Here, farming shifted towards more extensive forms: infertile arable land has been transformed into meadows and pastures and many former farmers took jobs in new industrial plants (Bičík et al. 2010). Large expanses of permanent grassland also contributed to increasing leisure time activities.

Apart from decrease of arable land and permanent grassland which can be understood as the most important changes within agricultural land between 1948 and 1990, there has also been a marked increase of permanent cultures. In the period between 1960 and 1990 (1948 data are not available) permanent cultures increased by 32,220 ha, i.e. by almost 16 %. Orchards (46 %) and vineyards (28 %) accounted for most of this increase.

In the period 1948–1990 forest areas were expanding especially in the peripheral regions of the mountainous frontier (Fig. 6.24). In other words, forests increased in size mostly in areas with less favourable natural conditions and typically "invaded" former grassland.

The advance of modern industry, mining, construction of new roads—all this contributed to a robust increase of built-up areas and remaining areas. Huge open pits swallowed much agricultural land and, in some cases, also villages and towns were destroyed for the sake of coal (about such tens settlements ceased to exist in mining areas between 1948 and 1990). The population of abandoned villages as well as in-migrants from other regions moved to newly created prefabricated housing estates on the fringe of existing Northern Bohemian towns. Thus, the dispersed settlement structure has been replaced by a concentrated one. Similar processes were recorded also in the heavily populated Ostrava region in north-eastern Moravia.

Figure 6.25 shows changes of the most heterogeneous land use class—remaining areas. Under Communist regime, remaining areas present the most expanding land use class of all. The most important changes have been recorded in metropolitan areas (Prague, Brno, Ostrava, etc.) and in the Northern Bohemian Coal Basin—in the latter case, large open pits came to existence. Remaining areas increased, though in a less intensive mode, also in the mountainous frontier

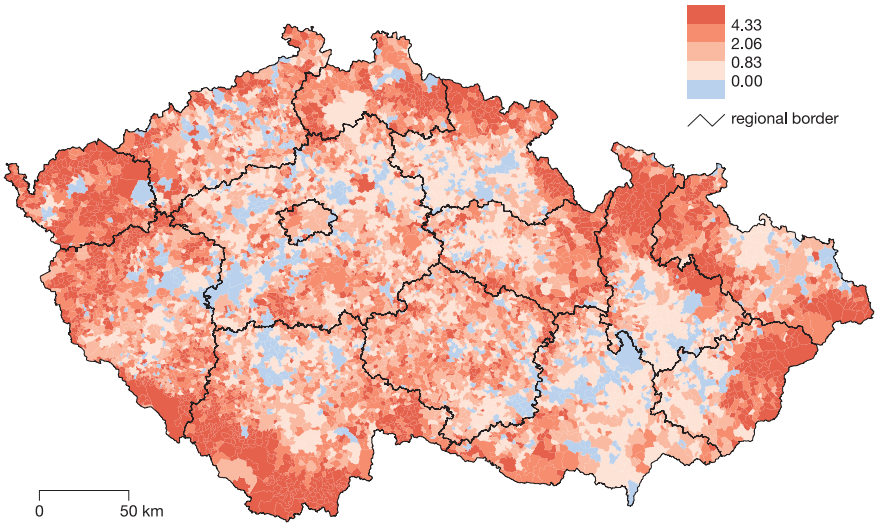

Fig. 6.24 Changes of forest areas proportion between 1948 and 1990 (percentage points). *Source* LUCC Czechia Database

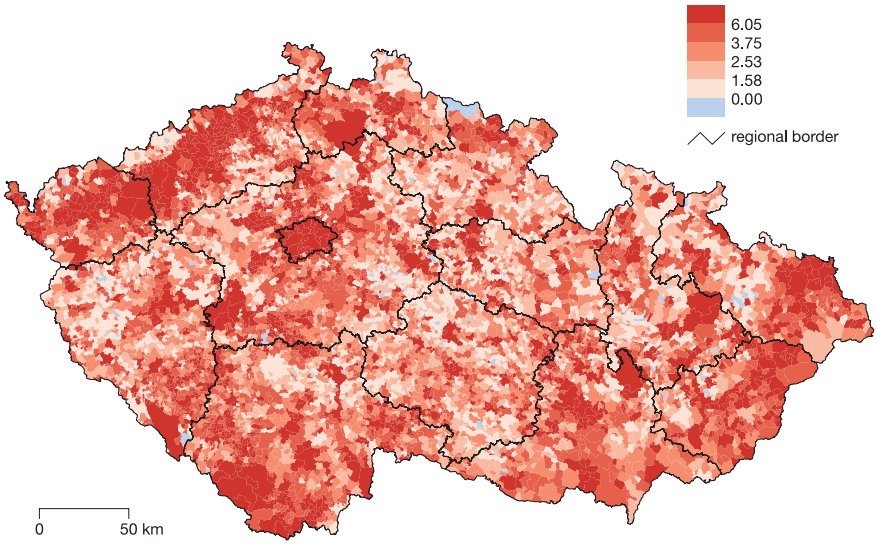

Fig. 6.25 Changes of remaining areas proportion between 1948 and 1990 (percentage points). *Source* LUCC Czechia Database

(Bohemian Forest, Beskydy Mountains) and in military training areas (in the latter case, largely due to administrative reasons).

Figure 6.26 shows the marked increase of built-up areas in most Moravian regions. This can be partly attributed to the general shift of geographical median (of population and industry) towards east. A certain increase of built-up areas,

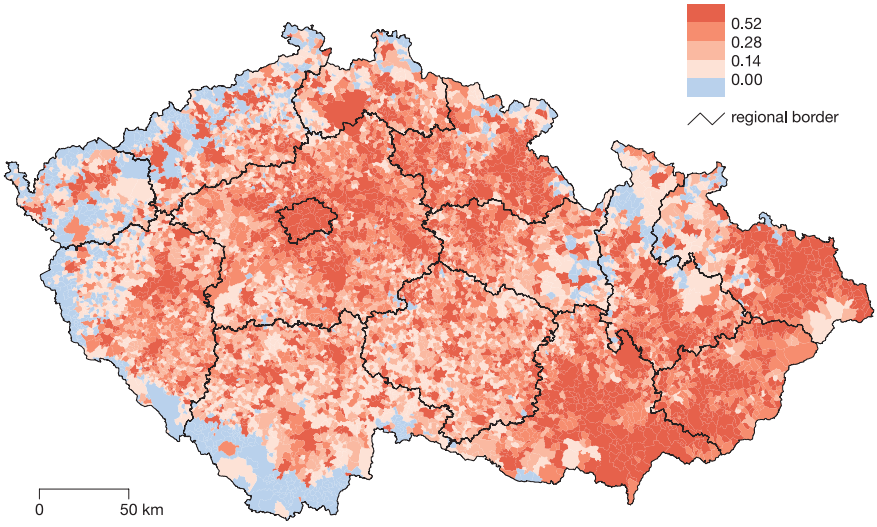

Fig. 6.26 Changes of built-up areas proportion between 1948 and 1990 (percentage points). *Source* LUCC Czechia Database

however, can be seen in most areas throughout Czechia due to higher living standards and advance of modern industry. Exceptions are few, especially in the south-western frontier and in Krušné hory (Ore Mountains) in the north-west where many villages ceased to exist and consequently built-up areas shrank.

6.6.4 Land Use Changes 1948–1990: Synthesis

Land use patterns in Czechia in the period 1948–1990 were characterized by decrease of agricultural land and increase of forests and other areas. These changes resulted from general modernization as well as from little interest paid to the agricultural land. Within agricultural land, arable land and permanent grassland were typically shrinking while permanent cultures were expanding. Built-up areas, remaining areas, and forests were increasing in terms of size in most regions.

Mountainous regions, coal basins, and some metropolitan areas show the most important land use changes. Index of change has been used to assess the rate of these changes. This index shows the lowest values in the most fertile areas but also in the Bohemian-Moravian Highlands (Vysočina; see Fig. 3.1). Though the latter region does not possess favourable natural conditions, the landscape changes have been modest there including just a slight decrease of agricultural land. Kabrda (2004) studied this interesting phenomenon; the relatively stable conditions are probably influenced by the lack of jobs outside agriculture, especially in industry.

Figure 6.27 shows important regional differences of the index of change. It seems reasonable that the highest values are recorded in the core areas with intensive social and economic development. However, majority of peripheral, mountainous border regions have witnessed rather intensive changes too. On the national level, the index of change equals 11.4 in the period 1948–1990. It means that some kind of land use change has been recorded on more than one-tenth of the Czech territory (0.27 % per year—much more than in other periods, see Fig. 6.27). Land use changes were less intensive in the interior part of the country, usually between 5 and 8 %.

The coefficient of ecological importance reflects the high quality of natural environment in the mountainous areas (Fig. 6.28). Moreover, the quality of environment has improved in these regions between 1948 and 1990. This is the general picture; in some STUs, however, when geoecological methods are employed, results can be different (Lipský 2001). On the national level, the "ecological significance" has increased in most regions (59 % of STUs), thus the human pressure became weaker. This was the case namely in the mountainous, peripheral regions in the northern frontier, but also in some of the peripheral areas in the interior of the country: afforestation was taking place and part of the arable land was being converted into permanent grassland.

The coefficient of ecological importance (Fig. 6.28) has typically decreased in the fertile plains (Moravian lowlands, Labe river lowland; see Fig. 3.1), in the metropolitan areas, and in the mining regions of north-western Bohemia. Agricultural

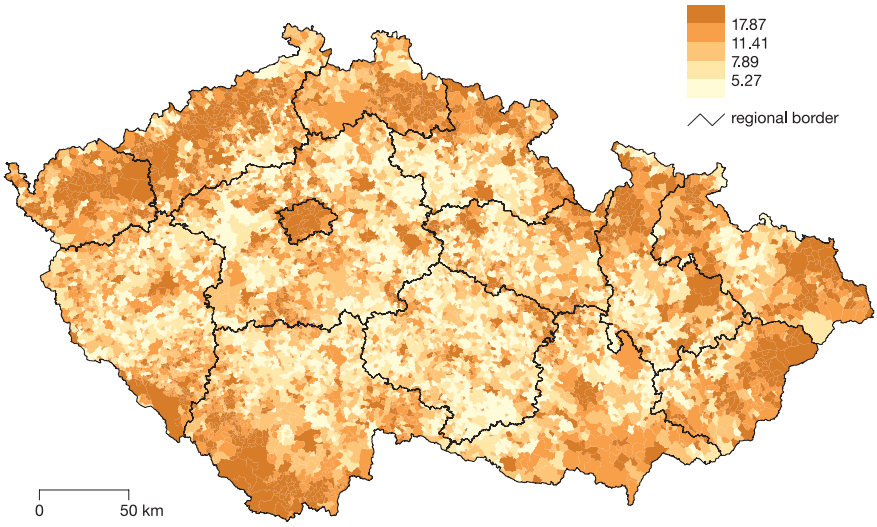

Fig. 6.27 Index of change between 1948 and 1990 (%). *Source* LUCC Czechia Database

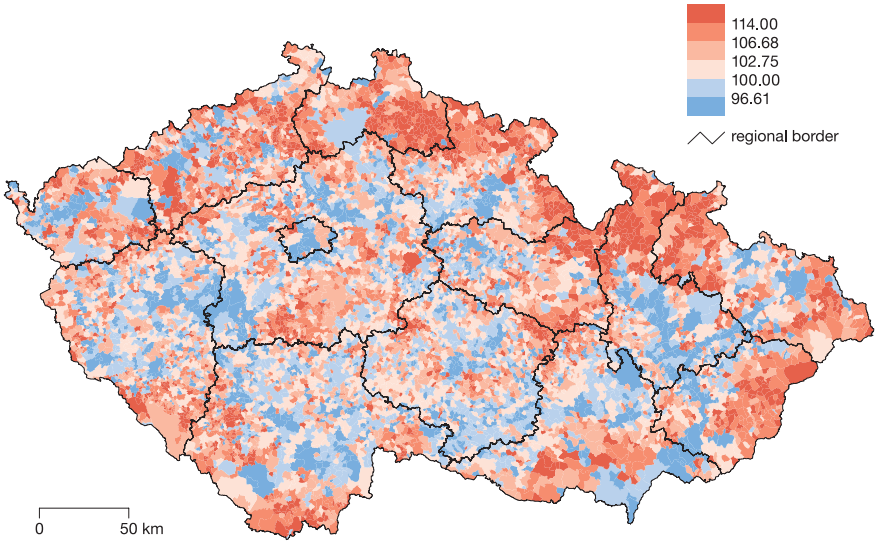

Fig. 6.28 Coefficient of ecological importance change between 1948 and 1990 (%). *Source* LUCC Czechia Database

land has often been developed in these areas; in some cases permanent grassland has been converted into arable land.

In general, the regional differences of land use patterns have increased in the period 1948–1990. A clear shift towards a less intensive use of the landscape was recorded in the mountainous border regions; on the other hand, intensification processes were

going on in the plains and urban areas. Such an increase of inter-regional heterogeneity (Bičík 1991; Hampl 1998; Bičík et al. 2010) that included increased spatial differences and functional concentration resulted from an increased interconnection of the geographical system and more complex regional division of labour. Modernization and advance of new technologies—i.e. phenomena that are more general than politics (see Haberl et al. 2001; Sýkora 2002)—can be seen as driving forces behind these changes. It is likely, however, that such changes would have been even bigger under conditions of free market and unrestricted competition.

Land use patterns have changed profoundly under Communism as regards the total extent of individual land use classes. These changes varied greatly region by region. The microcomponents of the landscape (field boundaries, forest margins, solitary trees and shrubs, etc.) and aesthetic values have undergone big changes too (see Lipský 1999). When it comes to agricultural landscapes, the amalgamation of fields meant for instance that field boundaries were being eradicated. Forests were plagued by acid rains (due to coal mining and large coal fired plants) and clearcutting. Thousands of various cultural artefacts that dotted the Czech landscape in the past (chapels, roadside shrines, ways of the cross, little monuments, etc.) were lost due to devastation or theft. The data used in this research, of course, cannot reflect these processes; however, there are scholars that keep analysing them (Lipský 2001; Kolejka et al. 2012; Kolejka and Klimánek 2014; Hrnčiarová et al. 2009).

6.7 Political and Economic Transition, Integration into International Organizations: 1990–2010

The fall of the Berlin Wall became the best-known symbol of democratic movements that were taking place in the end of 1980s in Central and Eastern Europe, including the "Velvet Revolution" in Czechoslovakia. Since then, Central European countries have no longer been dominated by Russia and turned face towards the West. The Visegrád Group (Poland, Hungary, and Czechoslovakia—since 1993 Czechia and Slovakia) was at the forefront of this movement. Despite a number of problems, the above-mentioned countries were the fastest in the move towards the West, in their societal and economic transformation. Full-scale political and economic liberalization was achieved, Central European countries became EU and NATO members and constitute standard capitalist and democratic regimes based on market economy.

Decades of Communist regime and the effects of rigid central planning left Czechoslovakia in a very bad shape in the end of 1980s. Lack of free market and economic competition as well as long-term isolation badly damaged democratic traditions as well as the national economy that once belonged among the most developed in Europe. As a reaction, in 1990s Czechoslovakia (Czechia) went through a number of reforms advocated by the right-wing governments: economy was liberalized, most subsidies and regulations were abolished. This included rural and regional subsidies; under socialism, the social and regional inequalities in Czechoslovakia were among the lowest in the world.

After 1990, archaic factories and production-oriented agriculture could not cope with the international competition which led to a sharp decline. The "Czech way" of transition from "socialism" towards capitalism in 1990s, however, included also unsuccessful privatization of many state enterprises, corruption, clientelism, and led to sceptic attitudes towards political institutions in general.

Apart from the post-socialist transformation which was a regionally specific process, the Czechia had to cope with global challenges too. The small Czech economy was all of a sudden exposed to the pressures of supranational companies, to global competition, and different cultures. This "double transformation" of 1990s (post-socialist and global) created in the Czechia a sort of a "laboratory" where the effects of economic and political driving forces could be studied—including land use and landscape changes.

The first decade of the twenty-first century can be labelled as a period of integration. Circumstances became more stable and the economic decline came to a halt, largely due to foreign investments and the more developed neighbouring countries, Germany and Austria. A number of much needed political reforms were adopted just before the accession to the EU (2004). After that, the national economy became even more open, under circumstances similar to those that were already in effect in the West. Massive EU subsidies were of a big help to farmers and boosted regional development. Though a number of political and social problems persist, future prospects of Czechia Republic are one of the best in history.

6.7.1 Institutional Reforms of Czech Agriculture After 1989

The Czech agriculture of late 1980s was relatively modern: intensive, with a high degree of mechanization and fertilizers. The great majority of agricultural land was either directly nationalized (mostly in the border regions due to post-war transfer of Czechoslovak Germans) or de facto controlled by the state, i.e. managed by cooperatives and large state-owned estates (in total 98.5 % of arable land—see Table 6.13). Division of labour was highly developed in these giant enterprises; however, environmental impacts were negative, labour productivity

Table 6.13 Agricultural businesses by legal status and size in Czechia after 1990

	Proportion of agricultural land (%)					Average size (agricultural land, hectares)		
	1990	1995	2000	2005	2010	1990	1995	2010
Private farmers	0.4	21.6	23.5	26.4	27.8	4.0	38.9	35.9
Limited companies (s.r.o.)	0.0	20.2	21.7	22.3	23.2	×	755.9	423.1
Limited companies (a.s.)	0.0	7.6	21.6	22.7	22.6	×	1205.8	1357.9
Cooperatives	61.4	47.0	29.3	24.4	23.4	2561.0	1507.4	1454.4
State-owned estates	25.3	3.6	3.9	4.2	3.0	6261.0	N/A	N/A
Other	12.9					N/A		

Source Zelená zpráva MZe 1994, 2000, 2005, 2010

was relatively high, but the composition of farming sectors was often unsatisfactory. Agricultural companies were receiving high subsidies which resulted in low efficiency and overproduction.

Large-scale reforms of the whole farming sector were implemented during 1990s. Prices, previously dictated by the state, were liberalized. Farming subsidies were severely cut. The equivalent of production subsidies (EPS) that reflects the combined agricultural subsidies from the public sources equalled just 14 % in Czechia (1995); on the contrary, in EU countries it was 49 %, in OECD countries 40 % (Zelená zpráva MZe 1996). Czech farmers were facing stiff international competition.

The original landowners (and their heirs) whose property had been confiscated by the Communists after 1948 were entitled to reclaim the property back. The result was an extreme fragmentation of the land—after 40 years of discontinuity. Of the 4.2 million hectares of agricultural land, some 3.8 million is owned privately: by individual private farmers, business companies, or various associations (Půda 2012). Persons who were given the confiscated land back number 3–3.5 million (Bičík and Jančák 2005; Bičík et al. 2010).

As a result, up to one-third of the population owns a certain portion of agricultural land (in most cases just 0.1–10 ha, often fragmented into several plots). Many plots are owned by two or more persons, often heirs of the original owners who usually do not live in the area and do not practice farming. Fields still tend to be vast, resulting from the collectivization of 1950s, and typically consist of tens of small plots. Since 1991, the state has been attempting to arrange the land tenure in a better way through the so-called "plot rationalization": the goal is to create a more effective and environment-friendly system. This rather costly plot rationalization has been implemented on 22 % of agricultural land and started on some 11 % (Půda 2012). Such a fragmented and complicated land ownership, which has profound effects on agriculture, landscape, and land use, differs from most other EU countries.

The former state-owned estates have been transformed into limited companies (a. s. or s. r. o.) through privatization. The socialist-style cooperatives have been transformed into cooperatives managed by landowners that nowadays constitute relatively functional units. Under Communist regime, the state directly owned hundreds of thousands of agricultural land which has been gradually privatized since the end of 1990s. In 1996, the state either owned or rented out (to private farmers) some 900,000 ha of agricultural land; in 2012 the same figure was just 200,000 ha (Zelená zpráva Mze 1996; Půda 2012).

Due to restitution a certain proportion of the land and agricultural property previously managed by cooperatives and state-owned estates became part of the newly created private farms. However, the optimistic assumption that a new strong rural middle class would emerge (family farms with 50–200 ha—enough large for economic surviving especially in productive lowlands) proved to be false.

There are various reasons why many landowners do not have any interest in farming. Land tenure remains fragmented, the division of labour and labour specialization in socialist cooperatives was highly developed and consequently the

farm workers did not possess the whole spectrum of experiences, abilities, and competencies needed to run his/hers own farm (from field work and machinery maintenance to financial management and decision-making). People do not have affiliation to the land. In most cases, the new owners who regained the land through restitution did not start farming but rather rented the land out. Thus, in Czechia there are less private farmers than in most other European countries (accounting for some 28 % of agricultural land) and the proportion of private farming rises slowly. The biggest share of agricultural land is managed either by limited companies (46 %) or by transformed cooperatives (23 %). In the European context, these companies are rather big which secures cost-effective farming and competitiveness. However, the social and environmental impacts on the rural areas are rather negative.

The large-scale transformation of land tenure and land management in Czechia after 1989 resulted in a paradox: land tenure is pretty fragmented, but in practice agricultural land is managed by large businesses—most small landowners rent out their plots to big agricultural companies. Though the share of land which is being rented out declines, it is still high by European standards: in the year 2000 some 92 % of agricultural land was rented out, in 2010 the same figure was "only" 77 % (Půda 2012). Since the accession to the EU (2004) the prices of agricultural land have been rising constantly and the market has become more developed; citizens of other EU countries are entitled to buy Czech agricultural land from the year 2011 (at the moment foreigners own some 0.5 % of land and co-own some 6.5 %: Půda 2012).

6.7.2 Institutional Reforms of Czech Agriculture: Outcomes

The large-scale transformation of Czech agriculture resulted in a sharp decline of agricultural production in 1990s. Though widely criticized, this process can also be viewed as the period when Czech agriculture began to adopt Western standards (overproduction was reduced as were the negative environmental impacts).

One of the effects of the agrarian crisis was that fertilizers were no longer excessively used. On average, 223 kg of nutrients per hectare were added to the soil in 1989; this figure declined to 76 kg in 2000 (93 kg in 2010). Similarly, the use of pesticides declined from 2.0 kg per hectare (1990) to 1.4 kg (2010) (Zelené zprávy MZe 1996, 2000, 2010). As a result, in most cases also yields declined (Kušková et al. 2008; Grešlová-Kušková 2013). The political changes and liberalization led to a collapse of agricultural exports to Eastern countries; on the contrary, the share of imported products increased especially from western countries, EU, Germany, etc. (mainly beef, pork). Nutritional habits have changed since, too: the diet is more healthy now, people consume less pork, beef, milk, and dairy products (decline by 25–60 %!). Due to the above-mentioned changes many agricultural companies experienced economic troubles, the land under cultivation shrank, and the agricultural production became restructured.

Table 6.14 Production of selected crops /agricultural products after 1990 in Czechia

	1990	2000	2010
Cereals total (thousands of tonnes)	8946.9	6454.2	6877.6
Potatoes (thousands of tonnes)	1755.1	1476.0	821.9
Sugar beet (thousands of tonnes)	4017.3	2808.8	2919.3
Rapeseed (thousands of tonnes)	304.5	844.4	1042.4
Forage crops (thousands of tonnes)	20625.1	10934.7	7645.6
Milk (millions of litres)	4702.0	2708.1	2612.5
Beef (thousands of tonnes)	511.0	208.0	170.6
Pork (thousands of tonnes)	792.0	583.9	366.4
Poultry (thousands of tonnes)	210.0	294.3	250.9

Source Zelené zprávy MZe 1994, 1998, 2001, 2006, 2010

Decline has been recorded in most agricultural branches in 1990s (see Table 6.14), namely in animal husbandry, Dairy farming, production of beef and pork went down significantly. On the contrary, poultry farming expanded as the nutritional habits were changing. The general decline of animal husbandry resulted in decline of forage crops. The production of sugar beet and potatoes (traditional Czech farming products) also went down significantly. On the contrary, rapeseed expanded as it was increasingly used to produce subsidized fuel and exported. The total production of cereal crops, though it fluctuated year by year, did not change much over the past 20 years. To sum up, during 1990s production of crops declined less than animal husbandry did.

Overall, the period after 1990 can be characterized by a marked decline of the total agricultural production with a certain shift from animal husbandry towards crops. Exact numbers are not available as methods of data collection changed. It is estimated that while in 1992 animal husbandry accounted for 58 % of the total agricultural production (in financial terms), in 2000 the same share was 55 %, and in 2010 only 43 % (Zelené zprávy MZe 1994, 2000, 2010). There have been clear signs of stabilization since 2005; Czech agriculture as a whole keeps profiting from EU membership and from the subsidies in the framework of the Common Agricultural Policy (CAP).

Decline of production and sharp decrease of jobs in agriculture were parallel trends. While in 1989 there were 530,000 people engaged in farming, numbers dropped to 160,000 (2000) and 110,000 (2010) (Zelené zprávy MZe 1997, 2000, 2010). The decline of agricultural employment was especially sharp in early 1990s when many jobs in the former socialist cooperatives were abolished. However, an important part of this decline was just theoretical as it included also a number of "non-agricultural activities" that were widespread within socialist cooperatives.

Still, agricultural employment declined significantly also in the primary production, faster than the outputs did. Consequently, labour productivity and competitiveness were rising. Paradoxically, the Czech agriculture is now in a rather good shape and quite competitive on the European market, thanks to large farms, vast fields, and up-to-date mechanization—largely heritage from the Communist period. After 1989, the socialist-style agriculture was exposed to market forces and the effects of differential land rent which led to an increase of regional differences as regards structure and intensity of production.

6.7.3 Agricultural Policies in Czechia After Accession to the EU

Land use changes after 1990 were primarily driven by renewed market-oriented relations, and also by changing agricultural policies that include subsidies and various regulations. The rather generous socialist-style agricultural policy was abolished in early 1990s and the government interventions into agriculture were limited till 1995. Public funds invested into farming have been rising again since 1997 and these have been chiefly spent on restructuring schemes (support of landscape sustainability, farming in Less Favoured Areas, permanent grassland increase, afforestation). This was a push for a controlled extensive farming, especially in the mountains and highlands; farming jobs were supported too. In the beginning, Czech agricultural policies often changed; since the end of 1990s, however, the national laws must have been harmonized with CAP through the SAPARD programme. The EU funds that became available en masse since 2004 increased substantially the total amount of subsidies and agriculture in Czechia again became a profitable business (Table 6.15).

The so-called Horizontal Rural Development Plan (HRDP 2004) and Operational Programme for Rural Progress and Multifunctional Farming (OPRVMZ 2007) were implemented after the accession to the EU in order to meet the requirements of CAP. These two schemes were amalgamated into the Programme of Rural Progress (PRV 2007) for the period 2007–2013. PRV had four main parts:

1. agricultural competitiveness;
2. environmental and landscape quality;
3. quality of life in rural areas;
4. cooperation and local groups in rural areas (LEADER).

The second part, focused on environmental and landscape quality, is crucial for the rural landscape state and development (see Box 6.8).

Table 6.15 Selected measures important for rural landscapes in Czechia after 1995 (selection)

	Area (thousands of hectares)				Costs (millions of €)			
	1995	2000	2005	2010	1995	2000	2005	2010
Less Favoured Areas (LFA)	–	*	707.5	830.0	–	*	91.1	103.4
Permanent grassland maintenance	*	*	693.0	793.5	*	*	67.9	79.9
Conversion of arable land to permanent grassland	N/A	6.8	14.6	31.2	2.0	1.5	3.9	15.9
Afforestation	0.6	0.9	0.7	0.4	1.0	1.7	1.5	1.6
Direct payments (SAPS and Top-Up)	–	–	3469.0	3516.8	–	–	445.2	595.7
Agricultural policy in total	X	X	X	X	251.3	737.9	1141.1	1661.4

Note: Data come from various sources and are approximate only; * = part of broader schemes; costs are based on the exchange rate 1€ = 27 CZK
Sources: Zelené zprávy MZe 1996, 2001, 2006, 2011; PRV 2010

Box 6.8 Programme of Rural Progress, Part 2: tools implemented (selection)

1. Direct payments to Less Favoured Areas (LFA)—subsidies per hectare of permanent grassland in areas less suitable for farming. Some 50 % of agricultural land in Czechia is located in LFAs; 15 % is in the "mountainous" LFAs that receive the highest assistance.
2. Afforestation of agricultural land.
3. Support of organic farming.
4. Maintenance of permanent grassland (subsidies per hectare of meadows/pastures with special emphasis on areas with high environmental value).
5. Conversion of arable land to permanent grassland (in vulnerable areas, LFAs, along rivers and creeks) (Fig. 6.29).

The second part of Programme of Rural Progress helped to increase the incomes of farmers maintaining permanent grassland. Thus, farmers are motivated to convert arable land to permanent grassland rather than simply abandon it. Though it is unclear what were the effects of free market and those of political measures, the Programme of Rural Progress undoubtedly contributed to the increase of permanent grassland especially in the mountains and highlands. The whole complex of agricultural policies helped to increase the farmers' incomes significantly and protected them against international competition. Consequently, agricultural land could survive also in areas with poor natural conditions.

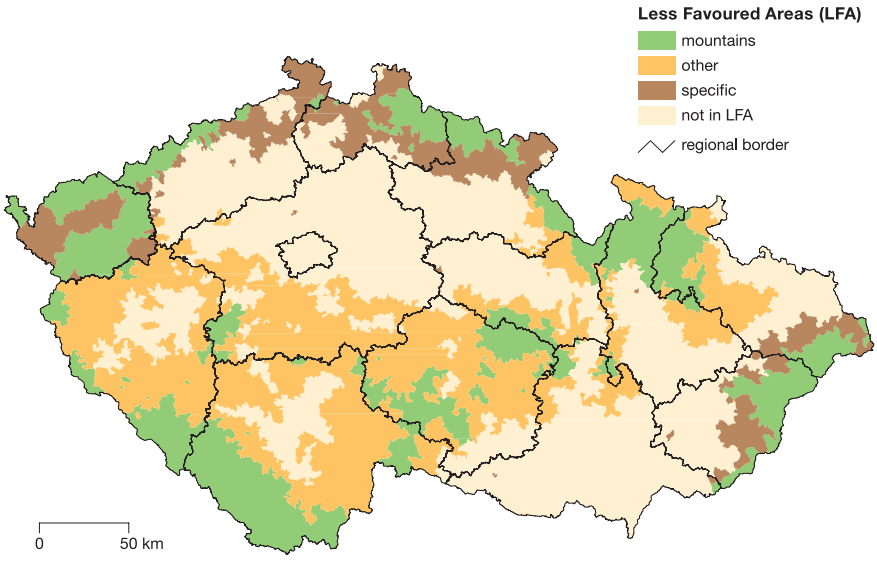

Fig. 6.29 Less favoured areas (LFA) as defined by horizontal rural development plan (2004–2006). *Source* HRDP (2004)

The fact that Czech farms are quite large on average poses problems when it comes to CAP implementation. Farming lobby is strong and personal relations from the socialist times as well. As a result, agricultural policies often focus on "hard" production-oriented subsidies; modern farming trends (multifunctional agriculture, environmental issues, rural development) are underestimated. A small number of large farms receive a high proportion of agricultural subsidies. Farm owners often do not live in the area and their chief goal is to generate high profits as soon as possible. In other words, subsidies that should improve "rural progress" are in fact often used in another way and the effects on local employment and economic improvements remain limited.

6.7.4 Overview of Major Land Use Changes After 1990

The continuing decrease of arable land is the most important land use change after 1990. It resulted from the general decline of farming in the period of transition and was much influenced by the new agricultural policies. Some 220,000 ha of arable land (almost 7 % of the total area) has been lost between 1990 and 2010. In most cases arable land was converted to permanent grassland—the extent of the latter (meadows and pastures combined) has increased by 20 % (160,000 ha) over the same period. Agricultural land as a whole has decreased slightly (by some 60,000 ha), largely due to afforestation and suburbanization. Forests have expanded by some 30,000 ha between 1990 and 2010, built-up areas by 6000 ha, and remaining areas (usually directly linked to built-up areas) by more than 20,000 ha (LUCC Czechia Database).

A great deal of the above-mentioned changes happened in 1990s resulting from the "shock therapy" and agrarian crisis. On the contrary, afforestation accelerated later—some 70 % of the forest increase happened during the first decade of the twenty-first century. In other words, the transition towards a less intensive use of the land follows the pattern "arable land—permanent grassland—forests".

When interpreting the land use data one should take into account that the quality of cadastral data (used in the LUCC Czechia Database 1845–2010) has deteriorated since 1990. In many cases cadastral offices are not notified of land use changes and legal instruments to penalize land owners are limited. Thus, the actual use of land use can differ from that recorded in the files. In reality, the decrease of arable land over the period 1900–2010 was somewhat higher than the data shown.

It is difficult to determine how many imperfections the LUCC Czechia Database really includes. The CORINE database suggests that the decrease of arable land in Czechia between 1990 and 2006 amounted at least 360,000 ha while permanent grassland increased by at least 330,000 ha. According to the cadastral data, however, the arable land decrease was "only" 220,000 ha and permanent grassland increase 160,000 ha over a similar period of time (1990–2010). The CORINE (2013) database has some methodological imperfections too (large grid, heterogeneous character of some land use classes). Other research programmes suggest that despite the above-mentioned differences the basic trends are similar (Romportl et al. 2010).

In other words, though the post-1990 data from LUCC Czechia Database are less accurate and probably underestimate the scope of changes, they still reflect well the major land use trends on national and regional levels.

Large tracts of unused agricultural land (fallow land, not cultivated) began to appear in the Czech landscape after 1990. Such plots are not included in any files and it is impossible to determine their exact extent. Around the year 2000, the Czech Ministry of Agriculture estimated that such unused agricultural land may have covered some 300,000 ha, or 7 % of all agricultural land (Zelené zprávy MZe 1999, 2003). Since then, however, the extent of unused agricultural land has probably decreased due to accession to the EU, more stable conditions, and more precise data records. Agricultural land that is not being used over a long period of time may gradually change into the so-called "new wilderness" (Lipský 2001, 2010). On the one hand, this "new wilderness" is often of a high environmental value including a lot of biodiversity; on the other hand, it can easily become a source of unwanted weeds.

Most of the post-1990 land use changes (Fig. 6.30) are similar to those of the earlier periods. In other words, when the mode of production and technologies used do not differ too much, the land use patterns are surprisingly similar regardless of the political system (Haberl et al. 2001, p. 3). The big exception to the above-mentioned rule, however, constitutes the changes of permanent grassland which began to increase after 1990 following a long period of decline. Conversion of arable land to permanent grassland and afforestation are clear signs of a move towards a less intensive use of the landscape. More grassland and less arable land result in lower human impacts on the environment and higher ecological stability. Consequences may include increase of biodiversity, lower erosion, higher carbon fixation (Lorencová et al. 2013) and possibly also less floods that present an ever-growing problem. The increasing extent of grassland has positive effects on rural tourism too (accessibility of the landscape, aesthetic values).

The loss of arable land due to suburbanization (Ouředníček 2007) and increase of built-up and other "artificial" areas in general have negative impacts on the environment. Suburbanization that includes residential housing and commercial buildings started around 1995 in the major metropolitan areas; nowadays, signs of suburbanization can be found around most Czech cities and towns. Unfortunately, the Czech-style suburbanization often lacks proper planning and includes a lot of chaos due to incompetent public administration, corruption, and clientelism. The price of agricultural

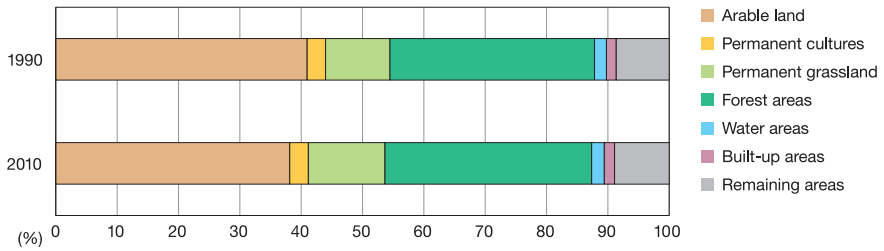

Fig. 6.30 Land use in Czechia between 1990 and 2010 (%). *Source* LUCC Czechia Database

land is low as well and the protection of farming land is inadequate. As a result of the chaotic (sub)urbanization after 1990 impervious surfaces increased a lot, open landscape in the environs of cities and towns practically diminished and the landscape as a whole became further fragmented. New houses, plants, stores, and large shopping centres are primarily localized in the countryside near the highways, etc. They are often being built on soils of the highest quality (Spilková and Šefrna 2010) which are irreversibly lost. Given the current surplus of food it may seem that quality soils are not needed any more; in the long term, however, soil cannot be recovered and due to rising world prices there may be a lack of agricultural land in the future.

6.7.5 Changing Land Use Patterns After 1990: Regional Differences

Marked regional differences of land use changes have been observed since 1990 in the Czechia. The conversion of arable land to permanent grassland has been especially intensive in the mountainous frontier; in these areas such conversion have been recorded on more that 5 % of the total area. The differential land rent came into effect again after 1990 and the shift towards extensive farming was concentrated to less fertile, peripheral areas. In the former Sudeten, i.e. in the border regions, consequences of the post-war German exodus and resulting depopulation are still being felt. The new settlers usually lacked any or small affinity with the region and many were not interested in agriculture. The inefficient state-owned estates in the frontier collapsed fast during the post-1990 period of transition.

In the interior part of the country, most STUs show changes of arable land and permanent grassland (see Figs. 6.31 and 6.32) on less than 2 % of the territory. Surprisingly, in some peripheral areas with poor natural conditions the decline of arable land has been negligible or even slight increase has been recorded. Paradoxically, the peripheral location itself may be the right answer—high density of rural population, conservative attitudes, and mainly lack of jobs outside agriculture (industry, services). The agricultural transformation has mostly been successful in these areas (Kabrda 2004).

The effects of differential land rent have been reflected in the case of forests too. Similar to permanent grassland, forests expanded especially in the mountainous frontier, also in the Bohemian-Moravian Highlands, and generally in peripheral regions with poor natural conditions (Fig. 6.33). A special example is afforestation that was taking place on reclaimed land in the coal mining regions (north-western Bohemia) and in military training areas (some closed after 1990, some still existing—see Fig. 6.37). In the case of military areas, however, the accuracy of data is low. In most other regions of Czechia the changes of forests were minimal.

When it comes to changes of built-up areas, the regional inequalities clearly show the importance of suburbanization (Fig. 6.34). Built-up areas expanded fast in the major metropolitan areas. The position of Prague as the most important core

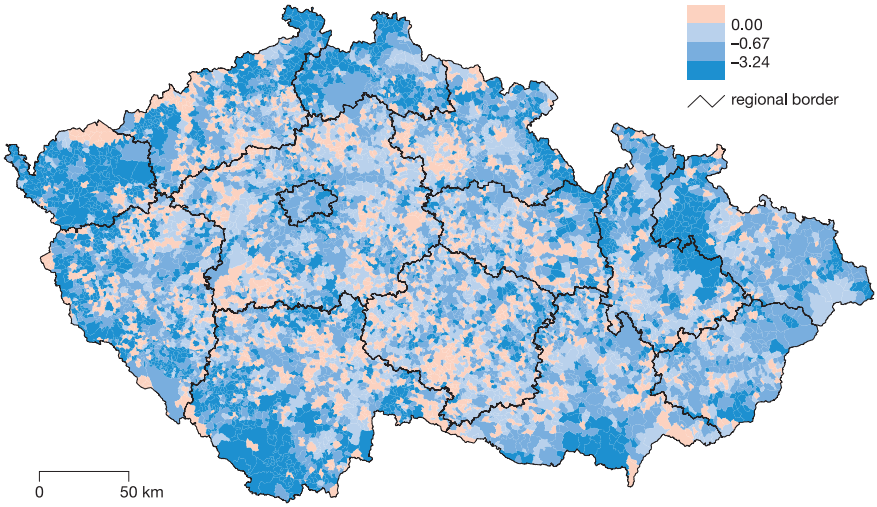

Fig. 6.31 Changes of arable land proportion between 1990 and 2010 (percentage points). *Source* LUCC Czechia Database

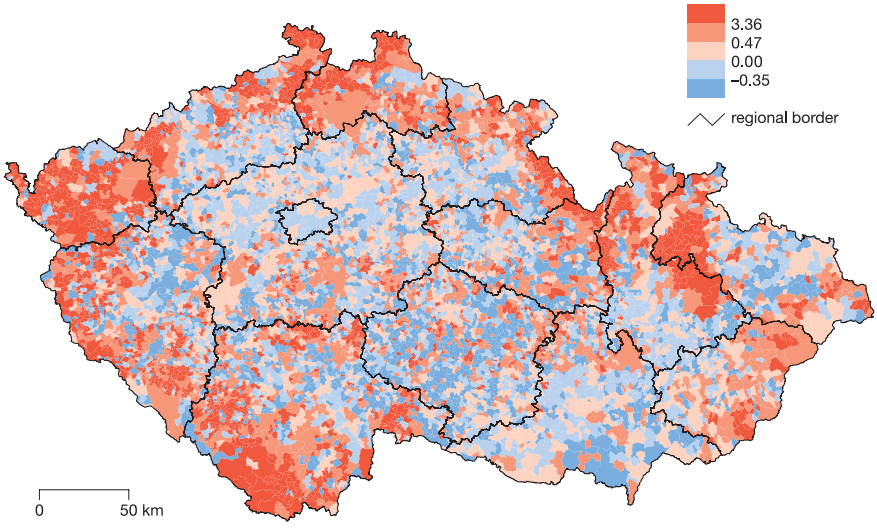

Fig. 6.32 Changes of permanent grassland proportion between 1990 and 2010 (percentage points). *Source* LUCC Czechia Database

area has strengthened since 1990 and the capital city keeps concentrating ever more economic activities. Some development has been observed also along the main axes connecting Prague with the key regional centres.

Surprisingly, no important increase of built-up areas has been recorded in Ostrava (centre and immediate surroundings); in this region, land has been

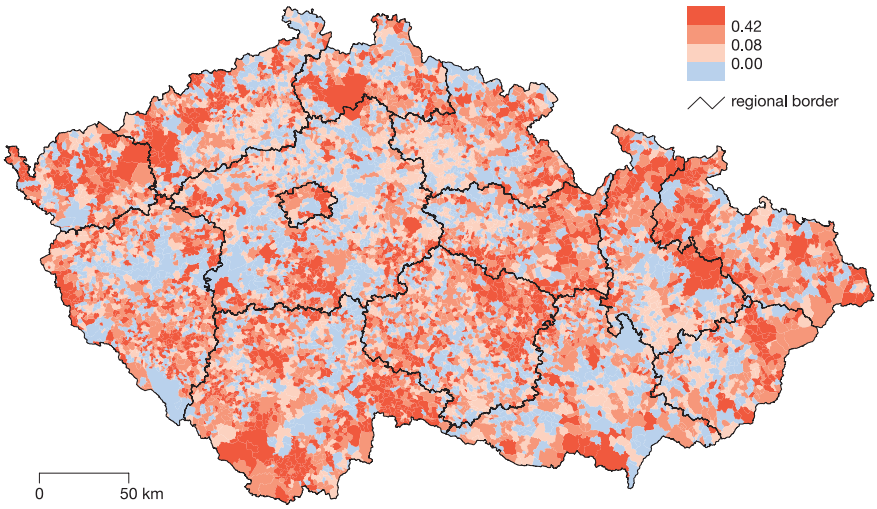

Fig. 6.33 Changes of forest areas proportion between 1990 and 2010 (percentage points). *Source* LUCC Czechia Database

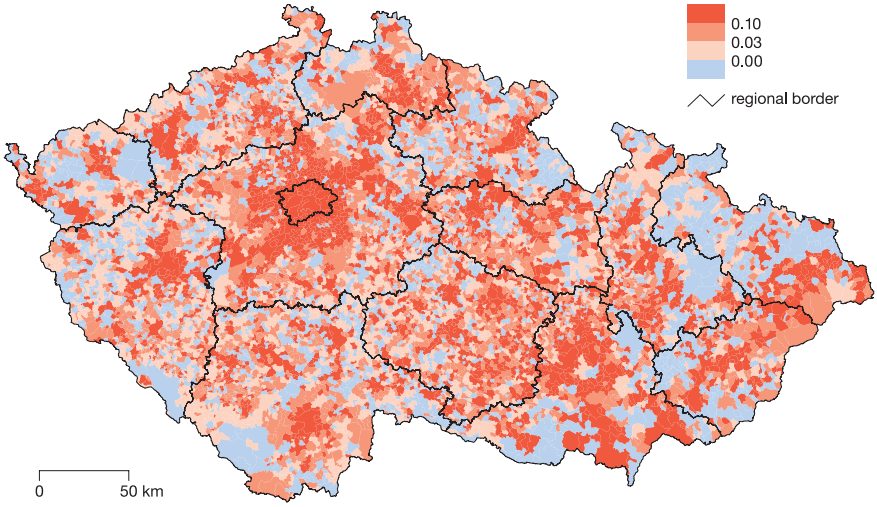

Fig. 6.34 Changes of built-up areas proportion between 1990 and 2010 (percentage points). *Source* LUCC Czechia Database

developed namely in the attractive foothills of Beskydy Mountains (see also Figs. 3.1 and 4.1). The central and northern parts of the Ostrava metropolitan region have even experienced stagnation and decline of built-up areas—possibly due to deindustrialization and economic decline of this traditional industrial area. Decrease of built-up areas has also been observed in military training areas; however, this may result from changes of land use classes.

Regional inequalities of land use patterns have risen in Czechia in the period 1990–2010. Land use has become more "specialized" depending on natural conditions, socio-economic location, and new spatial functions. There has been a clear shift towards a less intensive use of the landscape (conversion of arable land to permanent grassland, afforestation) in the peripheral, less fertile areas. On the contrary, farming land in the metropolitan areas, being under a strong human pressure, has often been developed (suburbanization). Large regions with good or average natural conditions, away from the major urban centres, have experienced very little land use changes and the agricultural production remained more or less stable there. Thus, the conditions of free market combined with agricultural policies contributed to an environment-friendly move towards extensive farming in the mountains and highlands, and also in protected areas (Fig. 6.37). In these regions there is now a good potential for rising biodiversity, less erosion, and "soft" tourism.

6.7.6 Land Use Changes in Czechia After 1990: Summary

Shift towards extensive farming has been the dominant factor of land use changes since 1990. The most intensive changes had been happening during 1990s; later the processes slowed down. LUCC Czechia Database (1845–2010) shows that some 160,000 ha of arable land (i.e. 5 %) have been converted into permanent grassland and some 30,000 ha of agricultural land (i.e. 0.7 %) have been afforested. Moreover, the Ministry of Agriculture estimates that in the year 2000 about 300,000 ha of agricultural land (ca. 7 %) lay fallow. The shift towards extensive farming has been taking place mostly in peripheral regions with poor natural conditions.

The shift towards a less intensive land use has been much influenced by the general decline of farming. After 1990, agriculture as a whole went through a difficult period of transition that included liberalization, privatization, and restitution of property seized under Communism. The interest in private farming, however, remained low; consequently, at the moment there is a contrast between fragmented land tenure and the fact that in most cases farming land is managed by big companies. The above-mentioned transition in 1990s resulted in agrarian crisis and decline of production (especially in animal husbandry). Liberalization led to more pronounced regional differences in intensity and structure of farming production.

Agricultural policies have changed too. Liberal attitudes had prevailed in early 1990s; later on, more money was spent on farming subsidies, especially since the accession to the EU (2004). Large sums have been allocated for agricultural restructuring, rural progress, and "landscape maintenance". A number of measures and tools (since 2007 in the framework of Programme of Rural Progress) support extensive farming especially in the Less Favoured Areas (LFA).

Large tracts of farming land, however, have been developed since 1990 (ca. 6000 ha); apart from built-up areas, also remaining areas (closely related to suburbanization) have risen significantly. Most of the new housing and business

developments have originated in the environs of major urban areas; in this way, high quality fertile land has been irreversibly lost.

The highest intensity of land use changes since 1990 has been observed in the mountainous frontier due to large-scale conversion of arable land to permanent grassland. In these regions, the index of change often exceeded 5 % (Fig. 6.35). Suburbanization on the fringe of metropolitan areas has also caused rather intensive land use changes. On the contrary, very small changes have been typical for large regions with medium and better natural conditions, far from the main cities (less than 1 %—Fig. 6.35).

Regional differences of land use structure have increased since 1990. There is now a clear contrast between favourably located regions with good natural conditions (facing strong human pressures) on the one hand, and peripheral regions with poor natural conditions (moving towards a less intensive use of the landscape) on the other hand. The above-mentioned fact is reflected by the change of coefficient of ecological importance (Fig. 6.36) that has increased over the period 1990–2010 in the mountains and in some highland, peripheral areas. Other regions rather show stagnation or even decrease (metropolitan areas) of the coefficient (Fig. 6.37).

The contrast between changes leading towards less/more intensive use of the landscape is typical for most European countries in the second half of the twentieth century. It has been studied by Correia (1993) in the Mediterranean, MacDonald et al. (2000) in mountainous regions of Europe, Sporrong et al. (1996) in Sweden, Falcucci et al. (2007) in Italy, Hamre et al. (2007) in Norway, Krausmann et al. (2003) in Austria, Gabrovec et al. (2001) in Slovenia, Oťahel' et al. (2002) in Slovakia—to name just a few. In Central Europe, this contrast is emphasized by the effects of post-socialist transition.

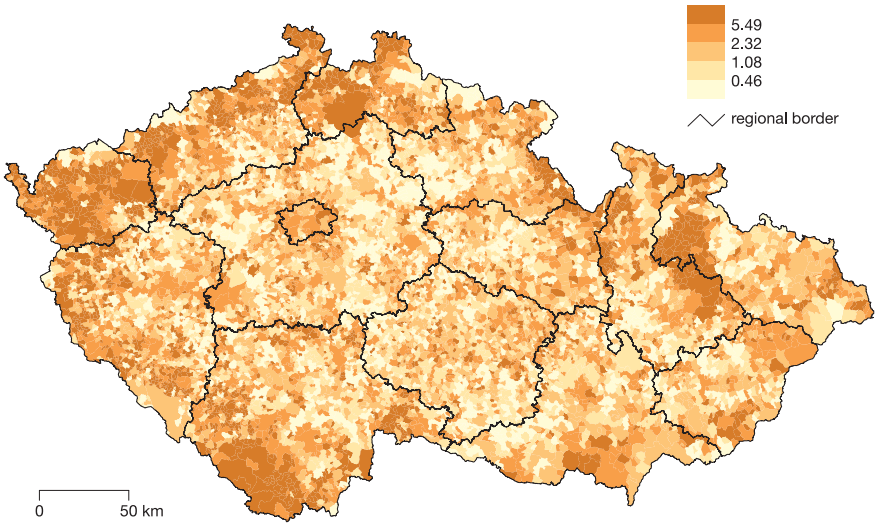

Fig. 6.35 Index of change between 1990 and 2010 (%). *Source* LUCC Czechia Database

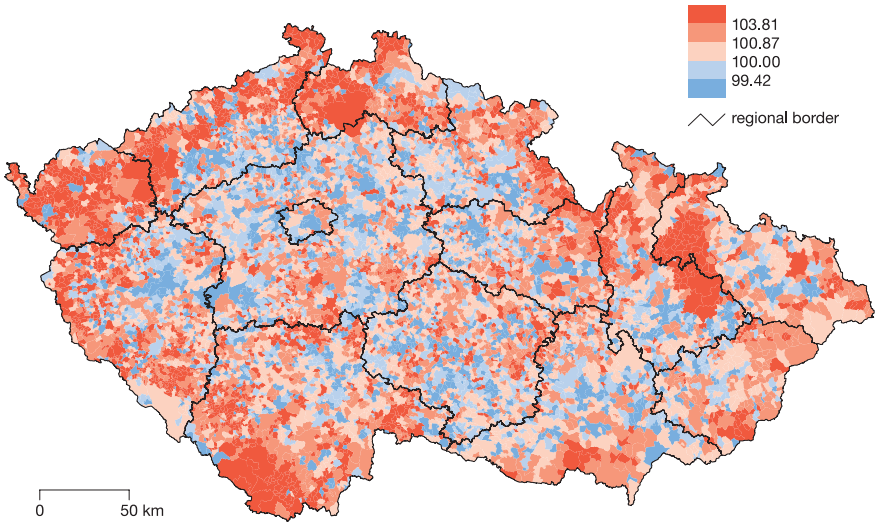

Fig. 6.36 Coefficient of ecological importance change between 1990 and 2010 (1990 = 100). *Source* LUCC Czechia Database

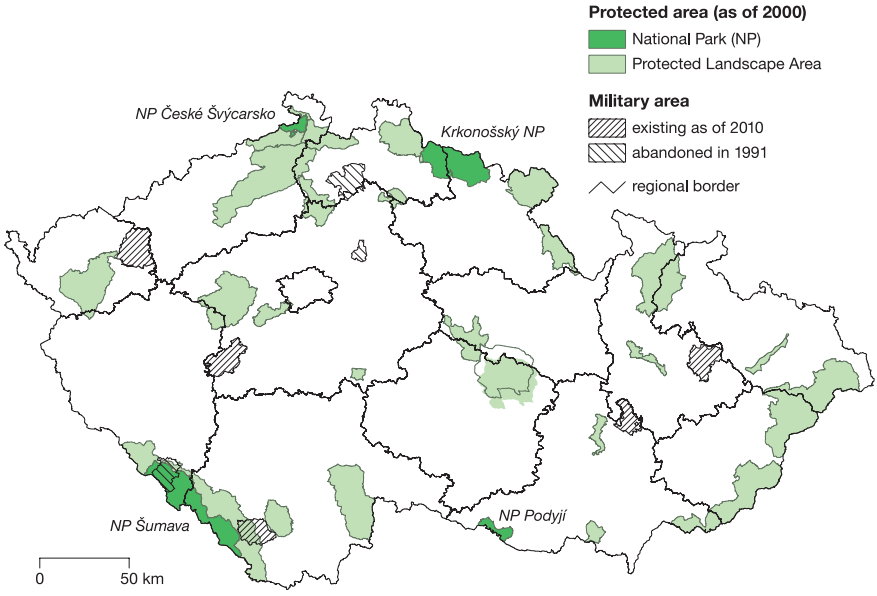

Fig. 6.37 Military training areas, large protected areas. *Sources* Baxa (2006); Agentura ochrany přírody a krajiny (AOPK 2013)

6.8 2010: Czech Landscape After One and a Half Centuries of Fundamental Changes

Land use patterns have changed crucially during the period of last 165 years that included important social, political, and economic changes (Fig. 6.38). Agricultural land has declined by 20 % and now covers just 54 % of the Czech territory. This decrease was basically caused by more effective farming: higher yields have surpassed increased consumption and consequently less cultivated land was needed. Growing international trade with agricultural products played an important role too (Grešlová-Kušková 2013). Arable land accounted for the largest part of the above-mentioned decline. The extent of arable land has dropped by almost 800,000 ha (20 %) between 1845 and 1990 and arable land currently covers only 38 % of the territory (Fig. 6.38) which constitutes an important change compared to the "agricultural peak" in 1896 (52 %).

Permanent grassland has been declining faster than arable land until 1990. Though this trend has been reversed during the last 20 years, permanent grassland now covers just 12.5 % of the Czech territory (25 % less than in 1845). Thus, the ratio of arable land to permanent grassland has increased from 2.75:1 (1845) to 3:1 (2010; see Fig. 6.38). The functions of permanent grassland has also changed: originally meadows and pastures simply sustained the livestock while nowadays permanent grassland rather form a stabilizing factor in the landscape (flood and erosion protection, tourism) and the direct economic function is less important (shift towards intensive animal farming—Gillmor 2001).

Permanent cultures have risen in terms of size and now cover 3 % of the national territory (compared to 1 % in 1845). Also in this case function has changed, especially when it comes to gardens that account for lion's share of permanent cultures (68 % in 2010—ČÚZK 2011). Until 1990 gardens were used mostly for growing fruits and vegetables; since then many serve rather for leisure-time activities (see Sects. 6.6 and 6.7).

The decrease of agricultural land in the second half of the nineteenth century led to the "forest transition" (Sect. 2.4), i.e. to a slow, yet lasting expansion of forest areas. Forests have increased by 15 % (400,000 ha) since 1845 and now cover 34 % of Czechia (Fig. 6.38). Originally, forests were primarily seen as a

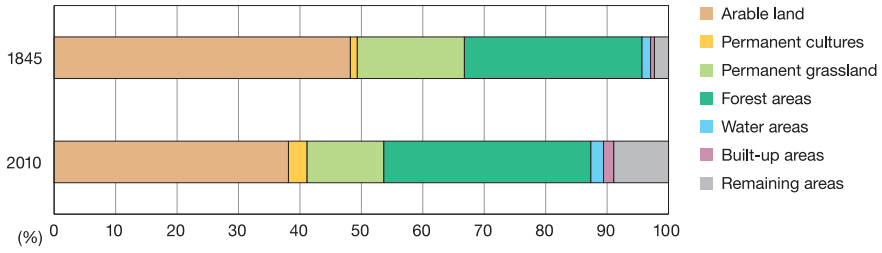

Fig. 6.38 Land use structure in Czechia between 1845 and 2010 (%). *Source* LUCC Czechia Database

source of fuel and construction material; nowadays leisure time is important too (Krausmann and Haberl 2000). The composition of forests has changed as well. Monoculture plantings, usually firs, prevail at the present time which makes harvesting more efficient; this type of forest management, however, alters the habitats and makes the forests more vulnerable to insects (bark beetle) and strong winds.

The abandoned agricultural land has often changed into forests, but in many cases it has been developed, i.e. "invaded" by built-up and remaining areas. Built-up areas have increased threefold due to urbanization and industrialization over the examined period (1845–1990) and now cover 1.7 % of the national territory. Remaining areas have expanded even more: from 2 % in 1845 to 9 % in 2010, i.e. by more than 500,000 ha (Fig. 6.38). The socialist period (1948–1989) is responsible for most of this radical increase (almost 90 %). Currently, 10 % of STUs show the proportion of remaining areas of 10 % and more (LUCC Czechia Database 1845–2010).

Remaining areas (seen as a land use class) include a number of different subclasses (see Chap. 5): artificial areas created by humans (roads, railways, dumps, open pits…), semi-natural areas of high environmental value (unused land, protected areas), etc. This fact also reflects the territorial distribution of remaining areas that are found chiefly in metropolitan and industrial regions (north-western Bohemia) and along the major highways, but also in the mountains (Šumava Mt/Bohemian Forest; see Fig. 3.1) and military training areas. The vast expansion of remaining areas seems to epitomize the changes of Czech landscape since mid-nineteenth century: shrinking of land under cultivation, lack of interest in "landscape management" under socialism, and surplus of areas that are somehow of no interest. Though in the pre-industrial society it was crucial to use every single patch of land including ditches or field boundaries (Sect. 6.3), the industrial agriculture of the present time—following decades of ruthless socialist farming—is based on different principles and large tracts of the land are not "needed" any more.

The regional differences of land use patterns have increased since mid-nineteenth century—compare Figs. 6.39, 6.40, 6.41, 6.42, 6.43, and 6.44 in this chapter (year 2010) with Figs. 6.2, 6.3, 6.4, 6.5, and 6.6 in Sect. 6.3 (year 1845). Table 6.16 shows that the span between upper and lower quartiles has increased over the time in all examined land use classes as well as in the case of CEI. In other words, "normal" STUs (around the median) are becoming rare while "extreme" STUs are more common than in the past.

The increasing regional inequalities stem from the complex social and economic modernization and have been influenced by the transition from pre-industrial to industrial production (compare Sect. 6.3). Cheaper and more straightforward modes of transport were among the important driving forces (Jeleček et al. 2003). Long-distance transport allowed increased inter-regional competition and division of labour (Hampl 2000). On the regional base, it became possible (and necessary) to specialize in the most profitable land use; other products could be imported. From the spatial standpoint, specialization reflected the influence of differential land rent (see Sects. 2.3 and 4.3), i.e. local natural

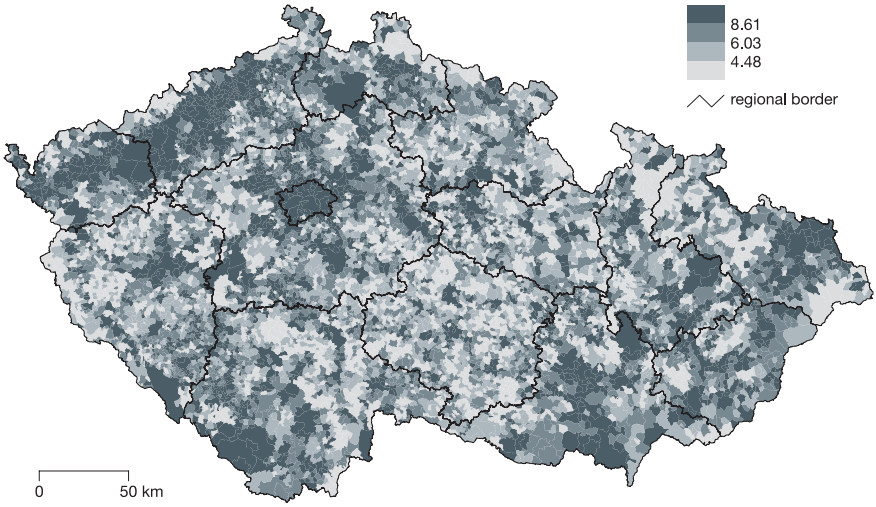

Fig. 6.39 Proportion of remaining areas in 2010 (% of STU area). *Source* LUCC Czechia Database

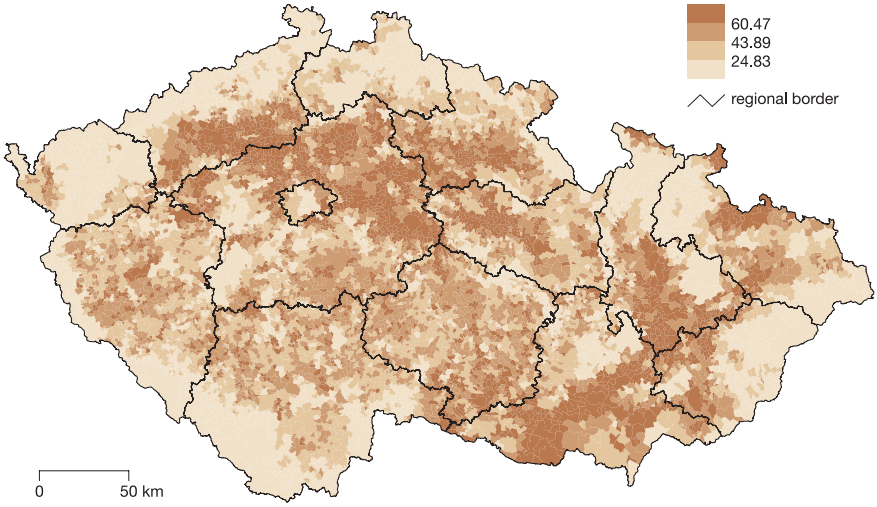

Fig. 6.40 Proportion of arable land in 2010 (% of STU area). *Source* LUCC Czechia Database

conditions and geographical location. Paradoxically, this influence existed also under Communism, though artificial measures were widely used (see Sect. 6.6).

In such a way, different land use patterns, closely interconnected in the past, became spatially divided (Krausmann et al. 2003). The whole system reached a new, more advanced complexity. Thus, land use patterns on the local level became more homogeneous while on the national level heterogeneity (differentiation)

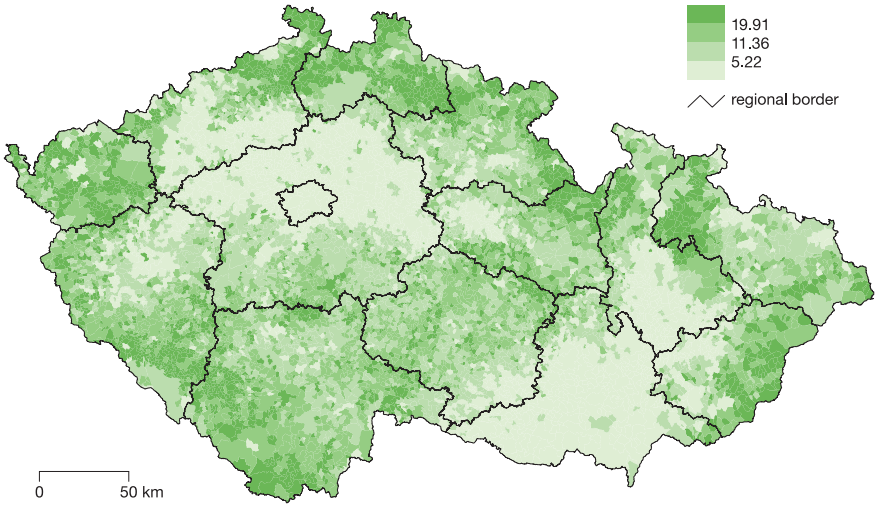

Fig. 6.41 Proportion of permanent grassland in 2010 (% of STU area). *Source* LUCC Czechia Database

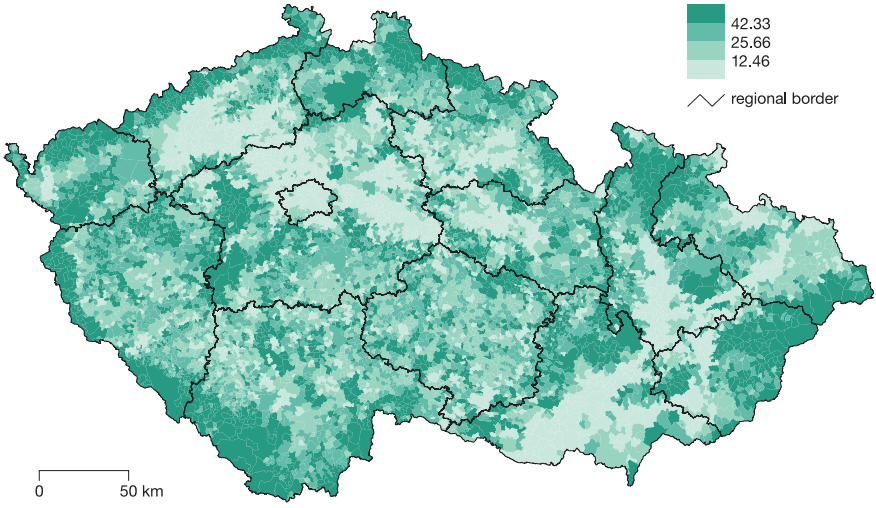

Fig. 6.42 Proportion of forests in 2010 (% of STU area). *Source* LUCC Czechia Database

rose—process that is in accord with the general theory of systems' differentiation (Hampl 2000). As a result, the traditional "average" landscapes (typically with a mixture of fields, meadows, pastures, and forests) vanish and are gradually substituted with large featureless regions—urban, agricultural, or forest areas. The circulation of material, energy, and nutrients on the local level became disrupted too

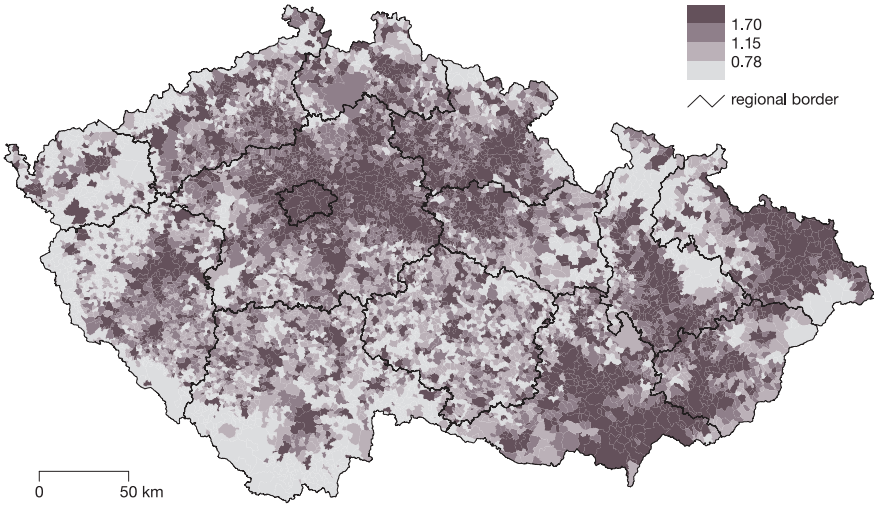

Fig. 6.43 Proportion of built-up areas in 2010 (% of STU area). *Source* LUCC Czechia Database

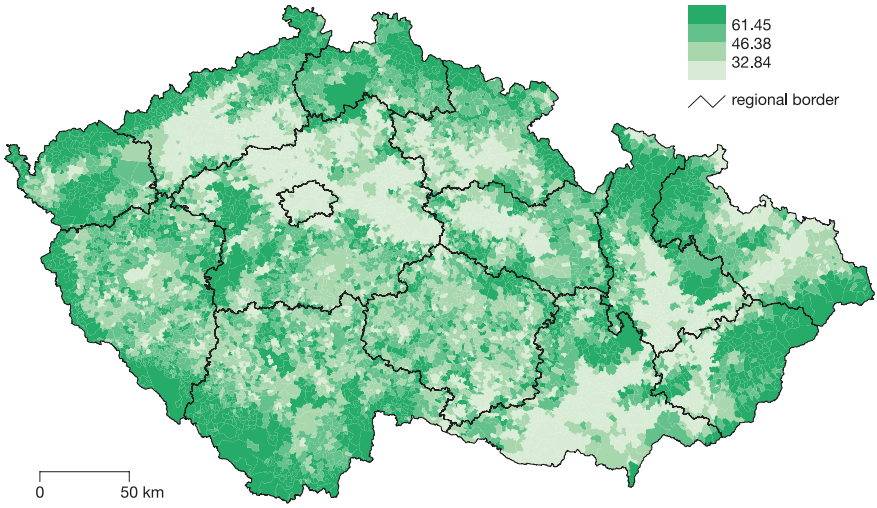

Fig. 6.44 Coefficient of ecological importance (CEI) in 2010 (%). *Source* LUCC Czechia Database

(Gingrich et al. 2013). Instead, new systems—bigger, more open, with high turnaround—came to existence, with largely negative environmental impacts (local imbalance).

At present, arable land is concentrated in lowlands—the proportion of arable land in the low-lying areas has either risen or remained stable over the period

Table 6.16 Statistical distribution of proportions of selected land use classes on STUs areas (%) and that of coefficient of ecological importance (CEI, %) in 1845 and 2010—lower quartile (Q1), upper quartile (Q3), and difference

	Arable land		Permanent grassland		Forest areas		Built-up areas		CEI	
	1845	2010	1845	2010	1845	2010	1845	2010	1845	2010
Q1	40.7	24.8	11.1	5.2	8.6	12.5	0.40	0.77	32.8	32.8
Q3	65.5	60.5	22.6	19.9	34.9	42.3	0.70	1.70	54.3	61.4
Q3–Q1	24.8	35.7	11.5	14.7	26.3	29.8	0.30	0.93	21.5	28.6

Source LUCC Czechia Database

1845–2010. On the contrary, ploughed fields have much declined in the high altitudes and practically disappeared in the mountainous frontier (compare Figs. 6.40 and 6.2). The number of STUs with minimal proportion of arable land has risen dramatically: in 1845, only 10 % of STUs had less than 25 % of arable land; in 2010 the same figure was 25 %. On the contrary, the proportion of STUs with more than 75 % of arable land remained more or less stable (LUCC Czechia Database 1845–2010). Even more important have been the changes of spatial distribution in the case of permanent grassland. Meadows and pastures had been rather evenly distributed in mid-nineteenth century (see Fig. 6.3); with the progress of time, however, permanent grassland became practically non-existent in the lowlands and concentrated in highlands and mountains. The proportion of permanent grassland in higher altitudes has remained stable or even increased (compare Figs. 6.41 and 6.3). The number of STUs with less than 10 % of permanent grassland has doubled since 1845 while those with more than 25 % are roughly equally frequent (LUCC Czechia Database).

To sum up, the distributions of arable land (mostly low-lying areas) and permanent grassland (highlands, mountains) have become spatially divided. Production of crops and animal husbandry are no longer closely interconnected: farm animals are fed by a whole array of fodder and are not directly "linked" to meadows and pastures. Animals are not needed any more as a source of power or manure (replaced by fertilizers) in the fields.

The spatial distribution of forests has not undergone any important changes (Table 6.16). In the mountains, the increase of forests has been slightly higher than in other Czech regions (compare Figs. 6.42 and 6.4). There are now clusters of STUs along the border where forests cover more than half of the area. Such an increase of forests has been influenced by poor natural conditions; in most parts of the frontier the post-1945 transfer of Czechoslovak Germans played a major role, too (see Sect. 6.5).

The spatial distribution of built-up areas currently shows more regional inequalities than in the past too (Table 6.16). Built-up areas were previously quite evenly spread in the lowlands with favourable natural conditions (Fig. 6.5); currently, built-up areas are typically found in metropolitan areas and along major transport routes (Fig. 6.43). Such a shift reflects the general rule that natural predisposition as driving force is being replaced by selection and concentration during the process of urbanization (Hampl 2000).

The above-mentioned changes illustrate the existence of two contradictory processes described in previous chapters (Sect. 6.6, etc.). General shift towards a more intensive use of the landscape has been recorded in favourably located regions with good natural conditions (stabilization of arable land, increase of built-up areas, remaining areas, and permanent cultures). The opposite is true when it comes to peripheral areas with poor natural conditions that show clear signs of less intensive use (transition of arable land to permanent grassland, afforestation). Both processes combined have led to a lower diversity of the Czech landscapes. (Sub) urbanization dominates the metropolitan areas, open landscapes are disappearing or becoming fragmented. Industrial farming keeps expanding in fertile lowlands, destroying natural and semi-natural elements in the landscape. Traditional cultural landscape in highlands and mountains gradually vanishes (Sporrong et al. 1996).

The above-mentioned trends are proved also by the increasing regional differences of coefficient of ecological importance (CEI). The difference between upper and lower quartiles has increased by one-third over the period 1845–2010 (Table 6.16). High and low values are spatially divided now (compare Figs. 6.6 and 6.44). In the lowlands there are currently large areas with CEI below 30 %; on the contrary, CEI over 70 % is common in large areas of the mountainous frontier (Fig. 6.44, LUCC Czechia Database).

Decrease of arable land, increase of forests and permanent grassland combined have been recorded on the national level and especially in less fertile regions. In general, it is an environment-friendly change towards a less intensive use of the landscape. However, this positive trend was largely reduced by dramatic changes of the landscape under Communism (see Chap. 7).

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Chapter 7
Land Use Changes in Selected Model Areas

Abstract Land use changes between mid-nineteenth century and present in four selected model areas are outlined. The analyses are based on research by individual plots and bring detailed results that cannot be obtained using conventional statistical methods. The model areas were chosen so that they would represent different landscape types in different parts of Czechia. The first one, Abertamy-Hřebečná, is a remote village located in the border mountains. The place has poor natural conditions and has been much influenced by the expulsion of German speaking population after World War II. In other words, human activities decreased significantly over the past 160 years; shift towards permanent grassland and forests was typical. Second, Kutlíře is found in the fertile Elbe Plain in Central Bohemia and typifies the long tradition of farming. Unlike many other regions, farming remains crucial also nowadays, with emphasis on grain and other crops that require favourable soils and climate. Third, Čestlice is located near Prague adjacent to the main freeway, also in a quite fertile area. Due to the proximity of the capital city, however, the place has been recently much affected by suburbanization. In land use terms the result was a significant expansion of built-up and remaining areas. The last model area, Břekova Lhota, represents the so-called "inner periphery", placed outside the major economic zones and part of the Less Favoured Areas (LFA). The traditional reliance on subsistence agriculture has been replaced over the past 150 years by a mix of agriculture and leisure activities (second homes). Changing patterns of land use are shown in tables for each of the model areas that include eight basic land use classes. Importance of aerial images as an evidence of land use/cover change is documented using an example of the mountainous cadastre Horní Rokytnice nad Jizerou.

Keywords Model areas · Detailed analysis · Peripheral location · Fertile soils · Suburbanization

This chapter outlines land use changes between mid-nineteenth century and present using detailed analyses by individual plots in selected model areas. Four model areas representing different landscape types in Czechia have been selected.

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Springer Geography, DOI 10.1007/978-3-319-17671-0_7

Table 7.1 Selected geographical data of model areas

Cadastral area	Area (ha)	Population		Average altitude (m a.s.l.)	Average price of agricultural land 1992 (CZK/m2)	Average inclination of slopes (°)	LFA
		1869	2001				
Břekova Lhota	189.7	107	44	395.4	3.8	0.8	Yes
Čestlice	442.5	313	405	300.8	8.5	1.1	No
Kutlíře	217.8	86	27	232.8	10.5	1.2	No
Abertamy-Hřebečná	857.5	3310	1197	840.1	2.52	4.1	Yes

Sources LUCC Czechia Database; ČSÚ (2006)

First, Abertamy-Hřebečná is located in a peripheral position in the mountains close to the border. Poor natural conditions are typical; this area has been much influenced by the transfer of Czech German after World War II and by the extraction of uranium ore. Second, Břekova Lhota is a sort of "inner periphery". Such territories are typically located outside the major economic zones and usually can be identified with less favoured areas (LFA). Third Kutlíře lies in the Elbe Lowland (Polabí) in Central Bohemia and has fertile soils as well as a long tradition of farming. Fourth Čestlice is found on the margins of Prague near the main Czech freeway (D1) and recently has been significantly affected by suburbanization.

Basic geographical data of the model areas are shown in Table 7.1. History and specific features are described in further subchapters.

7.1 Abertamy-Hřebečná

The cadastral areas Abertamy and Hřebečná are situated in Northwestern Bohemia in Krušné hory (Ore Mountains; see Fig. 3.1). It is a rather peripheral location in high altitude (600–900 m a.s.l.). Consequently, the local climate is classified as cold and very cold. Podzols are the most typical soils; cambisols, and peat bogs are common, too. None of these soils are suitable for farming. Abertamy and Hřebečná are classified as LFA.

The first written note of Abertamy dates back to 1529. The place was given the status of royal mining town in 1579 as rich deposits of silver and tin had been found there. Mining was especially important in the second half of the sixteenth century; in that time the area produced most cassiterite (tin ore) in the whole Ore Mountains. The whole area became a restricted zone after World War II. The extraction of uranium ore had profound effects on Abertamy and Hřebečná: new mines opened and new buildings were constructed to provide accommodation for workers and prison guards. Thousands of political prisoners were used as cheap workforce in the uranium mines. The extracted uranium ore was exported to Soviet Union and mostly used for nuclear weapons.

Abertamy-Hřebečná was plagued by the post-war transfer of Czechoslovak Germans. The population decline had been significant and continued after the closure of uranium mines in 1960s. New glove factory created some jobs, many people were commuting to the industrial towns at the foot of the mountains. There are some 1100 permanent inhabitants in Abertamy and Hřebečná combined at present (Table 7.1). Local industry, including the glove factory, closed down, and cattle grazing declined seriously; on the contrary, tourism is becoming more important.

The current landscape (see Fig. 7.1) still reflects the transfer of German speaking inhabitants in 1945–1947 and also the uranium mining that started immediately afterwards (various depressions in the terrain, dumps, ruined buildings, etc.). Figures 7.2, 7.3 and 7.4 and Table 7.2 show the changing patterns of land

Fig. 7.1 Aerial photo of the Abertamy-Hřebečná area. Mountainous landscape with forests, meadows and pastures. *Photo* http://geoportal.gov.cz/

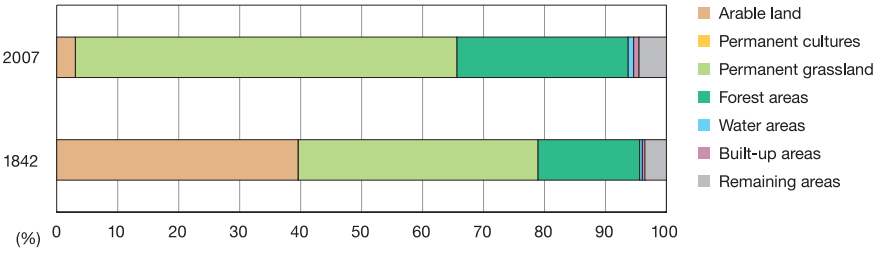

Fig. 7.2 Abertamy-Hřebečná—land use in 1842 and 2007. *Source* own calculations

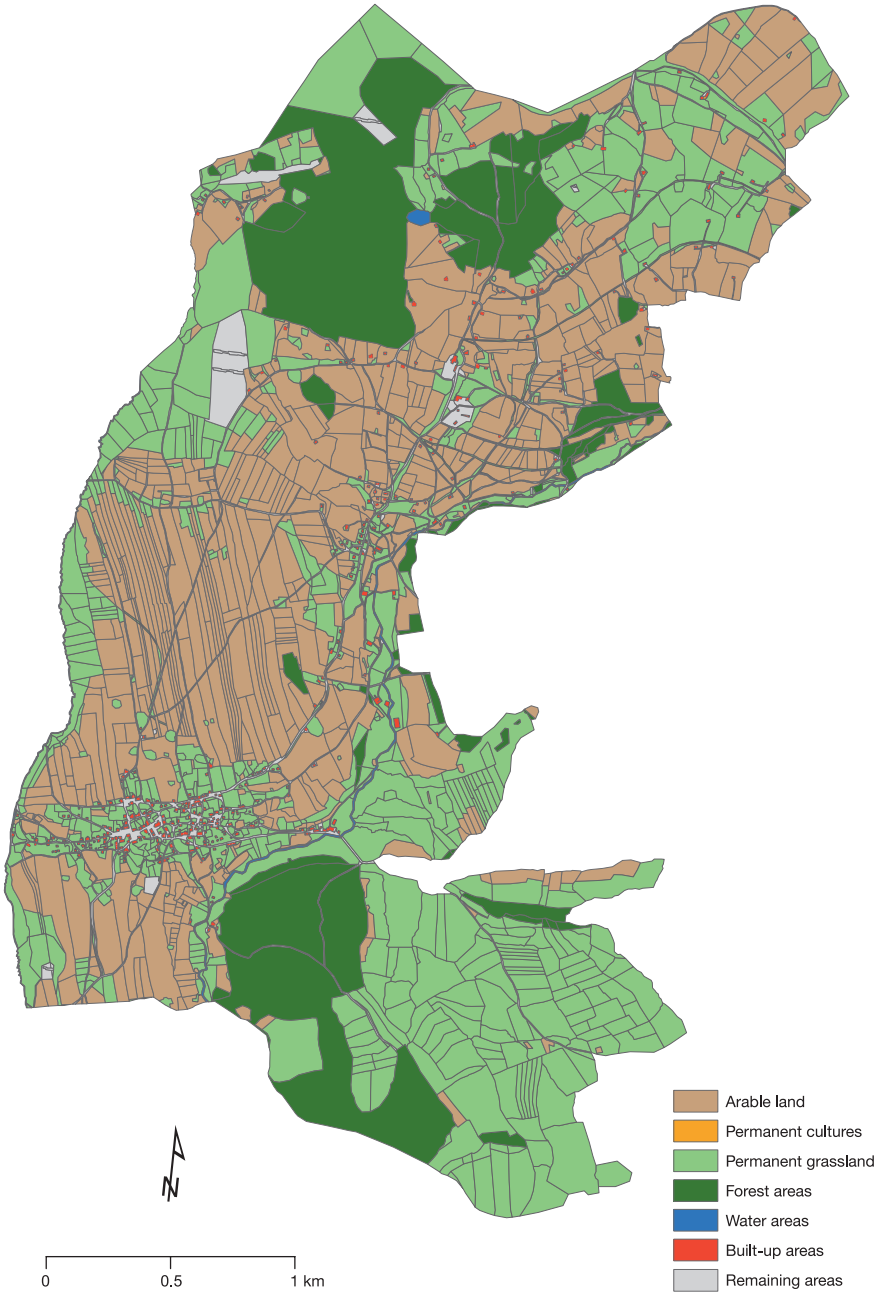

Fig. 7.3 Abertamy-Hřebečná—map of land use in 1842. *Source* Central Archives of Surveying, Mapping and Cadastre, Prague

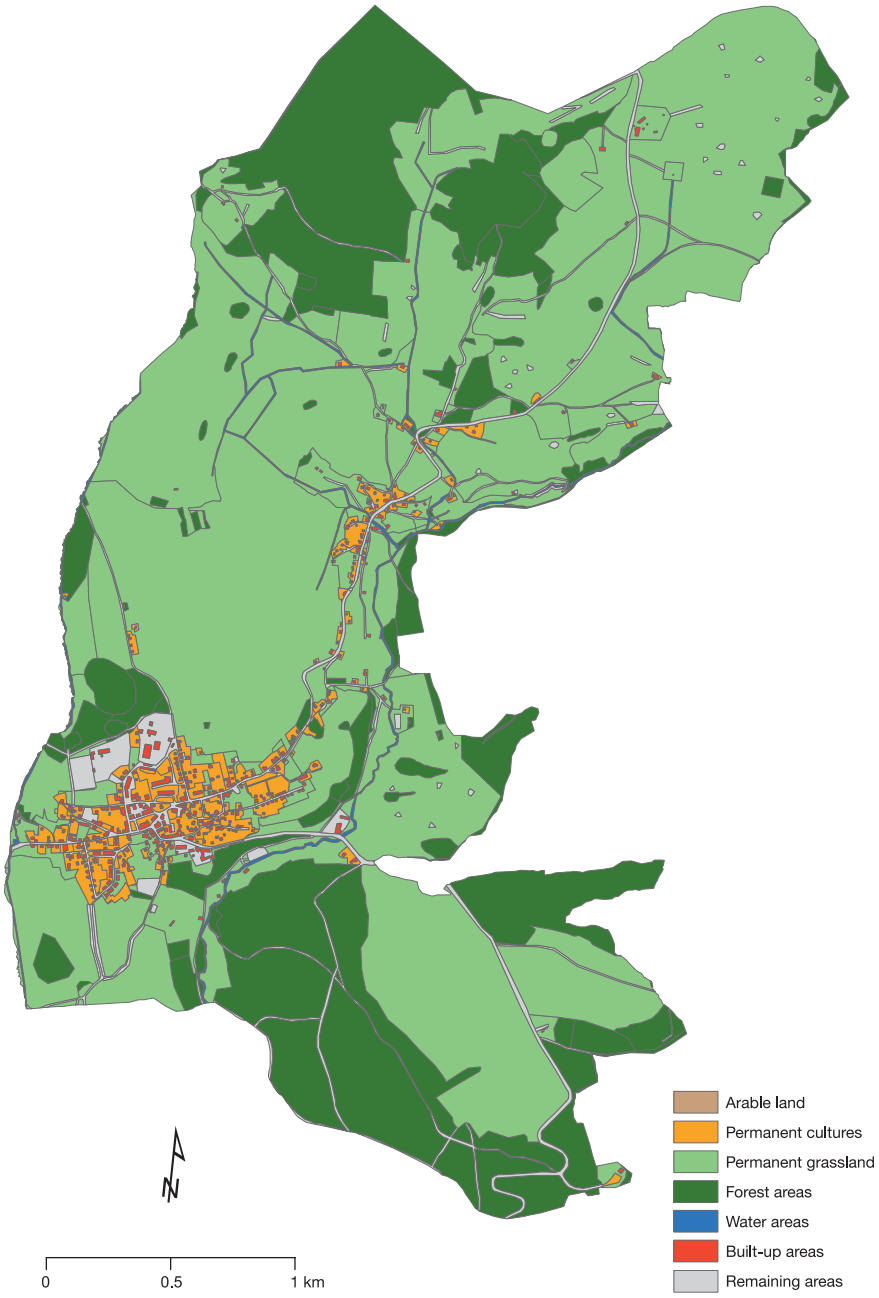

Fig. 7.4 Abertamy-Hřebečná—map of land use in 2007. *Sources* Field mapping Leoš Jeleček et al.; ortophoto—Czech Office for Surveying, Mapping and Cadastre

Table 7.2 Abertamy-Hřebečná—matrix of land use change 1842–2007 (ha)

857.52[a]	Arable land	Permanent cultures	Permanent grassland	Built-up areas	Forest areas	Water areas	Remaining areas	Total[d]
Arable land	0.00	9.78	284.02	2.09	27.67	2.30	13.44	339.30
Permanent cultures	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.02
Permanent grassland	0.00	13.82	211.46	3.42	91.00	3.30	13.65	125.19
Built-up areas	0.00	0.86	1.53	1.50	0.26	0.02	0.54	3.21
Forest areas	0.00	0.04	23.35	0.01	115.76	0.24	3.30	26.94
Water areas	0.00	0.00	1.66	0.02	0.32	1.63	0.18	2.18
Remaining areas	0.00	1.90	14.54	0.39	5.67	0.33	7.46	22.83
Total[c]	0.00	26.40	325.12	5.93	124.92	6.19	31.11	519.69[b]

Explanations [a]Total area (in ha) of observed locality in 1842 and 2007. [b]Amount of hectares with change of class. [c]Total amount of hectares newly in arable land (etc.) in 2007 from classes in rows. [d]Total amount of changed class from into class in columns. On the diagonal of the table: from the size in 1842 in the same class "survived" till 2007. *Source* own calculations

use between 1842 and 2007. Any kind of land use change has been recorded on 60.6 % of the whole area, which is a much higher figure than that on the national level. The decline of cultivated areas is apparent; less intensive use of the landscape became common. Agricultural land covered almost 80 % of the territory in mid-nineteenth century; arable land covered 40 %. Since then, agricultural land has been gradually shrinking and arable land has virtually disappeared. As a result of advancing technologies, farming on poor soils could no more cope with competitors in more favourable conditions in the plains. Thus, arable land was to a great extent converted into permanent grassland that increased by some 60 %. The poorest soils became gradually covered by forests that expanded by more than 100 ha. This afforestation was partially planned, but partially also natural process. Built-up areas doubled in size; the remaining areas expanded six times as a result of mining.

Though the changes over the past 150 years have been significant, the landscape of Abertamy-Hřebečná has maintained much of the natural beauty, now largely consisting of a mosaic of forests, meadows, and pastures. High environmental qualities of the area attract growing number of visitors; winter and summer recreation and tourism are now among the most important sources of income for the local people.

7.2 Břekova Lhota

Břekova Lhota is situated some 60 km south of Prague, near the little town Sedlčany. The surrounding landscape, part of Středočeská pahorkatina (Central Bohemian Hills; see Fig. 3.1), is an undulating one, with altitudes around 400 m a.s.l. Břekova Lhota belongs among Less Favoured Areas (LFA). The location is peripheral, with inadequate roads, far from major economic centres. Since many

Fig. 7.5 Landscape surrounding Břekova Lhota belongs among less favoured areas. It is the landscape of "inner periphery", where farming and forestry prevail. *Photo* Přemysl Štych

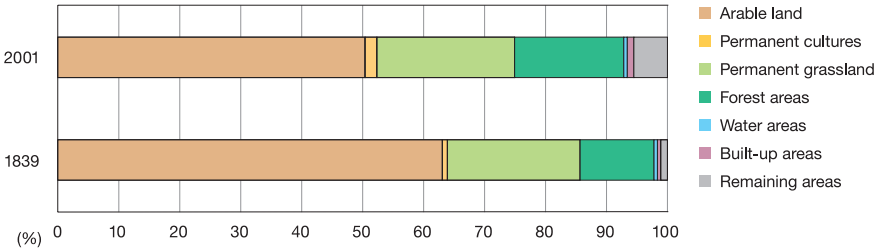

Fig. 7.6 Břekova Lhota—land use in 1839 and 2001. *Source* own calculations

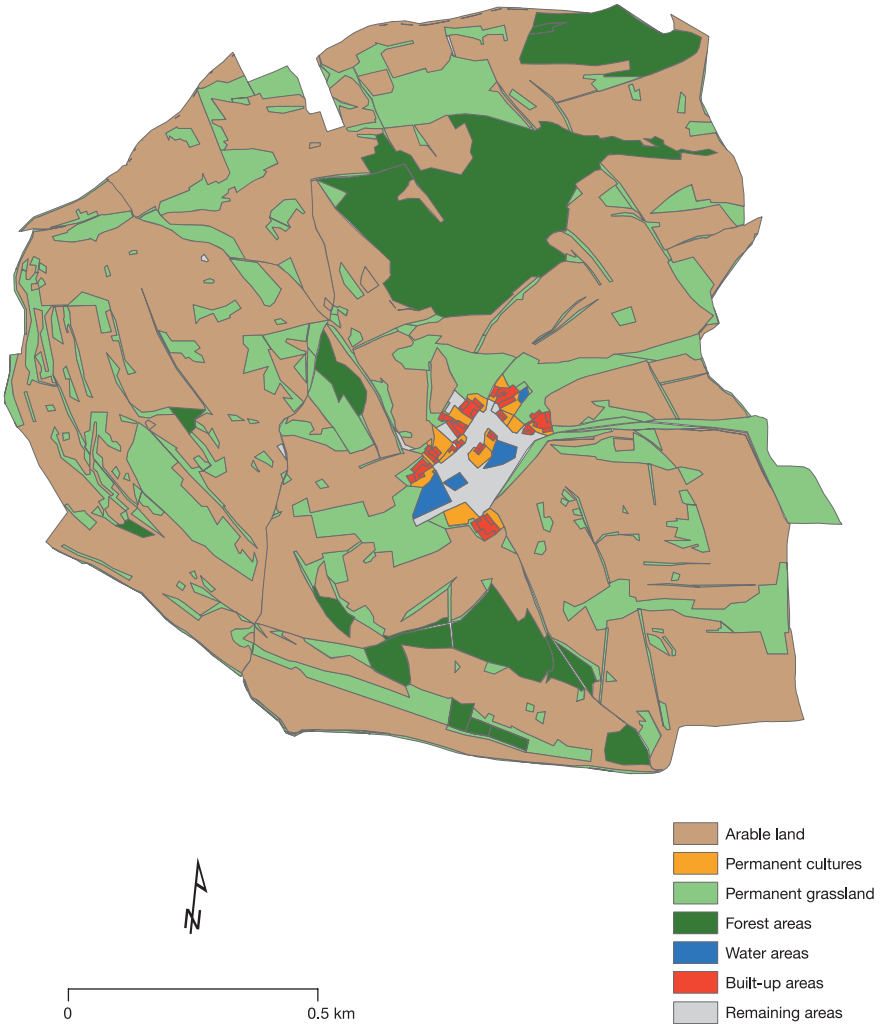

Fig. 7.7 Břekova Lhota—map of land use in 1839. *Source* Central Archives of Surveying, Mapping and Cadastre, Prague

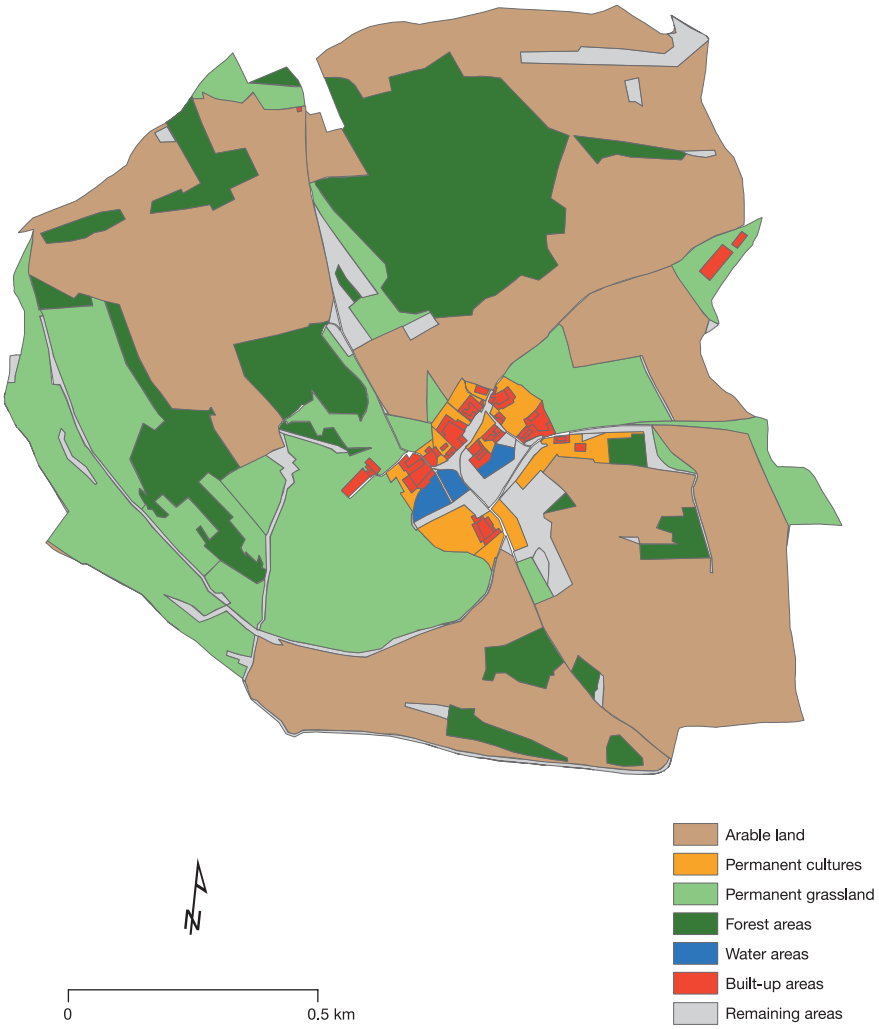

Fig. 7.8 Břekova Lhota—map of land use in 2001. *Sources* Field mapping Přemysl Štych; *ortophoto*—Czech Office for Surveying, Mapping and Cadastre

years ago, the whole Sedlčany Region has suffered from depopulation and poor economic performance. Farming and forestry prevail; the beauty of local nature and relatively untouched environment provide good conditions for leisure time activities (Fig. 7.5). Second homes, mostly former farmhouses converted for recreational use, are common.

In land use terms, agricultural land and forests dominate in the whole examined period (see Fig. 7.6). Cartographic analysis (Figs. 7.7 and 7.8), however, reveals that there have been important changes in the landscape between 1839 and

Table 7.3 Břekova Lhota—matrix of land use change 1839–2001 (ha)

188.3[a]	Arable land	Permanent cultures	Permanent grassland	Built-up areas	Small scale green areas	Forest areas	Water areas	Remaining areas	Total[d]
Arable land	75.2	1.4	30.0	0.6	2.8	8.0	×	1.9	44.7
Permanent cultures	×	0.8	×	0.4	0.0	×	0.0	0.0	0.4
Permanent grassland	13.5	1.2	12.1	0.2	1.1	10.3	0.0	1.5	27.8
Built-up areas	×	0.1	0.0	1.0	×	×	×	×	0.1
Small scale green areas	×	×	×	×	×	×	×	×	0.0
Forest areas	5.8	×	0.6	×	1.2	15.4	×	0.1	7.8
Water areas	×	0.0	0.0	×	0.0	×	0.7	0.0	0.1
Remaining areas	0.0	0.3	0.1	0.2	1.0	×	0.2	0.4	1.9
Total[c]	19.4	3.0	30.7	1.4	6.1	18.3	0.3	3.6	82.7[b]

Explanations [a]Total area (in ha) of observed locality in 1839 and 2001. [b]Amount of hectares with change of class. [c]Total amount of hectares newly in arable land (etc.) in 2001 from classes in rows. [d]Total amount of changed class from into class in columns. On the diagonal of the table: from the size in 1839 in the same class "survived" till 2001. *Source* own calculations

2000. More than 40 % of the area experienced a change of land use. Table 7.3 explains in detail these changes, often contradictory ones. Shift from arable land to permanent grassland has been recorded on some 15 % of the territory; in the same time, however, permanent grassland has been converted into arable land, too (7 %). Similar situation appears when it comes to changes from forests to arable land (5.8 ha) and vice versa (8 ha). Afforestation has been important as forests expanded by 10 % in the area, with new forests mostly covering former low-quality arable land. Some land use types became less fragmented and the boundaries between different land use types are more straight now—the landscape loss a bit of its former distinctively mosaic-like character. Though the forced collectivization in 1950s and 1960s had largely negative effects (destruction of field boundaries, creation of very large units), the landscapes of "inner periphery" still retain high environmental values which can help to boost tourism (cycling, hiking, agrotourism…) in future.

7.3 Kutlíře

Kutlíře presents a small cadastral area both in terms of size and population. It is situated in Central Bohemia west of Kolín in the fertile Elbe Plain (Polabská nížina; see Fig. 3.1) at an altitude of 230 m a.s.l. Relatively warm climate and high-quality soils provide good conditions for intensive farming (sugar beet region). Already the land use map of 1841 (see Figs. 7.11 and 7.12) shows that agriculture was very important then: agricultural land covered more than 90 % of the total area (see Fig. 7.10). Thanks to favourable natural conditions and high yields the extent of agricultural land has not changed much over the years

Fig. 7.9 The central part of Polabí (Elbe Plain—Kutlíře near Kolín) is still intensively farmed. Land use changes have been minimal over the past 150 years in this area. *Photo* Leoš Jeleček

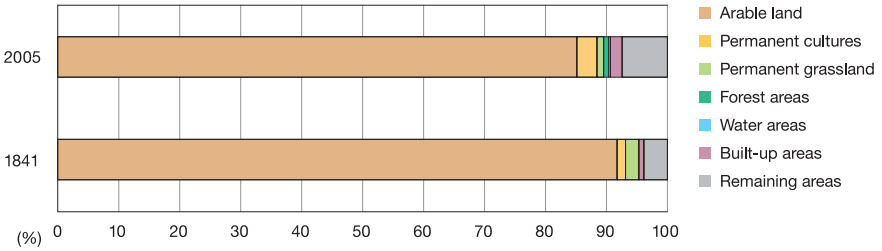

Fig. 7.10 Kutlíře—land use in 1841 and 2005. *Source* own calculations

Fig. 7.11 Kutlíře—map of land use in 1841. *Source* Central Archives of Surveying, Mapping and Cadastre, Prague

Fig. 7.12 Kutlíře—map of land use in 2005. *Sources* Field mapping Leoš Jeleček et al.; orto-photo—Czech Office for Surveying, Mapping and Cadastre

(Fig. 7.9). Large amounts of sugar beet were being transported to the sugar factory in Kolín. Since 1990, however, the importance of sugar industry has declined and consequently sugar beet fields have been reduced in size.

A small and shallow valley in the slope exposed to the northeast (to the river Elbe) with a small creek forms a sort of a landscape peculiarity in Kutlíře. This piece of landscape had been originally covered by grassland; in the second half of the twentieth century a number of second homes and small gardens originated here.

Table 7.4 Kutlíře—matrix of land use change 1841–2005 (ha)

210.1[a]	Arable land	Permanent cultures	Permanent grassland	Built-up areas	Small scale green areas	Forest areas	Water areas	Remaining areas	Total[d]
Arable land	172.0	3.9	2.5	2.1	5.6	1.9	0.2	4.6	20.8
Permanent cultures	×	1.3	×	0.3	0.6	0.2		0.3	1.4
Permanent grassland	1.6	1.3		0.1	1.3	0.0	0.1	0.3	4.8
Built-up areas	0.1	0.3	×	0.9	0.0	×	0.2	0.1	0.7
Small scale green areas	×	×	×	×		×	×	×	0.0
Forest areas	×	×	×	×	×		×	×	0.0
Water areas	×	×	×	×	×	×		×	0.0
Remaining areas	5.0	0.2	0.1	0.3	0.4	0.0	0.1	2.2	6.1
Total[c]	6.7	5.7	2.6	2.8	8.0	2.1	0.6	5.3	33.7[b]

Explanations [a]Total area (in ha) of observed locality in 1841 and 2005. [b]Amount of hectares with change of class. [c]Total amount of hectares newly in arable land (etc.) in 2005 from classes in rows. [d]Total amount of changed class from into class in columns. On the diagonal of the table: from the size in 1841 in the same class "survived" till 2005. *Source* own calculations

The case of Kutlíře proves that when it comes to fertile areas, even the profound structural changes in agriculture (land tenure, size of farms, structure of crops, etc.) have had just modest effects on land use patterns. Table 7.4 shows that any change of land use has been recorded on just 16 % of the area between 1841 and 2005. The differential land rent II played a crucial role between late nineteenth century and mid-twentieth century. No important land use changes have been recorded in this traditionally farming region as high fertility of the land secures profitable farming—fact that remained unchanged even under the totalitarian regime.

7.4 Čestlice

Čestlice is located right on the southeast margins of Prague in a flat landscape with relatively fertile soils. In mid-nineteenth century it was a typical agricultural village. However, the location of Čestlice—in the immediate proximity of the capital and close to the core freeway/highway West–East (D1)—provided a very good background for future development. Cartographic analysis (see Figs. 7.13 and 7.14) shows clearly that tremendous changes have taken place over the examined period: farming that had originally dominated, was substituted with commercial activities. Čestlice has been subject to intensive suburbanization since 1990: in this period a huge commercial complex has been built, including large retail outlets, office space, warehouses, parking lots, etc. (see Fig. 7.15). The area can be easily accessed from Prague by car or by public transport and due to a vast array of services it is regularly visited by shoppers from Prague and Central Bohemia.

The most important land use changes have taken place during the past 25 years when built-up areas and remaining areas have expanded significantly (see Fig. 7.16, Table 7.5). The remaining areas are rather heterogeneous and include a number of subtypes ranging from tarred parking lots to green spaces within commercial compounds. Cartographic analysis reveals that some two-thirds of the total area remained stable in land use terms, while the remaining one-third showed some change: typically a shift from arable land towards remaining areas (54 % of all change) or transition from permanent grassland to arable land.

The currents landscape structure results from intensive suburban processes in the metropolitan area of Prague. It is the commercial function (not the residential one) that dominates at the moment. The agricultural land close to big cities is under critical threat and even high-quality arable land is often being invaded by developers—a process that still continues. The protection of agricultural land as part of regional planning is usually weaker than commercial pressure.

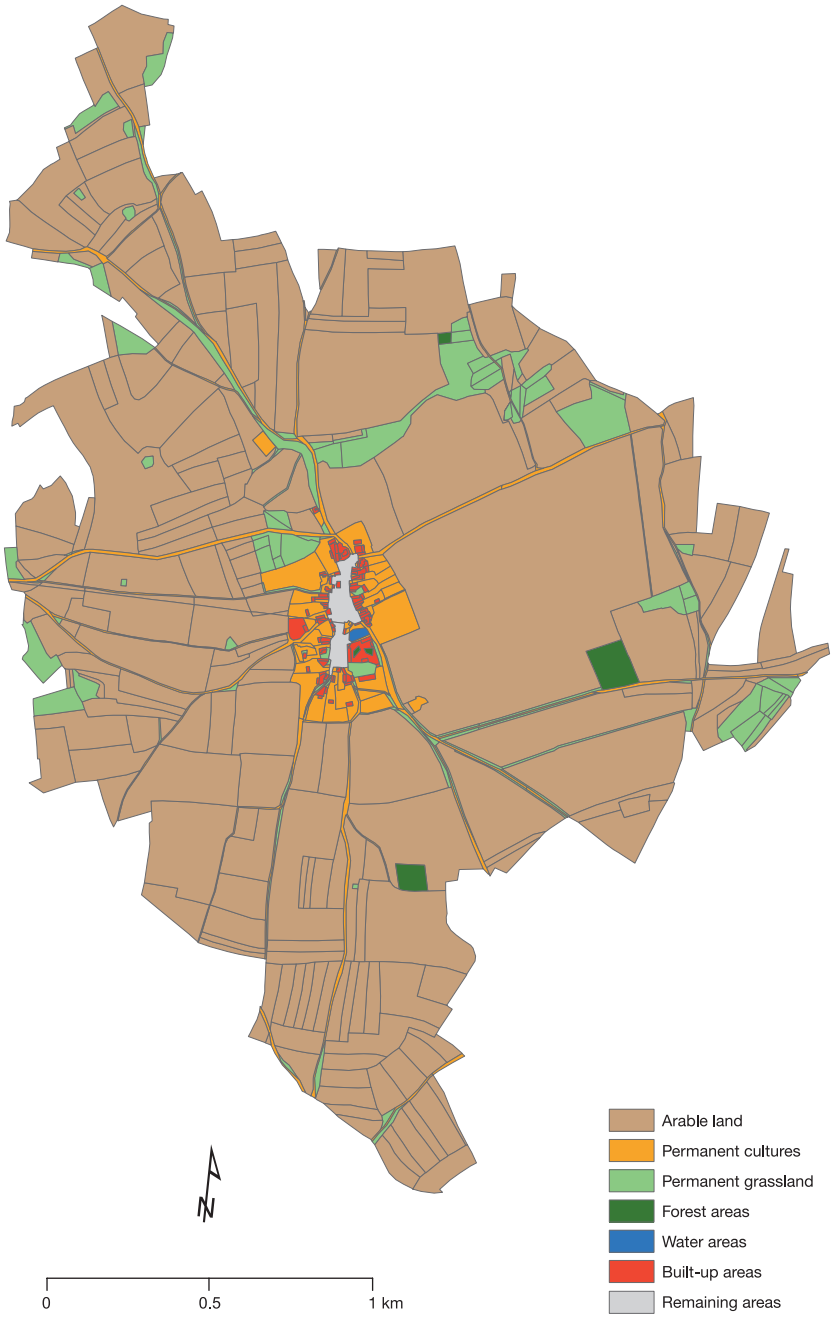

Fig. 7.13 Čestlice—map of land use in 1841. *Source* Central Archives of Surveying, Mapping and Cadastre, Prague

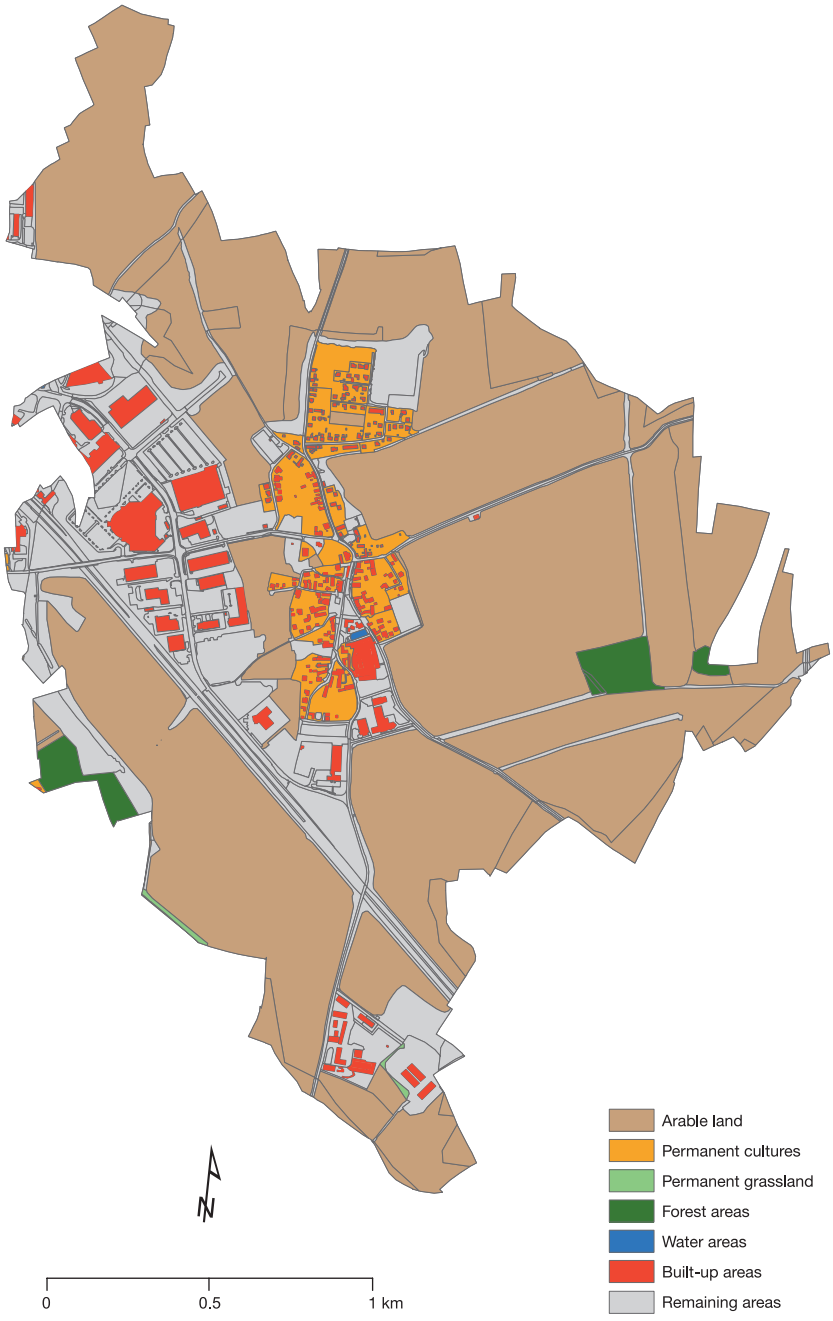

Fig. 7.14 Čestlice—map of land use in 2005. *Sources* Field mapping Přemysl Štych; orto-photo—Czech Office for Surveying, Mapping and Cadastre

Fig. 7.15 Aerial photo of Čestlice—commercial and residential suburbanization in the hinterland of Prague. *Source* Geoportal of Czech Office for Surveying, Mapping and Cadastre

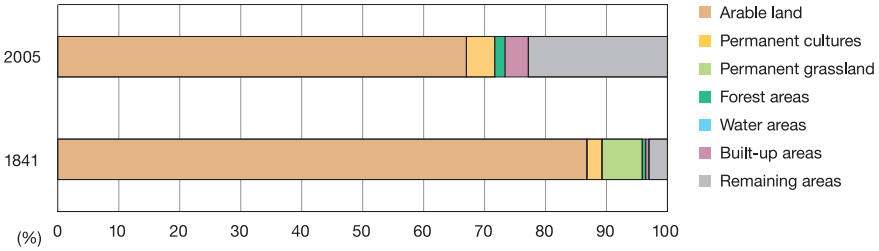

Fig. 7.16 Čestlice—land use in 1841 and 2005. *Source* own calculations

Table 7.5 Čestlice—matrix of land use change 1841–2005 (ha)

440.9[a]	Arable land	Permanent cultures	Permanent grassland	Built-up areas	Small scale green areas	Forest areas	Water areas	Remaining areas	Total[d]
Arable land	270.8	9.0	0.5	13.3	30.3	4.9	0.0	54.0	112.0
Permanent cultures	0.5	6.7	×	1.5	0.7	×	×	1.7	4.4
Permanent grassland	18.5	2.7	×	0.8	2.2	0.1	×	4.3	28.6
Built-up areas	0.0	1.6	×	1.1	0.1	×	×	0.2	1.9
Small scale green areas	×	×	×	×	×	×	×		0.0
Forest areas	0.9	×		×	×	1.5	×		0.9
Water areas	×	×	×	0.1	0.1	×	0.1	0.0	0.1
Remaining areas	5.3	1.2	0.0	0.5	2.6	0.2	×	3.1	9.8
Total[c]	25.3	14.4	0.5	16.2	35.9	5.2	0.0	60.2	157.7[b]

Explanations [a]Total area (in ha) of observed locality in 1841 and 2005. [b]Amount of hectares with change of class. [c]Total amount of hectares newly in arable land (etc.) in 2005 from classes in rows. [d]Total amount of changed class from into class in columns. On the diagonal of the table: from the size in 1841 in the same class "survived" till 2005. *Source* own calculations

7.5 Study Areas—Conclusions

Detailed analyses of land use changes within cadastral areas allow to reveal changes that cannot be identified when using just raw data related to cadastral units as a whole. Combination of different data sources and different scales help to indicate the validity of basic data. The above-mentioned cadastral areas typify different changes of Czech cultural landscape since mid-nineteenth century.

The selected four model areas represent basic landscape types in Czechia and differ from each other in terms of natural, social, and economic conditions. *The analyses proved that long-term land use changes have been very different in these model areas*. The frontier settlement Abertamy-Hřebečná was plagued by the transfer of Czech Germans after World War II; the subsequent resettlement proved inadequate. The main driving forces (differential land rent, change of agricultural practices, core-periphery relations, growing international contacts) resulted in a *significant decrease of human activities and led to a rather low-impact use of the landscape in peripheral areas*; *shift towards permanent grassland and forests was typical*. Though these changes had been started a long time ago, the process was accelerated by the transfer of Czech of Germans mentioned above. Transition towards modern agricultural methods, ongoing depopulation of the border areas, and uranium mining played an important role, too. The policy of the Communist government (1948–1989) that included large-scale agricultural subsidies and centrally planned industry could not reverse these trends. Political changes after 1990, introduction of market-oriented economy, changes of agricultural subsidies, and new environmental policies also contributed to decreasing use of the local landscape. As most border areas are part of the LFA scheme, farmers are given assistance to maintain the landscape rather than to produce crops: in land use terms this means a dramatic increase of permanent grassland. The high quality of natural environment and beautiful landscapes now attract tourism. To be successful, however, it is necessary to secure better access and more tourist-oriented services.

Kutlíře and Čestlice are located in fertile regions with favourable climate. Čestlice enjoys advantageous location close to main population centres and major transport routes and as such are prone to strong pressure from developers. In the case of Kutlíře, the exceptionally fertile soils in the Elbe Plain have provided a strong framework for intensive farming since centuries ago. Farming remains crucial also nowadays, with emphasis on grain and other crops that require favourable soils and climate. On the other hand, Čestlice was much influenced by the immediate proximity of Prague. The land use changes observed are typical for metropolitan areas, with increasing accent on residential and service functions. Built-up areas and remaining areas keep expanding significantly.

Břekova Lhota is situated in a low-income, peripheral area with poor natural conditions. It is part of the LFA scheme. Traditionally, the region relied on subsistence agriculture; this has been changed over the past 150 years towards a mix of agriculture and leisure activities. Second homes, used mostly in summer, form an important part of the landscape nowadays. *Forests tend to expand gradually*,

agricultural land keeps declining. These trends are typical for the "inner periphery" and are similar to those in the borderland, but with lower intensity: agricultural land still covers an important portion of the landscape. Typically, parts of agricultural land are being converted into permanent grassland, but the opposite process has been observed, too.

7.6 Aerial Images as an Evidence of Land Use/Cover Change

Aerial images are one of the sources that can give clear evidence of land use/cover changes. Based on aerial images we can document influence of some natural and societal driving forces on the landscape and its use approximately in the last

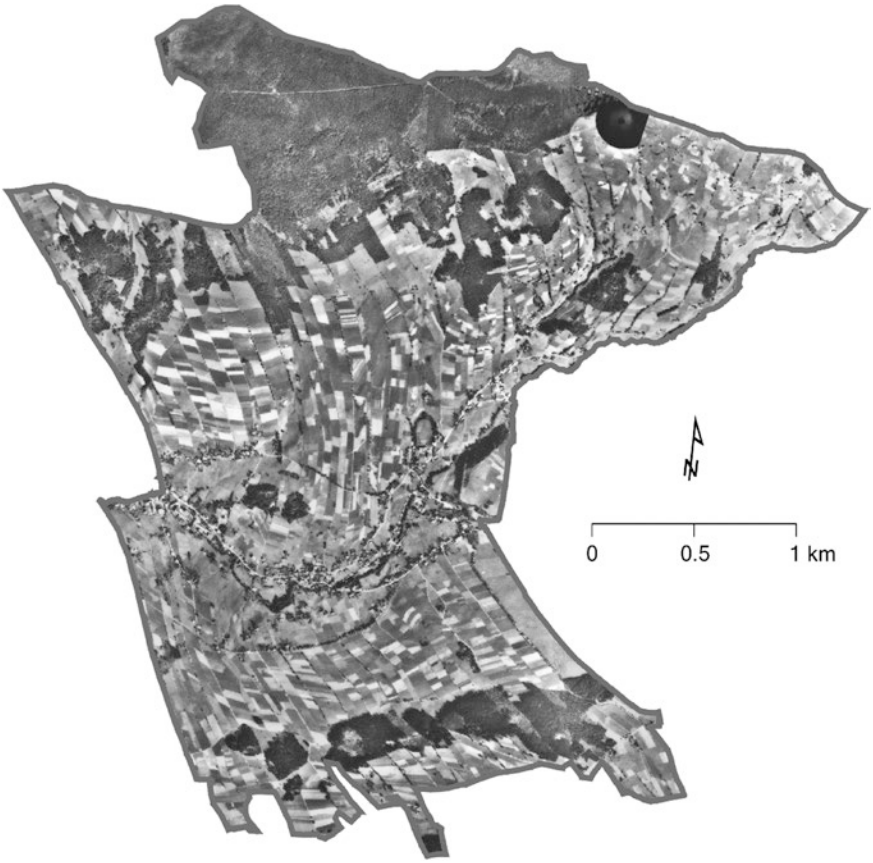

Fig. 7.17 Aerial image of Horní Rokytnice nad Jizerou in 1936. *Source* Military Geographical and Hydrometeorological Office Dobruška (Vojenský geografický a hydrometeorologický úřad *in Czech*)

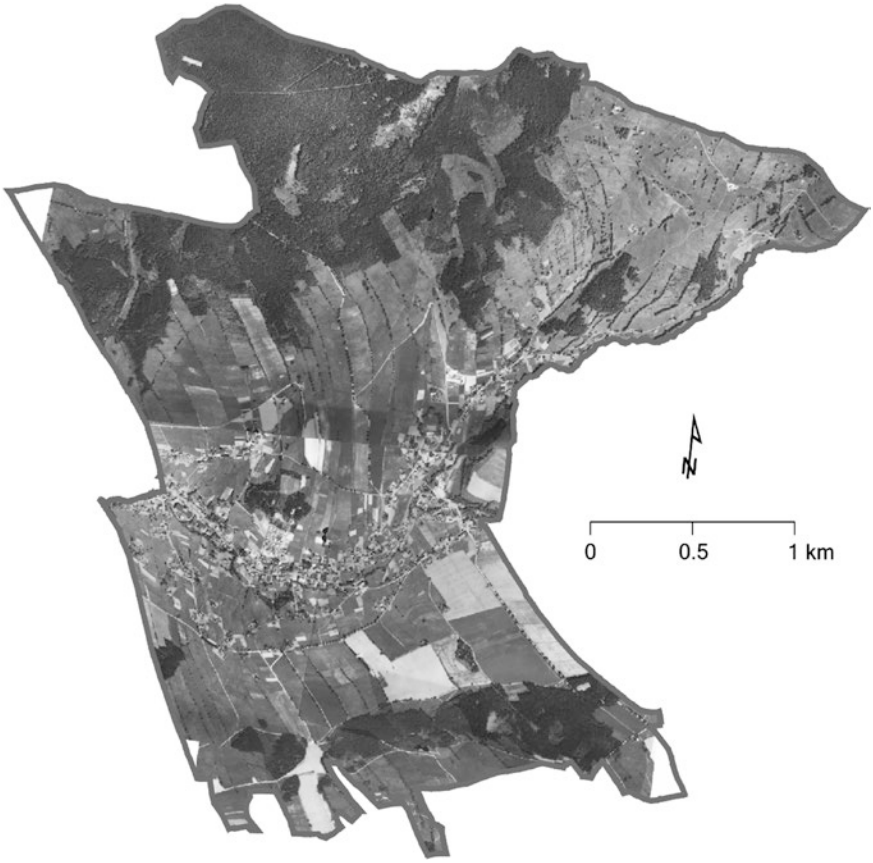

Fig. 7.18 Aerial image of Horní Rokytnice nad Jizerou in 1964. *Source* Military Geographical and Hydrometeorological Office Dobruška (Vojenský geografický a hydrometeorologický úřad *in Czech*)

90 years. The mountainous cadastre of Horní Rokytnice nad Jizerou was, in spite of its geographical location (Northeastern Bohemia, altitude 450–1400 m a.s.l., currently buffer zone of the Krkonoše National Park; see Fig. 6.37), intensively cultivated in the second half of the nineteenth century. Rectangular agricultural shapes of small-grained agricultural fields prevailed in the landscape till 1940s and the landscape matrix was comprised of arable land (Fig. 7.17).

The arable land proportion in 1842 was very high (49.7 %) mainly because of the so-called industrial colonization of mountainous areas (Häufler 1955). The cadastre was known for its developing textile and glass industry and for copper mining. Such industrial activities led to forest clearance. The necessity of self-sufficiency and quite a high density of population gave birth to 'islands of peasantry' even in high-altitude slope areas, to which no land cultivating would otherwise reach.

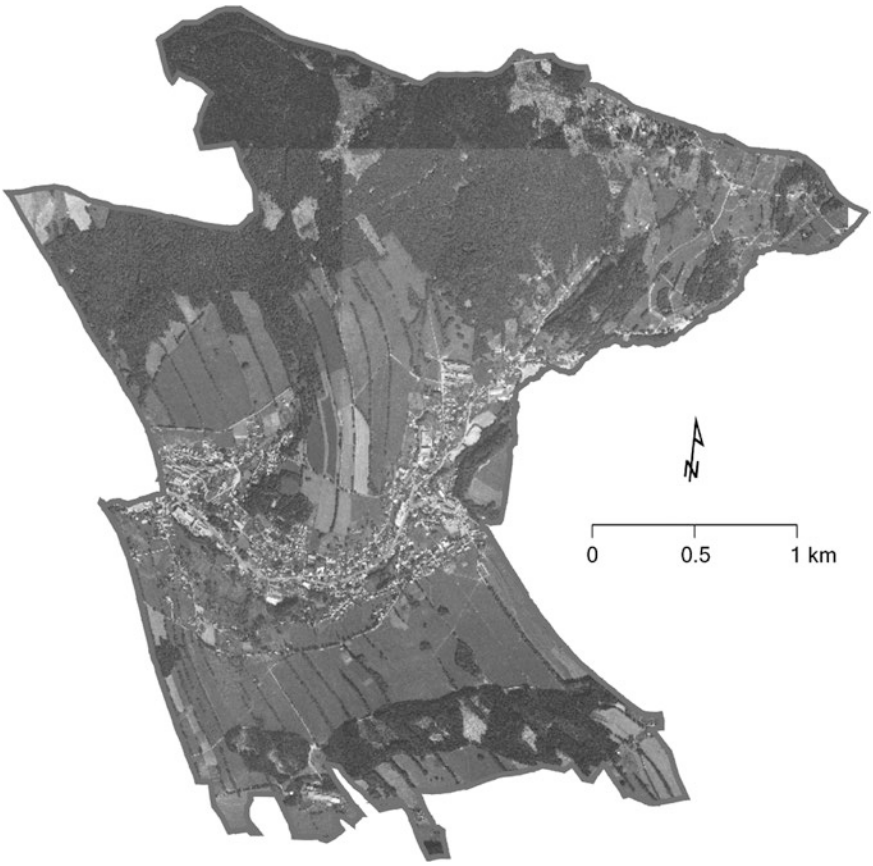

Fig. 7.19 Aerial image of Horní Rokytnice nad Jizerou in 1997. *Source* Military Geographical and Hydrometeorological Office Dobruška (Vojenský geografický a hydrometeorologický úřad *in Czech*)

Compared to 1991 when only 1985 people lived permanently in this cadastre, the highest population of 3193 inhabitants was reached in 1869. The decrease of human activities is on the contrary characteristic for the period after World War II. This decrease is due to the transfer of Czech Germans. The proportion of grassland and forest areas increased. In spite of the high-altitude and steep slopes socialist collectivization of agriculture has caused also in Rokytnice like in the whole territory of Czechia significant change of landscape structure (Fig. 7.18). Small-grained fields of arable land have been joined into extensive blocks of arable land, green corridors, avenues, and roads have been removed.

Further falloff in agricultural use was a matter of a number of combined factors, i.e. natural conditions, economic and political situation, change of landownership, subsidy policy, and National Park protection scheme policy. The whole

landscape has changed—meadows and pastures predominated arable land, forest areas enlarged to lower altitudes, and areas of the out-of-forest greenery increased (compare Figs. 7.17, 7.18 and 7.19). Almost complete grassing over of arable land after 1989, evident in the Fig. 7.19, was enabled thanks to the subsidy programmes of the Czech Ministry of Agriculture and the Czech Ministry of Environment meant for the support of agricultural extensification in regions with low productional potential of agricultural land. It may be interesting to note, that we can find a 9.3 % proportion of arable land for the year 2000 in the Central Land Survey and Cadastre Archive Files 2000, even though there was no arable land to be found in the area except for few tiny fields. This demonstrates and proves the lag of cadastre evidence compared to the reality and the necessity to combine different data sources in land use/cover change research.

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LUCC Czechia Database: Database of long-term land use changes in Czechia (1845–2010)

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Chapter 8
Conclusions

Abstract This chapter presents synthesis of the land use research covering the last 175 years and discusses the main findings. During this period, modernization trends and new forms of spatial organization have much altered the existing functions, including land use patterns. Major land use changes in different periods of time are presented. The first phase covered by the research (1845–1896) brought the peak of extensive farming; land use structure was rather similar regardless of different natural, social, and economic conditions. During the second period (1896–1948), though it included crucial political and economic events (World War I and II, independence), no major changes of land use patterns were recorded. On the contrary, the Communist period (1948–1990) brought fundamental changes. The transfer of ethnic Germans, transition to a centrally planned economy, and technological modernization were among the crucial driving forces of land use changes. Regarding the most recent period (from 1990 onwards), a number of different concepts have been enforced (restitution of property seized by the Communists, privatization, etc.) and these have profound effects on land use patterns. Regional differences in land use classes as well as major landscape processes in Czechia 1845–2010 are shown in maps and tables. In the very end, an outlook for future landscape changes in Czechia is given. These are likely to be affected especially by external factors that include EU Agricultural Policy, global food prices, and climatic changes. Though fertile regions will probably be intensively farmed also in the future, land use trends in uplands and highlands remain uncertain.

Keywords Land use patterns · Driving forces · Regional differences · External influence · Future prospects

8.1 Main Findings and Synthesis

The interaction between landscape and society has changed profoundly over the examined period (175 years). Society, originally organized at local and microregional levels, has been transformed into a more complex and more hierarchical

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system. Such a transformation included a number of modernizing processes defined by Purš (1973, 1980) as a "Complex Revolution of the Modern Era" (industrialization, urbanization, demographic and social restructuring, democratization, etc.). Within the new geographical organization, different levels of core and peripheral areas can be distinguished. Modernization and new spatial organization have much altered the existing spatial functions: some disappeared and new concepts, required by the society, came to existence.

Land use patterns have been affected by modernization trends too. Depending on the new spatial functions, different land use classes have undergone changes in terms of size and regional structure. The role of external driving forces (supranational, European, partly also global ones) has been rising steadily and kept influencing the new regional patterns. The highly urbanized core areas influence the spatial functions of the environs including land use patterns. The food industry in Czechia since 1850, relying on sugar beet, potatoes, and cereal crops (sugar factories, distilleries, starch factories, breweries), can be taken as an example. Hundreds of small, local processing factories had to close down and during the period 1948–1990 the production became concentrated into large businesses. When market economy had become re-established in 1990s, many of these giant companies had not survived and the importance of the remaining ones grew even more (see: Beranová and Kubačák 2010; Balej et al. 2011; Bičík and Jančák 2005).

Box 8.1 Sugar and dairy industries development impact on LUCC in Czechia 1845–2010

There were some 400 small sugar factories in Czechia in mid-nineteenth century. Distances among farms and processing units were small (see Box 6.3). The number of sugar factories declined to 149 (period 1920–1925) and later to 91 (period 1945–1950). Of these, only 50 sugar factories survived until 1990; as a result, the transport distances were constantly growing. That is not all: in 2003, there were just 13 sugar factories in Czechia, at present the number equals 7. Some of the surviving ones will probably close in the future.

Fifty years ago, the total sugar beet yield amounted 5 million tonnes per year; about one million tonnes of sugar used to be produced annually. The waste material from sugar beet factories was used as forage (production of milk and meat). Agricultural policies under socialism, i.e. concentration into large companies, plus the influence of EU regulations, and advancing globalization caused that the sugar production in Czechia decreased by about one-half (540,000 tonnes per year) and sugar must be imported now. In the fertile areas, the arable land where sugar beet was originally grown is now often occupied by other crops. The less fertile regions, however, have experienced a marked decrease of arable land under Communism as well as during the period of economic transformation. Due to better natural conditions and lower costs of production, much of the sugar industry has moved

> to Southern Europe. Dairy farming has been negatively affected by lower production of sugar beet, too, and consequently the structure and intensity of farming in the sugar beet regions have changed profoundly. The above-mentioned example (sugar beet production, processing, consumption, dairy industry) shows that the economic transition and landscape changes in Czechia have been very intensive over the past 175 years. Farming production kept rising until 1960s, stagnated in the period 1960–1985, declined later, and has been slightly rising since 2005.
>
> Some other crops have gone through similar process as sugar beet (hops, flex) and are rather unimportant at present. On the contrary, wine, maize, rapeseed, etc. have become more important over the time; some agricultural practices were renewed (grazing). The changing importance of different farming types has a big influence on land use and on the intensity and efficiency of farming.
>
> Balej et al. (2011)

Hampl and Müller (2011, pp. 211–212) studied the uneven speed of transition in different structures triggered by the post-1989 transformation. They argue that political and economic structures have changed quite fast (within days, weeks, or months). Social, cultural, and demographic changes are much slower and usually take years. Even slower are social-geographical changes and their reflection at regional level. Such a "delay", as defined by Hampl and Müller (2011), is confirmed by the above-mentioned example of sugar production/consumption and also by our land use analyses from different periods. Purš (1980) works with the same concept of "delay" on the example of Industrial Revolution.

Analyses of land use driving forces (Hampl and Müller 2011 take land use as one of social-geographical structures) show that within all examined periods land use changes have been somewhat slower than changes of other social-geographical structures. The increase of regional differences of land use types, resulting in new typological regions with similar land use patterns, was the slowest process of all. To sum it up, the uneven speed of changes mentioned by Hampl and Müller applies also to land use changes that have been always slower since the beginning of Industrial Revolution.

The earliest period analysed (1845–1896) includes the peak of extensive farming. The permanent increase of agricultural and arable land ended with the agrarian crisis; consequently, land use structure became stabilized during the last two decades of the nineteenth century. Intensive forms of farming have prevailed since then and regional differences of land use patterns began to increase—until the end of the nineteenth century land use structures in Stable Territorial Units (STU) were rather similar regardless of different natural, social, and economic conditions. Thus, the marked difference between low-lying, fertile areas (where arable land kept increasing) and less fertile regions (increase of forests) appeared first time.

The period 1896–1948 was a turbulent one and included important political and economic events in Czechia and Central Europe. Statehood and political regime changed five times during this period on the territory of the present-day Czechia. Though the first half of the twentieth century included also the agrarian reform and profound changes of land tenure, changes of land use patterns were surprisingly small. Rather big changes of land tenure were reduced or even negated by political reasons (see Sect. 6.7). The agrarian reform, launched in 1919, was largely a political action. From the economic standpoint, it brought negative results as the land tenure became much more fragmented. In a sense, this agrarian reform served as a "model" for the confiscation of German property after 1945, and also for confiscation of private land by the Communists after 1948 (Bičík and Jeleček 2005; Bičík et al. 2001).

On the contrary, the Communist period (1948–1990) brought fundamental changes in all social and economic structures. Regional differences of land use patterns increased. The transfer of ethnic Germans (1945–1947) was one of the crucial driving forces of land use changes. These changes, however, were taking place with a certain delay, also due to the fact that resettlement programmes in the frontier were largely unsuccessful and iron curtain was installed in the meantime. Transition to a centrally planned economy, which included collectivization and introduction of "socialist" manners in rural areas, constitutes the second important driving force. Agriculture became modernized, productivity rose. In general, technological modernization was advancing in the whole country as was urbanization and industrialization; many people found better living conditions in urban areas. Seen from the land use perspective, built-up and remaining areas were expanding, but agricultural land was shrinking.

The most recent period (transitional) reflects a whole array of different political and economic driving forces. In 1990s, the restitution of property seized by the Communists and privatization had dramatic effects on the land use structure, especially on arable land and permanent grassland. Restitution was very important politically. However, from the economic standpoint the logical outcome was fragmentation of land into smaller fields and plots—process adverse to that in Western Europe. Most people who legally regained the land, however, did not start any agricultural business; consequently, ownership became fragmented, but much of the land was still being managed in large units. The last decade of the twentieth century also brought a lot of corruption and uncontrolled suburbanization in the core areas. The agricultural intensity declined significantly, regional inequalities rose. Economic factors (differential rent) played an important role. The willingness of new landowners to farm varied region by region (Bičík and Götz 1998; Doucha 2001; Bičík and Jeleček 2005, 2009).

Two basic methods that help us to assess general land use changes in Czechia over the period of last ca. 180 years are employed. The first one works with types of land use "macrostructure". Land use structure is simplified into three aggregate classes: agricultural land, forest areas, and other areas. Increase/decrease of size within a certain period of time is shown by marks "+" and "–". In theory, six combinations (six types) exist (see Sect. 5.4).

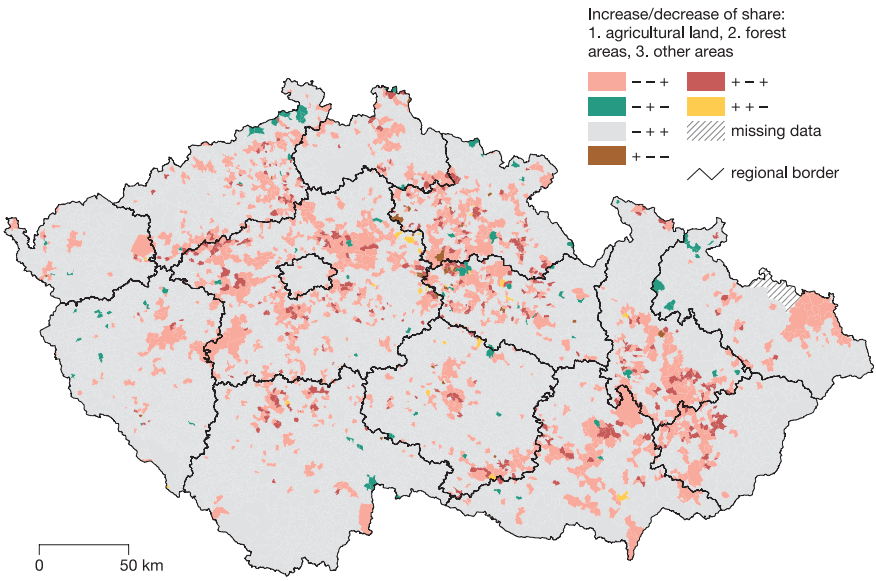

Fig. 8.1 Regional differences of aggregate land use classes (1845–2010). *Source* LUCC Czechia Database

Figure 8.1 documents the regional distribution of the two most frequent macro-types of land use changes. Almost 80 % of all STUs show the same type of change: decrease of agricultural land, increase of forests and other areas. The second type—much less frequent—combines decrease of agricultural land and forests with increase of other areas (16.5 % of STUs). Though the most frequent type covers much of the Czech territory, in the case of the second one a certain regional concentration exists: such STUs are located mostly in the low-lying areas (the Elbe Plain, along the Morava River, Ostrava Region). In these areas, the intensity of agriculture either remained at the same level or decreased only slightly; economic activities became concentrated in major core areas and their environs. Thus, farming now "competes" with new, non-agricultural spatial functions like suburbanization, logistics, transport, etc.

When comparing the land use structures in 1845 and 2010, decline of agricultural land is the most distinctive feature (STUs with such a decline cover 96.7 % of Czechia). Increase of forests, recorded on 80.4 % of national territory, is very typical too. Other areas (water, built-up, and remaining areas combined) have been expanding practically everywhere (98.4 % of Czechia).

Figure 8.1 does not reflect various land use changes that may have been taking place during shorter periods of time between 1845 and 2010. These partial changes were often very diverse in terms of structure and intensity. Table 8.1 shows in details different changes of land use structure within four shorter periods.

Table 8.1 Typology of land use changes by STUs in Czechia 1845–2010 (proportion of the national territory, %)

Type	Period				
	1845–1896	1896–1948	1948–1990	1990–2010	1845–2010
− − +	3.7	17.4	9.6	21.1	16.5
− + −	22.3	2.7	0.4	15.9	0.9
− + +	16.5	72.3	89.9	43.2	79.3
+ − −	32.7	0.6	0.0	5.0	0.2
+ − +	13.5	6.2	0.1	3.0	2.6
+ + −	10.9	0.4	0.0	11.7	0.2
No change	0.0	0.0	0.0	0.1	–
Missing data	0.4[a]	0.4[a]	–	–	0.3[a]

Note The first mark (+, –) indicates increase/decrease of agricultural land, the second one forest areas, the third one "other" areas (water, built-up, and remaining areas combined). [a]The regions of Hlučínsko and Valticko, plus České Velenice and its environs became part of the present-day territory of Czechia only after World War I. *Source* LUCC Czechia Database

Table 8.1 contains a lot of interesting information:

1. The first period (1845–1896) is the only one when increase of agricultural land was typical (57.1 % of all STUs). In the last decade of the nineteenth century, the historically smallest extent of built-up and remaining areas combined was recorded.
2. The period 1845–1896 shows the most regular distribution of land use types. The transition from late feudal system towards market-oriented economy, towards urban/industrial society was taking place in this period. The "1845 data" were actually collected between 1826 and 1843.
3. Major landscape changes were recorded under the Communist rule (1948–1989). Decrease of agricultural land, increase of forests and other areas (almost 90 % of STUs) resulted from large-scale industrialization, urbanization, and general modernization (including agricultural modernization). Environmental protection was inadequate.
4. All periods (excluding the earliest one) show dominance of one type of land use change: decrease of agricultural land, increase of forests and other areas. The same is true when the period 1845–2010 is examined as one unit.
5. Marked differences among types of land use changes in different periods reflect changing needs and expectations of the society.
6. Important increase of forests has been recorded in two periods: 1948–1990 (90.3 % of STUs) and the most recent period 70.8 %.

The above-mentioned types of land use changes reflect agricultural intensification (decline of agricultural and arable land in long term) and changing spatial functions. Forest kept expanding; see "forest transition" as discussed by Mather (2002, 2006); Mather and Needle (1998). The continuous expansion of other areas can be explained by ongoing modernization and new functions required by the emerging industrial and post-industrial society (industrial areas, logistics, transport, various technical structures, sport facilities, military areas, water reservoirs, etc.).

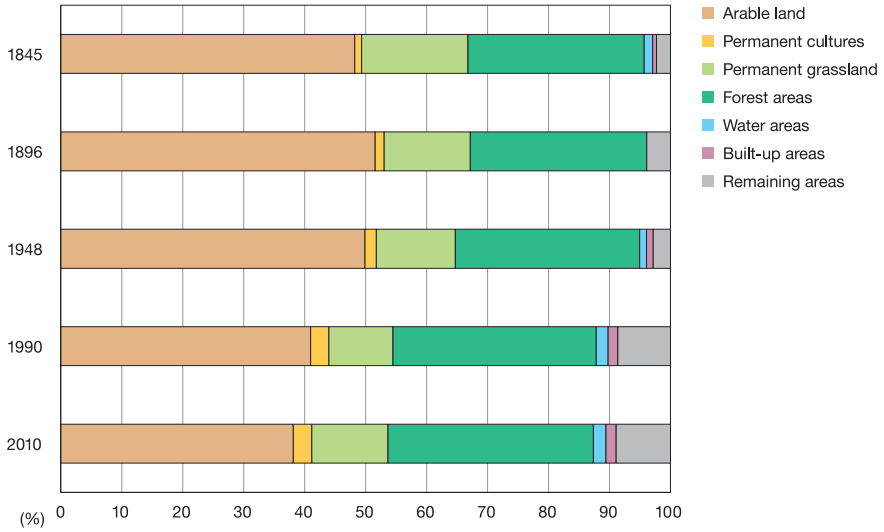

Fig. 8.2 Changing land use structure in Czechia 1845–2010. *Source* LUCC Czechia Database. *Note* In 1896, water, built-up, and remaining areas are shown together

The current trends of land use changes in Czechia show few signs of sustainability and future trends are unclear. Some scientific studies (Krausmann 2001; Krausmann et al. 2003, etc.) suggest that the ongoing expansion of other areas and decrease of agricultural land may soon pose big problems, especially with respect to the energy balance and food production. The concept of food security may become much more important in close future and many nation states may strive to be self-sufficient as much as possible—goal that is hard to achieve under conditions of EU single market.

Figure 8.2 clearly shows that arable land has been constantly declining over the past 100 years. The proportion of arable land (at present ca. 38 % of the national territory) is not too different from the proportion of forests (almost 34 % in 2014). The extent of permanent grassland fluctuated a lot. As of 2014, other areas (water, built-up, and remaining areas combined) cover more than 10 % of Czechia.

Land use database similar to the Czech one is used by Slovenian researchers (Gabrovec and Kladnik 1997; Gabrovec et al. 2001). They often employ synthetic/generalizing approach for assessment of major landscape processes; the same approach has been used on the Czech territory too. This method monitors four major processes of landscape changes: urbanization, agricultural intensification, afforestation, and increase of permanent grassland. Three grades are distinguished: strong, medium, and minor changes (for details see Chap. 5).

The Slovenian method has been used in this publication to analyse the main processes in the Czech landscape in the course of different periods between 1845 and 2010. Table 8.2 shows different processes and varying intensity of land use changes and confirms the above-mentioned results based on the changes of land use macrostructure. One should keep in mind, however, that the intensity of changes may actually be very different and depends on the accuracy of data and

Table 8.2 Major landscape processes in Czechia 1845–2010

Type	Intensity	1845–1896		1896–1948		1948–1990		1990–2010	
		Total number of STUs	Area (%)	Total number of STUs	Area (%)	Total number of STUs	Area (%)	Total number of STUs	Area (%)
Agricultural intensification	Strong	4,843	56.6	429	3.5	89	0.4	325	2.3
	Medium	1,203	13.2	527	5.8	272	1.9	129	1.0
	Minor	63	0.7	102	1.0	135	1.1	16	0.1
Increase of permanent grassland	Strong	195	1.6	280	1.9	177	0.8	2,195	24.2
	Medium	165	1.7	400	3.5	749	5.5	571	8.6
	Minor	16	0.2	129	1.6	339	3.3	59	1.0
Afforestation	Strong	1,057	11.2	1,958	19.2	399	4.2	337	3.2
	Medium	664	7.7	1,388	17.6	1,177	12.8	228	3.2
	Minor	38	0.4	185	2.2	283	2.8	30	0.5
Urbanization (other changes)	Strong	36	0.5	1,140	15.9	2,391	35.0	896	12.8
	Medium	67	0.9	1,082	13.9	2,297	27.2	359	6.2
	Minor	14	0.1	173	2.2	491	4.8	50	0.7
Stability (less than 1 % of STU area changed)		451	5.2	1,019	11.8	33	0.2	3,637	36.3
Total		8,812[a]		8,812[a]		8,832		8,832	

[a]*Note* Areas where data are missing (1845, 1896) cover about 0.4 % of Czechia. *Source* LUCC Czechia Database

statistical method used. However, the method clearly documents the basic trends of land use changes in each STU.

1. Each of the examined periods is characterized by different major landscape changes;
2. The intensity of processes varies greatly over time;
3. Agricultural intensification is typical (70.5 % of the national territory) for the earliest period (1845–1896);
4. In the period 1896–1948, afforestation as a "dominant process" was recorded on some 39 % of the national territory. During the following period (1948–1990) the pace of afforestation slowed down and the process was "dominant" in about 1,600 STUs that cover less than 20 % of the national territory;
5. The period 1990–2010 shows a relative stability ("stable land use structure" means that land use changes were recorded on less than 1 % of the examined territory). Stable STUs cover about 36 % of Czechia. One-third of the national territory experienced increase of permanent grassland;
6. Urbanization was the most important process in the period 1948–1990. Typically, built-up and remaining areas were increasing; such STUs (5,700 in total) cover ca. 67 % of national territory;
7. Under Communism (1948–1989) there were no regions that could be described as "stable". Only 33 STUs (covering 0.2 % of Czechia) showed less than 1 % change of land use structure.

Figure 8.3 shows major landscape processes/land use changes between 1845 and 2010 measured by the so-called Slovenian method (for details see Sect. 5.4.4). The map is important also due to the fact that the changes that occurred during partial

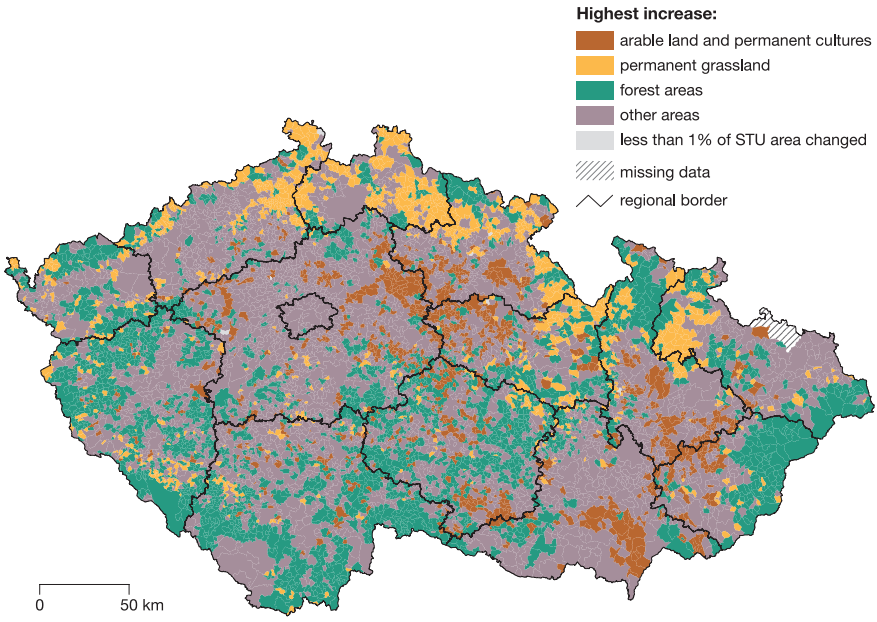

Fig. 8.3 Changes of land use structure between 1845 and 2010. *Source* LUCC Czechia Database

periods differed a lot from each other and in many STUs were even contradictory. Thus, the long-term changes over the period of last 170 years are shown here. Assessment, however, should be done with care: the main landscape processes may sometimes be based on minor changes of the four examined land use classes though within some STUs such a small change can in fact be the biggest one of all (see Sect. 5.4.4).

Regional differences reveal some of the key trends. These confirm previous results that have been obtained using other methods (all are based on the LUCC Czechia Database). The key findings suggest that vast majority of Czechia is covered by STUs where afforestation has been taking place and where remaining areas have expanded (about 40 % each). Both types of these key landscape processes tend to create contiguous regions.

Transition from arable land to permanent grassland as a dominant landscape process has occurred on some 20 % of Czech territory. It is typical in the northern half of the country, especially in elevated regions and on sloping grounds. To some extent it is found also in the foothills of Šumava and Český les.

Increase of arable land and permanent cultures as a dominant process has been observed on some 15 % of Czech territory, typically in the most fertile regions: in Pomoraví and Podyjí (Moravia), and also in Polabí (Bohemia)—see Fig. 3.1. This type is occasionally found also in other parts of Czechia, but it does not form compact areas.

The maps clearly confirm that there is a long-term tendency to form large contiguous regions with same or similar trends of land use changes. The society as a whole influences more and more the spatial functions of STUs and that of larger regions and consequently influences also gradual changes of land use patterns. In general, the figure reflects the fact that over the past 170 years the society has changed profoundly: there has been an important shift from mostly local processes (land use structure was first of all affected by decisions made on local level) towards a more complex matrix (large regions with similar land use types and similar functions are formed). These new functions that are "required" by the society gradually change the existing land use patterns; local inhabitants and local administration have only limited powers to influence such changes.

The outcomes of landscape research confirm the trends that have been described earlier in research projects focused on historical changes of settlement system and population. Differences among functions of urban areas keep rising as does the intensity of spatial relations with the environs (Hampl 2000; Musil 1977; Hampl and Müller 2011, etc.). Modernization trends during the last 200 years profoundly affected spatial organization of the society: local and microregional systems, largely "closed off" in the past, have been transformed into a more structured, multi-level spatial organization. As regards land use data, the above-mentioned changes, including changes of spatial functions, are reflected with a certain delay.

Figure 8.4 shows the most important trends of landscape changes over the past 50 years in Czechia. Regional differences of land use changes (extent, structure) are well presented. Great regional differences reflect the changing conditions of

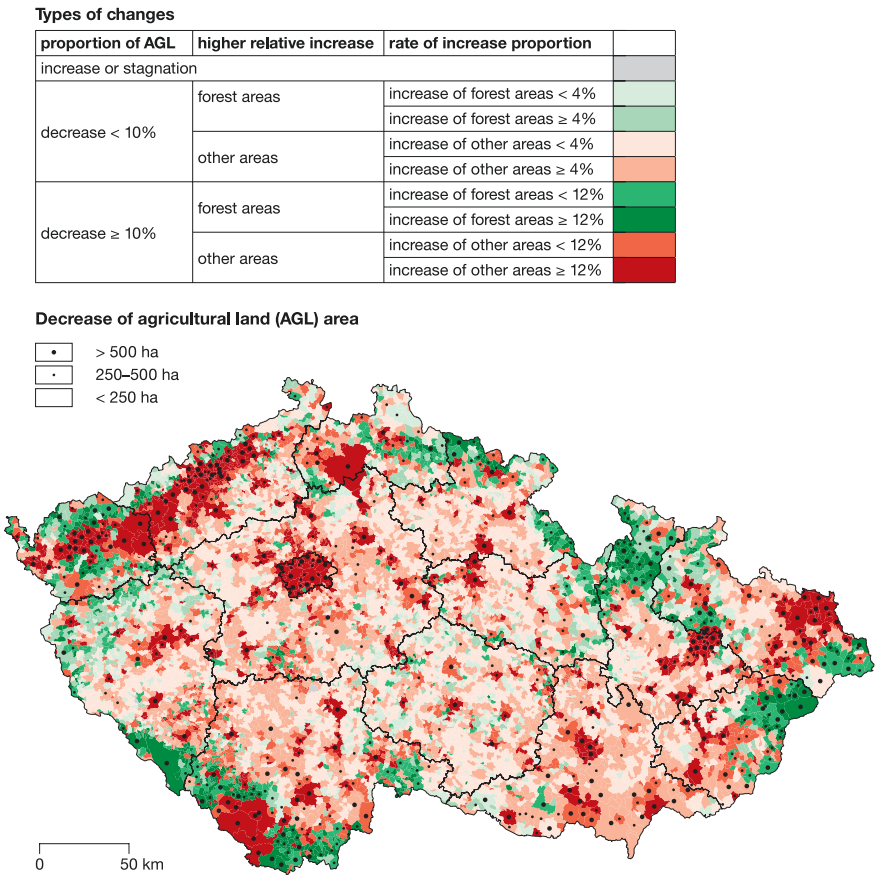

Fig. 8.4 Typology of landscape changes 1948–2000. *Source* LUCC Czechia Database

economic modernization and the effects of new functions in different regions required by the society. Great loss of agricultural land is shown as a typical process of larger regions with special mining and industrial functions (Ostrava region, brown coal region of north-western Bohemia, Prague).

Any land use change reflects new spatial functions of the landscape. It also reflects natural conditions, geographical location, and social-geographical phenomena (population, services, land prices, etc.). The analyses presented in this publication allow to define regions with similar spatial functions and similar land use structure. Stable territorial units (STU) with similar land use structure are grouped together to form typological regions. These differ significantly among each other. Though the creation of such typological regions is not yet complete and certainly some transition zones do exist, the following typological regions (defined by different long-term land use changes) can be defined in Czechia (Bičík and Kupková 2012; Bičík et al. 2010):

- Urban areas in big cities and towns;
- Hinterland of big and middle-sized cities and towns where farming has partly made way for residential development, depots, commercial centres, roads, etc., with microregional effects on the environment;
- Low-lying areas far from the major urban zones, with favourable natural conditions for farming. Arable land dominates; grassland and forests are rare;
- Undulating, hilly regions (altitudes 450–600 m a.s.l.) with average /below average natural conditions. Farming, residential function, partly also leisure time activities are typical;
- Highlands and low mountains that suffer from depopulation and decline of farming;
- Military training areas (existing and abandoned) where any kind of development was/is severely limited. Revitalization, new spatial functions may emerge in the future; the recorded land use changes often reflect reclassification only;
- National parks and other large-scale protected areas. Land use structure is rather stable with high proportion of forests and grassland and limited economic activities;
- Peripheral regions where long-term depopulation and extensive farming are typical. Leisure time activities are important in some areas;
- Mountainous areas with special spatial functions. Depopulation and long-term expansion of forests that now cover much of these regions are typical;
- Mining and industrial areas with devastated landscapes. Land reclamation schemes in effect over the past 30 years;
- "New wilderness" emerges locally forming new elements in landscapes that were originally used in an intensive way. Usually small patches of former farmland now abandoned, former quarries, overgrown paths, abandoned sheds, etc.

8.2 Generalization and Outlook for Future Landscape Changes in Czechia

The changing relations between nature and society over the past 170–190 years as reflected in land use data can be generalized into three main trends. First, there are long-term processes connected with shifts towards more extensive/intensive farming. Originally, agricultural landscapes covered up to two-thirds of Czechia; currently, it is just over one-half of the national territory. Extensive farming prevailed in Czechia until the end of the nineteenth century. Over the past centuries, farmland was gradually expanding, while forests—locally also bodies of water—kept declining (Lipský 1998, 2001; Jeleček et al. 2012). The traditional society was not capable to use natural resources in a more intensive way; it also was cheaper—though just until a certain point—to increase agricultural production by expanding fields. Intensification processes in agriculture have been gradually becoming important since mid-nineteenth century and brought a marked increase

of production. Intensification trends dominated in all developed countries in Europe during the twentieth century.

Intensification/extensification of farming has been reflected in changing proportions of arable land, permanent cultures, and grassland. Transition from arable land to permanent grassland and vice versa was especially common, traditionally used as a tool to improve fertility of the soil. The fluctuating extent of arable (agricultural) land in the past was often influenced by the size of population dependent on the land.

Historically, forests were directly affected by the fluctuating extent of agricultural land. The total extent of forests always reflected increase/decrease of agricultural land. The relative stability of population over the past decades also contributed to the expansion of forests. With the exception of low-lying areas, forests usually constitute the second (sometimes even the first) most important land use class in terms of size in most STUs. With the advance of modernization, forests were seen as a space with a whole array of new functions—not just as a source of wood. Consequently, less fertile patches of agricultural land have been gradually converted into forests—process that has been taking place at local level already since early nineteenth century. This is the so-called forest transition as defined by Mather and Needle (1998) or Mather (2002).

The above-mentioned trends (intensification/restructuring of farming plus expansion of forests) have become typical in Czechia since 1890s. In the end of the nineteenth century, almost one-half of the population were farmers or forest workers; farming and forestry created some one-third of GDP. Spatial changes of agricultural land and forests are closely interconnected with crucial social and economic changes started by the Industrial Revolution and Complex Revolution of the Modern Era (Purš 1973, 1980; Jeleček 1985, 1991).

The third important process is the marked increase of built-up and remaining areas. These are "artificial" land use classes, pure result of human activities. Expansion of these artificial areas has much to do with the true nature of industrial and post-industrial society: it is not the population boom that really counts but rather the growing ambition of humans to "consume" the space in different ways. Built-up and remaining areas have been growing first of all in the developed countries of Europe; in Czechia this has been happening since 1950s. Much of this growth is concentrated in low-lying areas, especially in regions with high quality farmland, sometimes also in former forested areas. This transition from natural and semi-natural land use classes to pure anthropogenic areas brings a sort of "competition" between intensive agriculture and new social and economic activities (residential, production). In Czechia, built-up areas have expanded by more than 50 % since 1948, remaining areas by more than 200 %. As a result, these two land use classes now cover ca. 11 % of the national territory. While built-up areas are clearly defined, remaining areas are very heterogeneous, also from the environmental standpoint.

Due to the high mobility of modern society, changing spatial functions of the landscapes are influenced by local people as well as by (often distant) urban dwellers. Thus, "artificial" surfaces like sports grounds, recreational areas, golf

courses, parking lots, roads, etc. keep expanding simply because part of the population perceive them as "essential". Future trends, however, are unclear. Further increase of built-up and remaining areas would trigger irreversible processes that are antagonistic to sustainable development.

Multifunctional landscapes and sustainable development are among the key targets of Czech agricultural and environmental policies. To be successful, however, a sound knowledge of long-term land use trends is required. "Multifunctional landscape" in Czechia may consist of very different land use patterns and consequently a number of different policies should be considered. Different spatial functions, and also land use structure have become regionally specialized over the past 200 years; the policy of sustainable development should reflect this fact (Bičík and Kupková 2012).

With the end of economic transformation and given the fact that Czech economy is likely to remain relatively stable, land use changes are expected to slow down in the future. Regional differences of land use will probably keep rising, especially the difference between fertile farmlands in the low-lying regions near core economic areas (intensification; i.e. growing proportion of arable land and permanent cultures) and peripheral regions with less fertile soils (extensification; i.e. increase of permanent grassland, afforestation). The total extent of abandoned agricultural land should gradually decline—due to the economic recovery part of the arable land that became abandoned in 1990s is being used again; small patches of abandoned agricultural land where ecological succession is in progress may gradually develop into forests. The ongoing suburbanization is likely to swallow agricultural land in the environs of urban centres also in the future; the character and pace of this process much depend on public awareness and activities of grassroots movements.

Future land use changes will depend on a number of domestic and international factors. Economic performance, especially competitiveness of Czech agriculture, will be among the key internal factors. Future reforms of EU Common Agricultural Policy will play crucial role at the international level—austerity cuts and a further reduction of tariffs will probably become inevitable. Production and consumption of food on the global scale plus global food prices may be very important too; as an example, consumption of animal products keeps rising fast in Eastern Asia, especially in China. Global climate changes (droughts, weather fluctuations), lack of basic resources (fossil fuels, water, Phosphorus), and changes of global farming production are likely to play an important role too.

Based on the above-mentioned premises, two contrasting future scenarios can be taken into consideration. First, rising global food prices (in theory also increase of protectionism in Czechia and Europe) may create a sort of pressure on future transition of permanent grassland into arable land, especially in uplands and highlands. Given the fact that in the global context the quality of Czech soils is just average, such a transition is not expected to be a mass phenomenon.

On the contrary, under conditions of (theoretical) liberalization of European agricultural policy and in case of future economic crisis, Europe may appear on the world periphery. Such a scenario would include further downturn of Czech

agriculture and even more intensive transition from arable land to permanent grassland; i.e. intensive farming would survive only in the fertile low-lying areas.

In other words, the single biggest uncertainty is the future of land use trends in uplands and highlands (intensification versus extensification). These areas, however, cover almost two-thirds of the national territory and therefore are crucial for the shape of Czech landscape as a whole. A broad range of economic and political driving forces (national, European, global) will play an important role here. Thus, as seen above, predictions and future scenarios are extremely difficult to create (Kupková and Bičík 2007).

Czechia, located in Central Europe, is significantly more densely populated than central parts of the other continents. High population density and long history of human activities have brought intensive conflicts among different spatial functions. Moreover, the integration processes in Europe create some special requirements linked to infrastructure, higher quality of residential projects, and outdoor activities. The availability of land and space, however, remains limited in Europe. Increasing demands bring a number of environmental problems. Land use changes in Czechia (to a certain extent also in the other post-Communist countries) have been much influenced by turbulent political events during the twentieth century and by the reintroduction of market economy in the course of the last 25 years. Thus, analyses of long-term land use changes (based on the LUCC Czechia Database 1845–2010) can serve as a useful tool for prediction of the future trends in Czechia and abroad.

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