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LANDSCAPES IN EASTERN GERMANY AT A TURNING POINT – LINKAGES BETWEEN POPULATION DECLINE, AGEING AND LAND CONSUMPTION

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Abstract: Since 1990, eastern Germany has been facing not only economic transformation but also demographic change. Two components of demographic change are population decline and ageing. They have a strong influence on landscapes, for example on land consumption by housing and industry. Three rural case study areas in eastern Germany are analysed which have been facing a strong population decline and ageing process over the past 20 years. Expert interviews were carried out and statistics as well as documents were analysed. It is argued that demographic change can be seen as a characteristic of instability in social systems. Moreover, it is an important driving force of landscape change, weakening the socio-ecological resilience of landscapes.

Keywords: demographic change, population decline, ageing, landscape change, land consumption by housing and industry, resilience of landscapes, Germany

Zusammenfassung: Seit 1990 sind die neuen Bundesländer verstärkt vom ökonomischen und demographischen Wandel betroffen. Zwei Komponenten des demographischen Wandels sind der Bevölkerungsrückgang und die Alterung. Diese beeinflussen die Landschaftsentwicklung und auch die Entwicklung der Flächeninanspruchnahme durch Siedlung, Gewerbe und Industrie. Es wurden drei Fallstudienräume in Ostdeutschland, die während der letzten 20 Jahre hohe Bevölkerungsrückgänge und einen starken Alterungsprozess erfahren haben, untersucht. Grundlage sind Experteninterviews und die Analyse statistischer Daten und Dokumente. Es zeigt sich, dass der demographische Wandel als ein Kennzeichen der Instabilität sozialer Systeme verstanden werden kann. Außerdem spielt er eine wichtige Rolle für den Landschaftswandel und schwächt die sozial-ökologische Resilienz von Landschaften.

Schlagwörter: demographischer Wandel, Bevölkerungsrückgang, Alterung, Landschaftswandel, Flächeninanspruchnahme, Resilienz von Landschaften, Deutschland

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1. Introduction

Landscapes in Central Europe have been changing rapidly since 1990. Key factors have been demographic change, macro-economic effects and the globalization of markets, as well as changes in technology and an increased mobility of people and goods (Vos & Klijn 2000). Landscapes are influenced by a wide range of driving forces acting over different temporal and spatial scales. Therefore they can be understood as diverse complexes. The holistic nature of landscapes makes it necessary not only to analyse the effect of one driving force, but also to take into account other factors and their interdependencies. Researchers stress that landscape research needs an integrative and holistic approach. But there is still a lack of these approaches in current landscape research (Antrop 2005, Bürgi et al. 2004).

Landscape change is caused mainly either by natural processes and disturbances or by human activities. Human influence has increased over the past 300 years to the extent that most of the change over this period can be ascribed to human activity, whether intentional or otherwise (Kates et al. 1990).

In the 1990s, rural landscapes in Central Europe were characterized by a polarisation between intensive and extensive use of land. It was assumed that people and their socioeconomic activities would increasingly concentrate in intensively used areas, while vast areas of land would be left behind or even completely abandoned (Antrop 2005). Since the end of the 1990s this has changed and land-use has been intensified almost everywhere, in peripheral and in central areas. An important reason is subsidies, particularly for biomass production and other renewable sources of energy.

The so called second demographic transition (SDT)[2] has been discussed in population research since the mid-1970s (van de Kaa 1987). Meanwhile, the concept has been elaborated, with investigations of the decline in fertility rates to well below the replacement level, later childbearing age, and other factors (technological, cultural, economic and political) which were leading to these developments (van de Kaa 1993). Demographic change is a phenomenon which can be seen throughout the industrial countries where birth rates are low, the average age of first-time mothers is over 30 years, and life expectancy is high. This is leading to population decline and ageing, which are causing problems in all realms of industrial societies. Social systems, labour markets, innovative potential, and landscapes are affected by this change. Especially peripheral and rural areas are suffering from depopulation because young people leave these areas to seek employment. Therefore it is necessary to understand the ongoing processes and to develop strategies for coping with the emerging changes.

There has not been much empirical research on the links between demography and landscape change. Some articles about landscape change consider demography as an influencing cultural factor. Hersperger & Bürgi (2009), for instance, determine the importance of different driving forces for the landscape change in the Swiss Lowlands. Demography is found to be a primary driving force. Similarly, Paquette & Domon (2003) highlight that landscape change must be considered along with social dynamics.

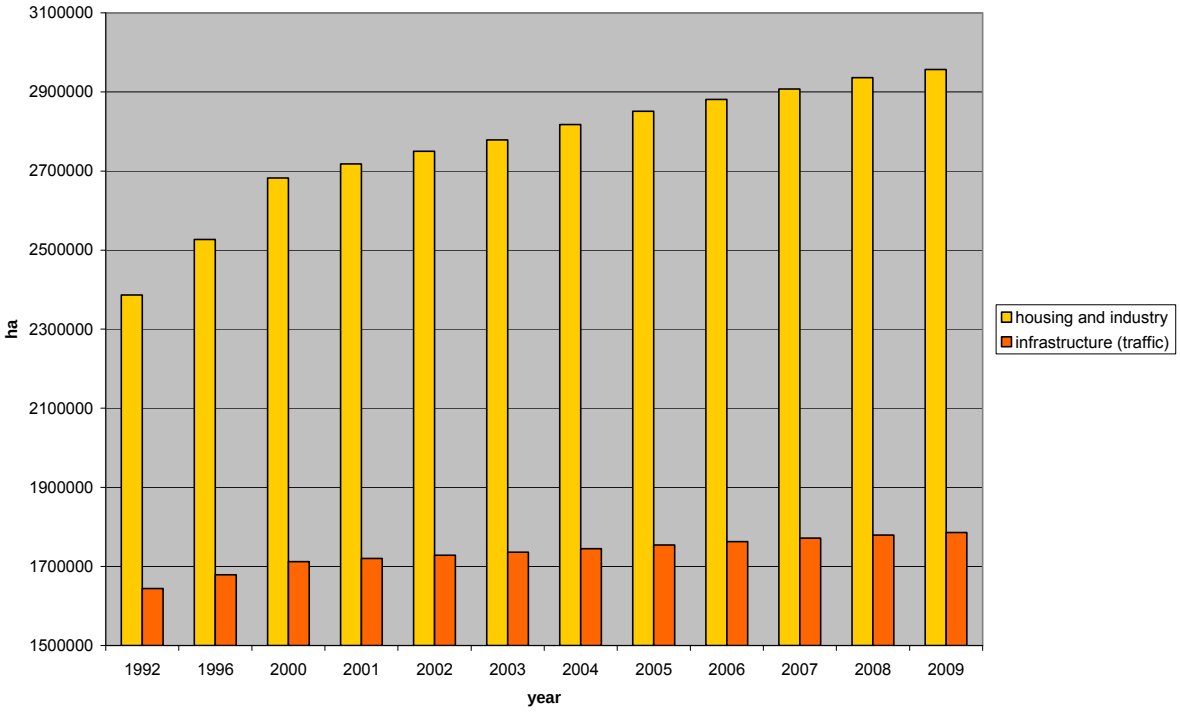
Demographic change and its characteristics (population decline, stagnation or growth; ageing, and cultural as well as ethnic heterogeneity) are widely discussed in Germany. Discussions focus on the effects of demographic change, e.g. on the social welfare system, technical and social infrastructure and spatial planning. In contrast, there is little research on the effects on landscapes (Demuth et al. 2010, Heiland et al. 2004, Müller et al. 2007, Wolf & Appel-Kummer 2005). Therefore it is still necessary to analyse the effects of demographic change on different realms of landscape change. Different approaches and theories can be used in order to explain the ongoing changes in landscapes as for example the panarchy and resilience concept, the constellation analysis (Schön et al. 2007) and path-dependencies (Apolinarski et al. 2004).

This article illustrates the effects of demographic change on land consumption by housing and industry in three administrative districts (*Landkreise*) of eastern Germany which can be

[2] In Germany the term ‘demographic change’ is used instead of “second demographic transition”.

characterized as rural and partly peripheral regions. The focus of this study lies on this type of region not on urban areas.

Land-use by housing, industry and infrastructure (in particular transport) is one of the major environmental problems, not only in Germany. Moreover it is an important indicator for sustainable landscape development. This was also recognised by the German Federal Government which stated in its sustainability report (Bundesregierung 2002) that its aim was to reduce land consumption by housing, industry and infrastructure to a maximum of 30 hectare per day by 2020. In its progress report (Bundesregierung 2008), the German administration noted that the trend for land consumption from 2003-2006 was still 113 hectare per day. In 2009 the daily land consumption was about 75 hectare per day. This was the lowest value between 1990 and 2009. So it seems that Germany might be on the right track. Nevertheless, despite all attempts to reduce land consumption for housing and industry, there is still an increase in the overall area (Graph 1). This is especially critical as space, landscape and soil are non-renewable resources.



Graph 1. Development of land-use by housing, industry and infrastructure (traffic) in Germany from 1992-2009 (source: Federal Statistical Office).

Land consumption has a great impact on ecological systems and their functionality. Furthermore it is interlinked with the ongoing demographic changes in the case study areas. Population decline and ageing are leading to abandoned houses and wasteland, affecting not only on the ecology but also on the social system in the case study areas. Therefore it is argued that both land consumption and demographic change are having an impact on the socio-ecological resilience of the landscapes in the case study areas, which will finally lead to a shift of the landscape system. Currently, it cannot be stated what the outcome will be, but it will be shown that landscapes are at a turning point.

The paper is divided into four parts. Firstly, the concept of demographic change is discussed on national, regional and local levels. Secondly, I present the selection process of the case study areas, methodology, materials, and the results. I show how population decline and ageing affect landscapes in the chosen case study areas, focusing on the example of land consumption. Thirdly, empirical results are discussed against the background of the concepts of panarchy and resilience. I analyse how landscape and population change affect socio-ecological resilience of the chosen landscapes. Finally data problems are addressed and conclusions are drawn.

2. Demographic change in Germany

In order to describe the linkages and interdependencies between demographic change, population decline and ageing on the one hand and land consumption by housing and industry on the other, it is necessary to characterize the appearance of demographic change over space and time. For that purpose it is shown that demographic change works on various temporal and spatial scales. Furthermore, it is discussed whether demographic change is a fast or slow working driving force.

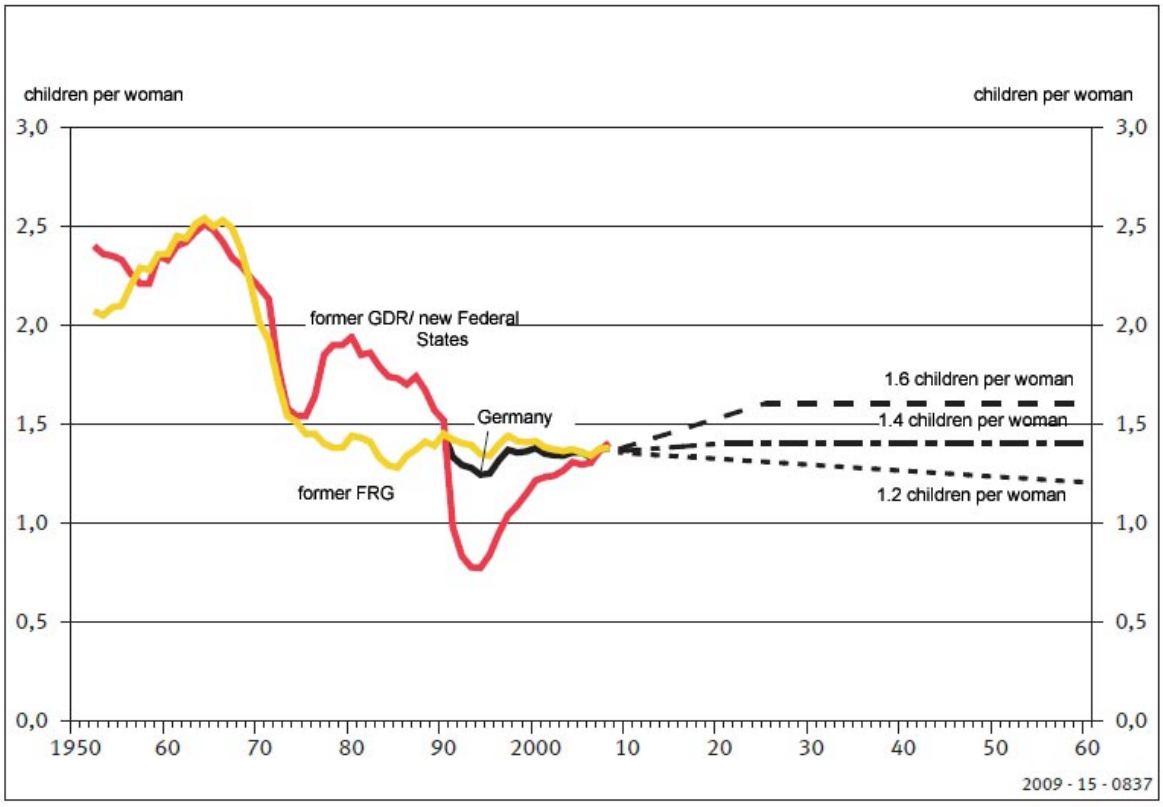


Fig 1. Total Fertility Rate in Germany till 2060, from 2009 results of the 12th population projection (source: Federal Statistical Office (2009): 28).

Using the concept of the SDT for Germany, differences in the development of eastern and western Germany have to be considered. Whereas, historically, the development of West Germany was similar to other populations in West European countries, demographic dynamics in East Germany were strongly influenced firstly by migration effects (population movements from East to West Germany), and after 1961 by family policies of the GDR government which tried to stimulate higher birth rates, e.g. by special loans for families (Grundmann 1998). At first, birth rates showed an increase, but then declined again. Birth rates in the former GDR were 1.8 children per woman. With the reunification they were decreasing to 1.2 children per woman. This development can be critically evaluated as birth rates are below the replacement level of 2.1 children per woman. In the mid 1990s the birth rate in eastern Germany drew near 1.4 as in western Germany and since then has been stable (Fig. 1). Even so, birth rates are still below replacement level which is leading overall to a declining population (Fig. 2).

In Germany, discussions about the SDT started in the 1980s (e.g. Birg & Koch 1987). Nowadays, demographic change is mainly understood as a change in absolute numbers of population (decline, stagnation, growth) and a change in population structure (ageing, cultural as well as ethnic heterogeneity) associated with low birth rates, late childbearing age, migration and high life-expectancy. As characteristics and their causes are different depending on the spatial scale – these differences will be illustrated for the national and regional/local level.

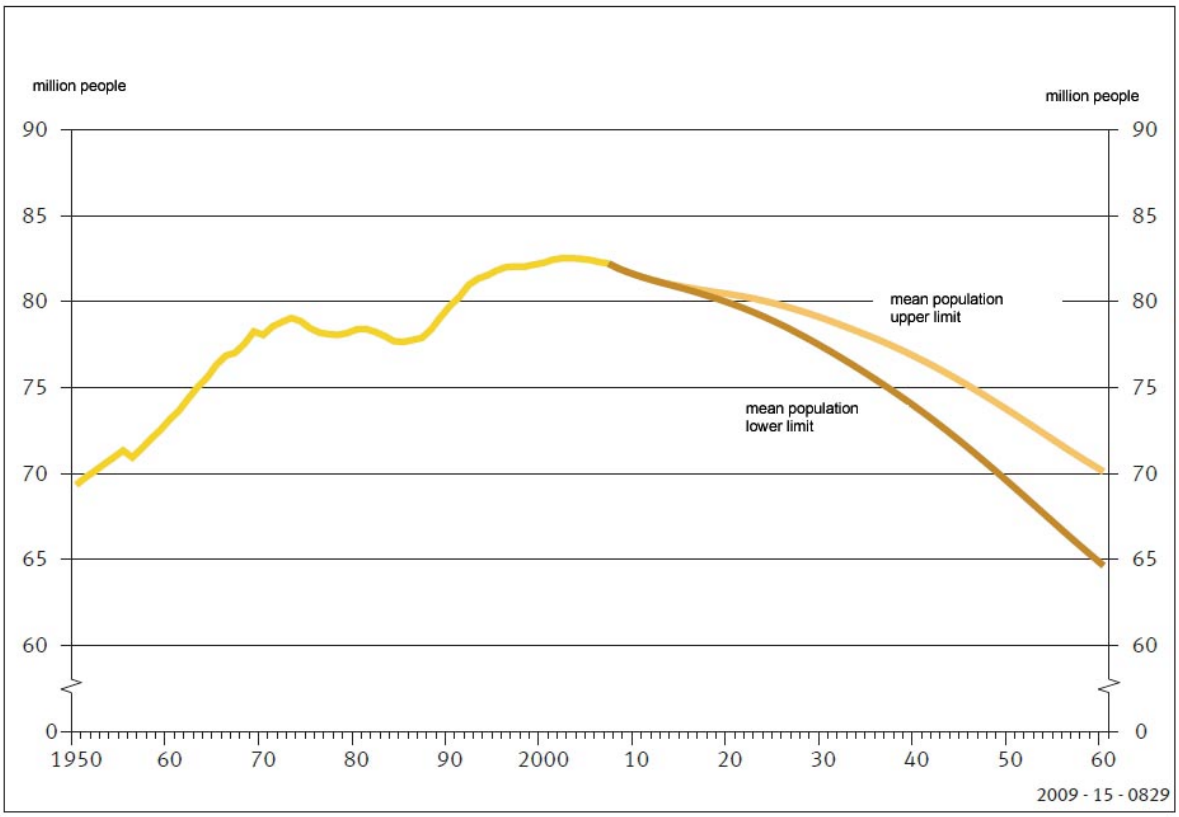


Fig 2. German Population from 1950 till 2060, from 2009 results of the 12th population projection (source: Federal Statistical Office (2009): 12).

As shown in Figure 3 low birth rates, late birth and a higher mortality rate are causing a negative natural population change which finally leads to population decline on national level. In 2003, the population in Germany was 82.5 million. At the end of 2009 81.8 million people were living in Germany. As this trend will continue, the German population will probably decrease to between 65 and 70 million people by 2060 (Statistisches Bundesamt 2009).

There are hypotheses for changing attitudes of German women toward childbirth, such as changing life styles, and increasing problems of reconciliation of work and family life – but there is still a lack of knowledge (Lipinski & Stutzer 2004, Pötzsch & Emmerling 2008, Reher 2007, Sobotka 2004, Sobotka 2008).

On national level the causes of population decline, ageing and cultural as well as ethnic heterogeneity of society and their consequences for different realms of society are discussed and different strategies are tested (e.g. Berlin-Institut für Bevölkerung und Entwicklung et al. 2006, Birg 2005). Strategies are trying to change birth attitudes by improving childcare, introducing child-raising benefits; on the other hand strategies are trying to cope with the consequences of demographic change such as changes in the social system. But long-term positive effects on birth rates cannot be identified at present.

Since birth rates will probably not increase in the future and immigration will not be sufficient to stabilize the German population, population decline will increase. Currently, demographic change is a slow driving force for landscape change but in the near future it will gain pace.

Not only population decline but also the changing population structure is visible nationally. The process of ageing is supported by low birth rates and late childbearing age as well as an increased life-expectancy. Whereas the number of younger people (0-20 years) will decrease from 15.6 million in 2008 to 10 million in 2060, the number of over-65s will increase from 16.8 million in 2008 to 22.9 million in 2060. Besides, German society is getting more heterogeneous. Life-styles are changing and the number of people with migration backgrounds is increasing, mainly in major cities.

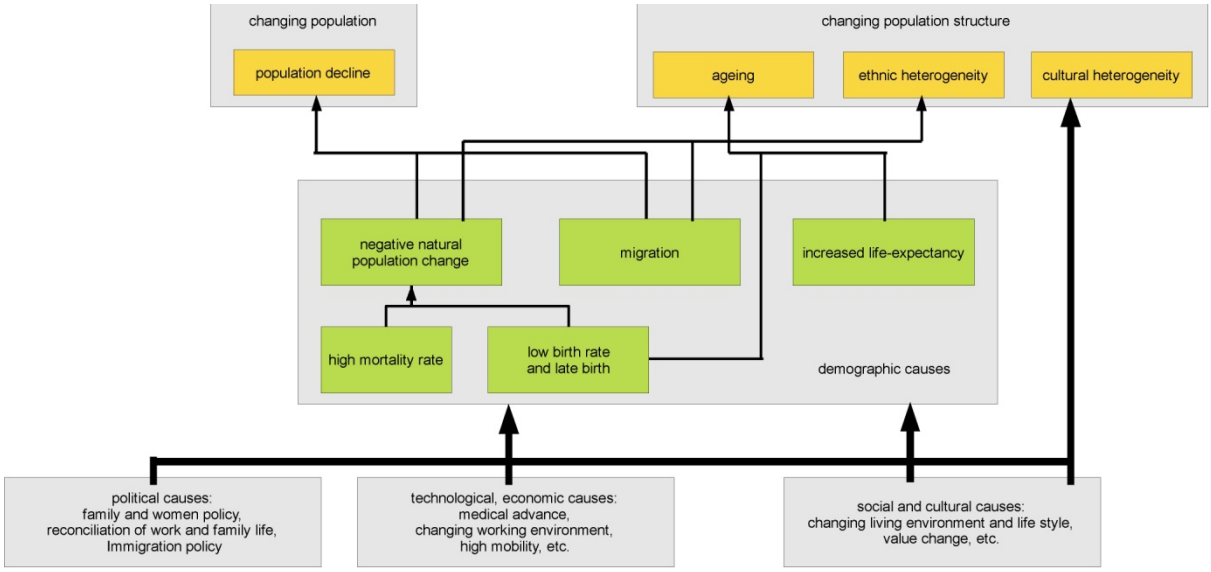


Fig 3. Characteristics and causes of demographic change in Germany (source: own).

Regionally, demographic change and its characteristics can appear differently. Whereas almost all of western Germany, especially southwest Germany, still has an increasing population, most of eastern Germany but also some of the western parts (e.g. Saarland and Ruhr) are characterized by population decline. Ageing can be seen in all parts of Germany. In the rural areas of eastern Germany, immigration and ethnic heterogeneity play a minor role. Only in bigger cities like Berlin, Dresden and Leipzig is this significantly visible.

Locally, areas of population decline and growth can be seen side by side. As the potential of regions differs (e.g. economy, employment, landscape), so do the effects and characteristics of demographic change. Whereas some regions still have a growing population, almost all regions of eastern Germany have a decreasing or stagnating population (Fig. 4). Internal migration, depending on the potential of a specific region, is a very important driving force regionally and locally. The case study areas lost a large part of their population because of economic decline, a decreasing labour market and depending on that internal out-migration. The region Oberspreewald-Lausitz lost about 36000 people from 1991 to 2008. 67% of this loss can be attributed to internal migration.

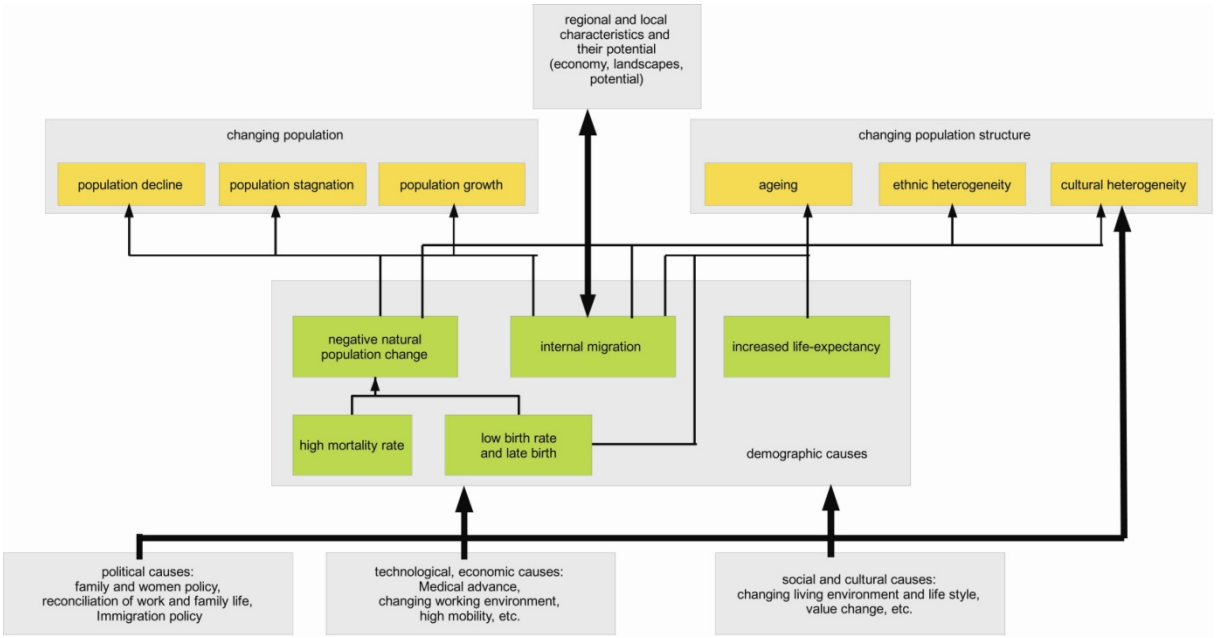


Fig 4. Regional and local characteristics and causes of demographic change (source: own).

The decline of the natural population and internal out-migration together are leading to a critical demographic situation in eastern Germany. Depopulation can be evaluated as a major problem which is still increasing and will gain more and more pace in the next years. Regionally and locally, various actors try to cope with this situation by adopting adaptive strategies such as developing infrastructure to the current and prospective needs, using subsidies to develop rural areas. Nevertheless, positive effects on the overall development of regions and their landscapes cannot be identified as yet.

3. Land Consumption in the Case Study Areas

3.1 Selection and characteristics of the case study areas

In order to analyse the effects of population decline and ageing on landscapes three case study areas were chosen, which are strongly facing both components of demographic change. As the analysis focuses on rural areas all administrative districts (*Landkreise*) of eastern Germany have been the basis of the selection – without regarding the main cities, which are independent of such administrative districts. In Figure 5 the selection process with its steps and criteria is illustrated.

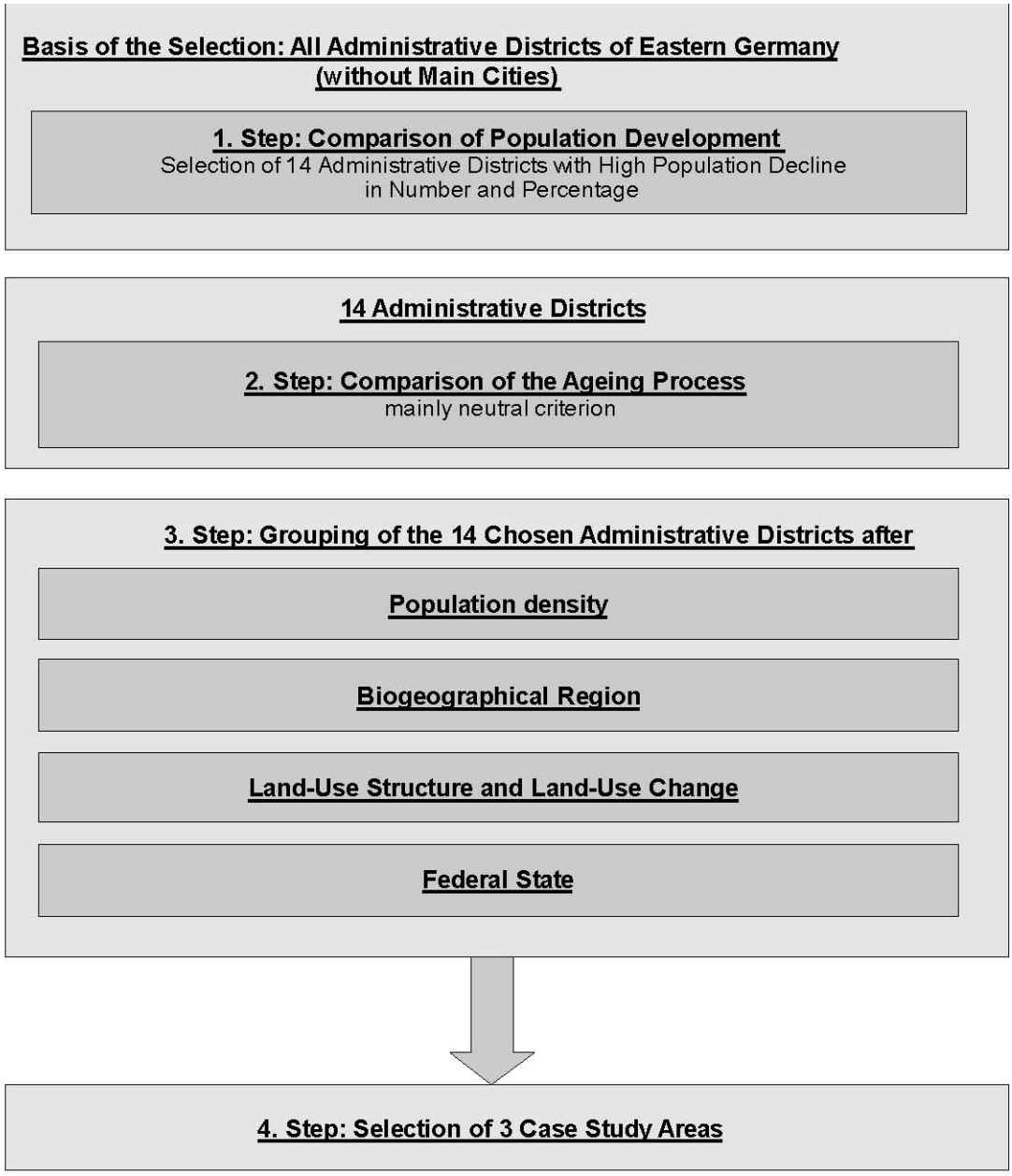


Fig 5. Selection process of the case study areas (source: own).

The first step was a comparison of the districts' population development in absolute numbers and percentage from 1991 to 2006. Twenty areas were chosen with the highest absolute population decline and twenty with the highest percentage population decline. Excluding all districts which were only on one list produced a list of 14 areas which have undergone a strong decline in absolute numbers as well as in percentage (Table 1).

The second step was a comparison of the ageing process in these areas. Looking at the average of all districts, the proportion of the population of the administrative districts aged 0 to 19 years decreased by between 11 and 8 per cent in the period 1991-2006. The proportion over 61 years increased by between 11.5 and 8 per cent (Graph 2).The third step was a grouping process. The areas were grouped regarding their population density (Table 2), land-use structure (Graph 3), rate of land-use change, main biogeographical regions (e.g. North German Lowlands) and finally the federal state they are located in Table 1.

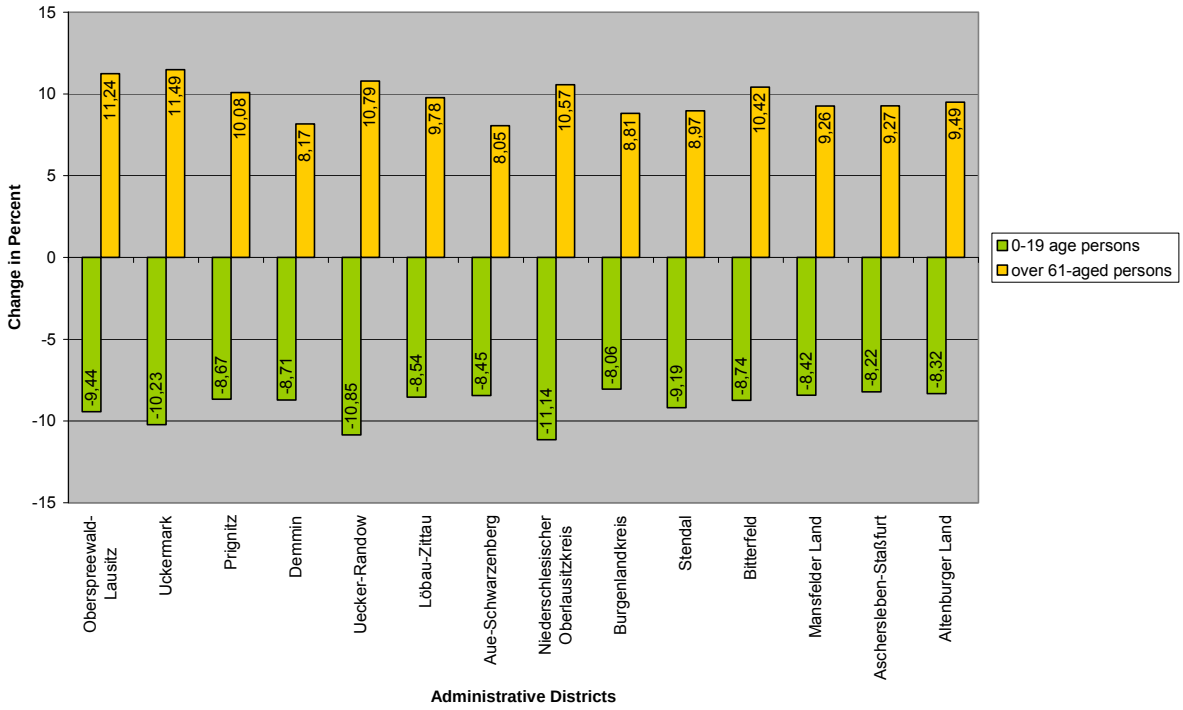
Finally, three case study areas were chosen - Löbau-Zittau, Demmin and Oberspreewald-Lausitz. The chosen areas are located in different federal states (Table 1). This allows a comparison of different strategies of landscape development and strategies for coping with demographic change or adapting to the changes in the areas.

They can be also distinguished by their population density (Table 2), land-use structure, rate of land-use change, and biogeographical region. The area of Demmin is in the north of eastern Germany, Löbau-Zittau in the very south-east, and Oberspreewald-Lausitz lies between these (Fig. 6). The three case study areas can be similarly characterized by their strong population decline (in absolute numbers and as a percentage) (Graph 4) and ageing process.

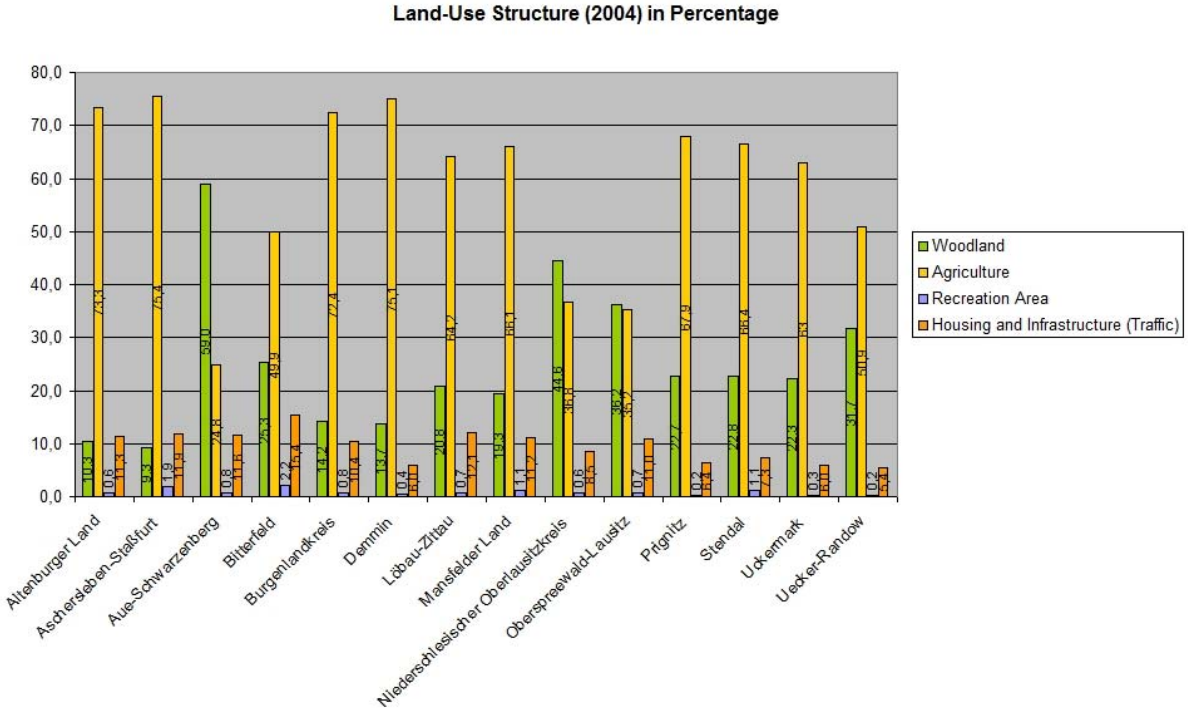
Administrative District	Federal State	Population decline in absolute numbers (1991-2006)	Population decline in percentage (1991-2006)
Oberspreewald-Lausitz	Brandenburg	-31648	-19.63
Löbau-Zittau	Saxony	-30910	-17.98
Uckermark	Brandenburg	-28333	-17.12
Aue-Schwarzenberg	Saxony	-27654	-17.63
Burgenlandkreis	Saxony-Anhalt	-24226	-15.53
Stendal	Saxony-Anhalt	-23755	-15.50
Bitterfeld	Saxony-Anhalt	-22700	-18.76
Altenburger Land	Thuringia	-20755	-16.54
Mansfelder Land	Saxony-Anhalt	-20524	-17.24
Aschersleben-Stassfurt	Saxony-Anhalt	-19980	-17.59
Prignitz	Brandenburg	-18766	-17.71
Niederschlesischer Oberlausitzkreis	Saxony	-17385	-15.50
Uecker-Randow	Mecklenburg-West Pomerania	- 17 358	-18.54
Demmin	Mecklenburg-West Pomerania	- 16 245	-16.01

Tab 1. 14 administrative districts with strong population decline in absolute numbers and percentage (1991-2006) (source: Statistical Offices of the Federal States).

The criterion of biogeographical region is necessary to identify the main characteristics of landscapes in regions (e.g. mountainous region or lowland). As the chosen areas belong to different biogeographical regions (Table 3) and have different land-use structures (Graph 3), developments connected with specific characteristics of one region can be analysed and related to its population development.



Graph 2. Ageing Process in the 14 Administrative Districts: Change of the two ageing groups from 1991-2006 in percent (source: Statistical Offices of the Federal States).



Graph 3. Land-use structure (2004) in percentages (source: Statistical Offices of the Federal States).

Demmin has lakes, rivers and swamps nearby but the main part of the region is intensively used by agriculture and has relatively little woodland. This is also the most important economic

sector. It is a region that has little industry and a poorly developed infrastructure. The main parts of the landscapes are less attractive for living and tourism compared to important touristic areas in the north (Baltic Sea) and south (National Park Müritz) of the region. The results are social and economic problems as well as depopulation, and resultant problems linked to land consumption, as later illustrated. This is why biogeographical regions together with land-use structures are important for the selection process.

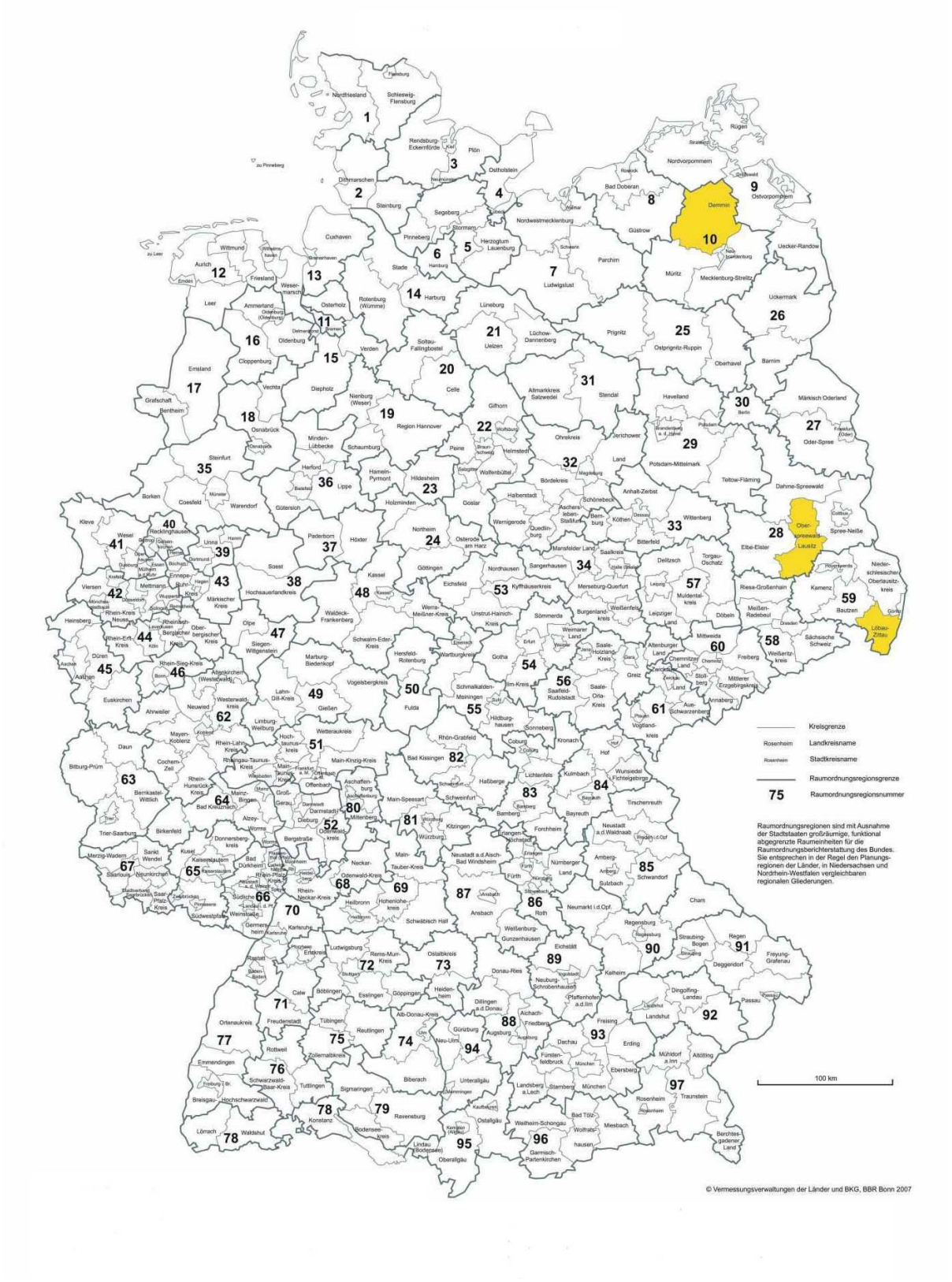
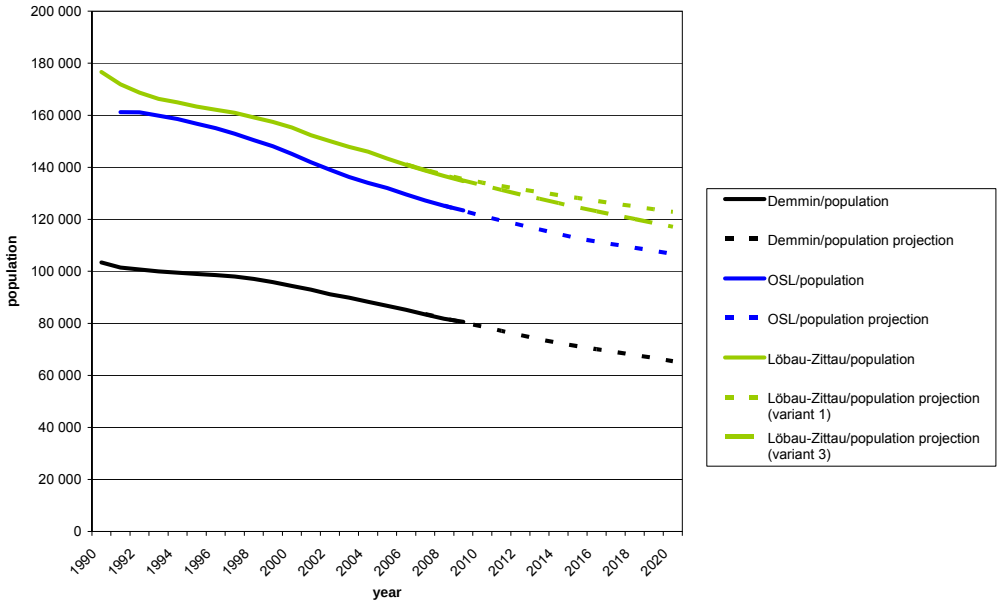


Fig 6. Location of the chosen case study areas in eastern Germany (adapted from: Bundesamt für Bauwesen und Raumordnung (BBR) (2007).

Administrative district	Population (2006)	Area in km² (2006)	Population density (2006, persons/km²)
Group 1: 0-100 persons/km²			
Altenburger Land	104721	5690.80	18.40
Prignitz	87221	2123.31	41.08
Demmin	85241	1921.54	44.36
Uckermark	137209	3058.12	44.87
Uecker-Randow	76262	1624.54	46.94
Stendal	129481	2423.00	53.44
Niederschlesischer Oberlausitzkreis	94750	1340.33	70.69
Group 2: 100-200 persons/km²			
Oberspreewald-Lausitz	129581	1216.69	106.50
Burgenlandkreis	131750	1041.08	126.55
Mansfelder Land	98538	758.83	129.86
Aschersleben-Stassfurt	93630	654.75	143.00
Group 3: >200 persons/km²			
Bitterfeld	98285	509.96	192.73
Löbau-Zittau	140982	698.54	201.82
Aue-Schwarzenberg	129246	528.32	244.64

Tab 2. Population Density (2006) in the chosen administrative areas of eastern Germany (source: Statistical Offices of the Federal States).



Graph 4. Population and population projection of the case study areas from 1990 to 2020 (source: Statistical Offices of the Federal States).

Oberspreewald-Lausitz has almost equal areas of agriculture and woodland. It is strongly affected by lignite mining and chemical industry. Despite many projects in recent decades, e.g. recultivation of former lignite strip-mining areas, economic development has not increased. The labour market is low, leading to depopulated areas.

Administrative District	Federal State	Biogeographical Region
Oberspreewald-Lausitz	Brandenburg	North German Lowlands
Löbau-Zittau	Saxony	Central German Uplands
Uckermark	Brandenburg	Central German Uplands
Aue-Schwarzenberg	Saxony	North German Lowlands
Burgenlandkreis	Saxony-Anhalt	North German Lowlands
Stendal	Saxony-Anhalt	North German Lowlands/ Central German Uplands
Bitterfeld	Saxony-Anhalt	mainly North German Lowlands, little Central German Uplands
Altenburger Land	Thuringia	North German Lowlands
Mansfelder Land	Saxony-Anhalt	Central German Uplands
Aschersleben-Stassfurt	Saxony-Anhalt	North German Lowlands
Prignitz	Brandenburg	Central German Uplands
Niederschlesischer Oberlausitzkreis	Saxony	North German Lowlands
Uecker-Randow	Mecklenburg-West Pommerania	North German Lowlands
Demmin	Mecklenburg-West Pomerania	North German Lowlands/ Central German Uplands

Tab 3. Biogeographical Regions of Administrative Districts in Eastern Germany (source: Meynen & Schmithüsen 1953, Meynen et al. 1962).

Löbau-Zittau is dominated by agriculture, but has a higher proportion of woodland than Demmin. Moreover it is an industrialized area (e.g. lignite mining), with a fully developed infrastructure. The south of Löbau-Zittau is a mountainous region which is famous for its attractive landscape and winter tourism. The whole area was formerly densely populated and used to have well-developed industry. As this area is peripheral, its economic development in the past decades had been poor.

3.2 Methods

The approach used is based on the 'constellation analysis' (Schön et al. 2004) developed at the Berlin Centre for Technology and Society. This interdisciplinary approach helps with analysing and describing complex problems of modern societies which can be seen at the interface of society, technology and nature and seeks to develop strategies and solutions. It helps to bridge disciplinary differences, e.g. in sustainability research. A useful tool is the visualization of elements of different categories (e.g. actors, technical and natural elements) and their interdependencies. They are related to each other regarding the specifics of their connectivity and distance. In this study it is therefore possible to show and analyse how demographic change affects land consumption by housing and industry.

The data and information on land consumption in the case study areas were received from expert interviews with actors of landscape development in the areas, land-use statistics from the statistical agencies of the federal states and from document analysis, especially land-use plans from municipalities of the case study areas.

The expert interviews were carried out from 2008 to 2010. Interviewed experts were from the administrations of the districts, regions and federal state (nature conservation, planning).

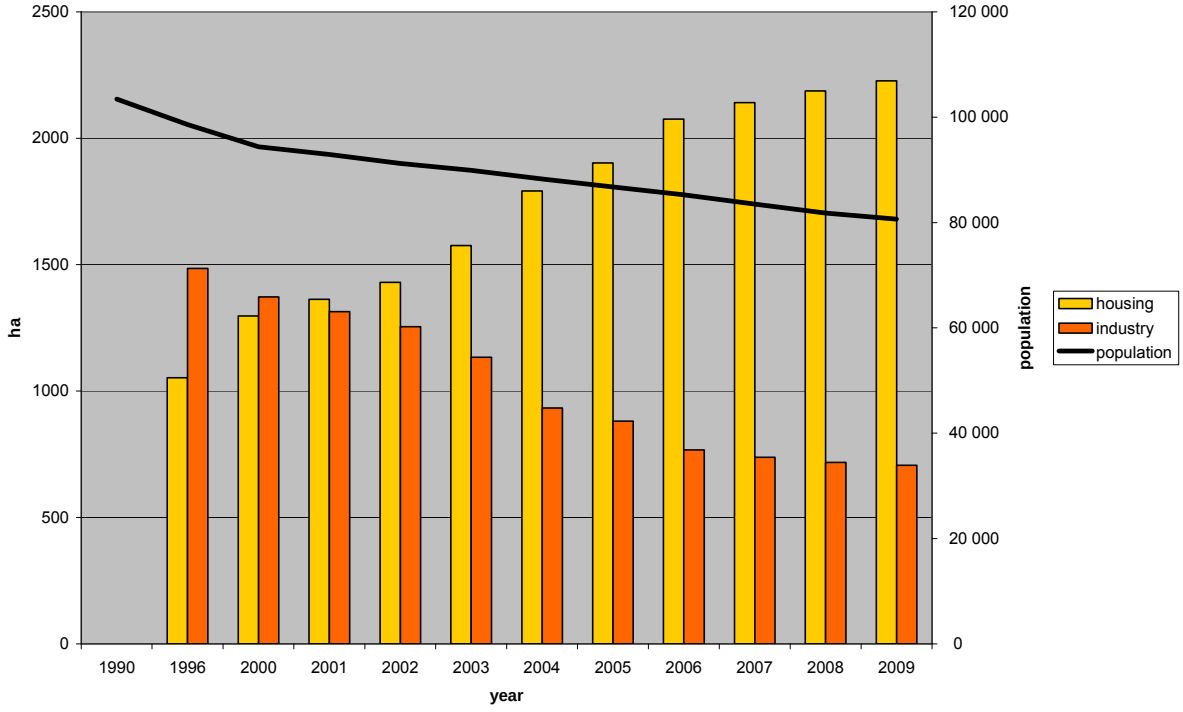
3.3 Results

In this section the development of land consumption by housing and industry in the case study areas is illustrated for the time period from 1990 to 2009. Linkages are identified between population decline, ageing and land consumption by using the constellation analysis.

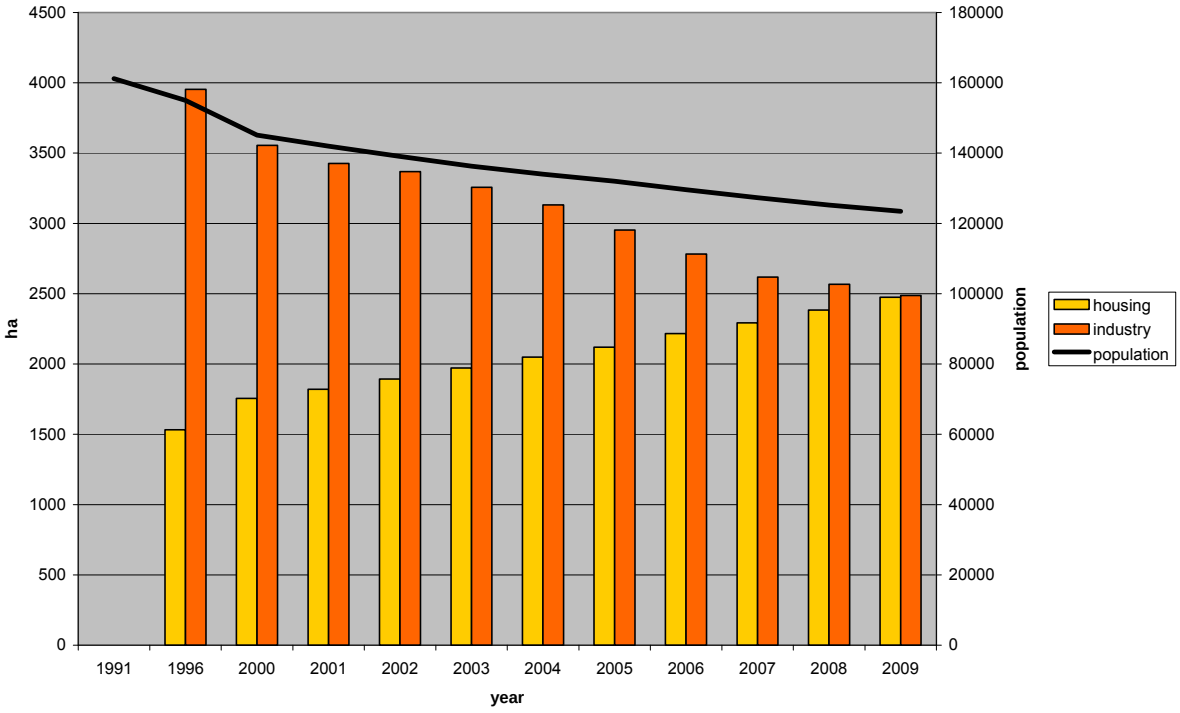
In a first step, statistical data of the administrative districts about land consumption and the population development are compared (Graph 5-7). There are enormous differences between the districts regarding the development of land consumption. Whereas land

consumption by housing in Demmin and Oberspreewald-Lausitz from 1996 to 2009 increased by 1174 and 943 ha respectively, land consumption by industry decreased by 778 and 1466 ha. Both districts experienced a marked population decline. The process of depopulation will continue (Graph 4).

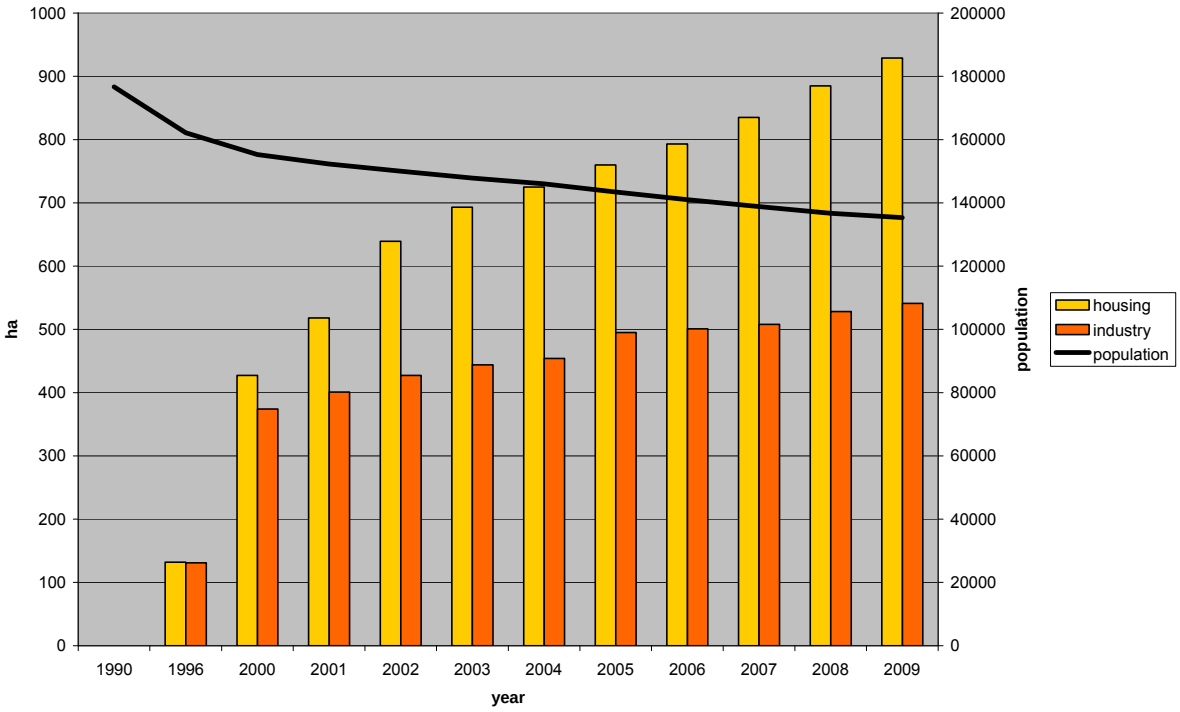
In contrast, Löbau-Zittau experienced less change. Land consumption by housing increased by 797 ha from 1996 to 2009, and land consumption by industry increased by 410 ha. Comparing the changes with the overall area of the districts (Demmin: 192154 ha, Oberspreewald-Lausitz: 121669 ha, Löbau-Zittau: 69854 ha) this is a relatively small change. The new daily land consumption by housing is much higher in Demmin and Oberspreewald-Lausitz than in Löbau-Zittau. But the area of industry sites increased in Löbau-Zittau, whereas in the others the amount decreased from 1996 to 2009. This development can be connected to the potential of the areas. Löbau-Zittau is more densely populated than the other two. There is enough living space, especially houses. Demmin und Oberspreewald-Lausitz have had a shortage of dwellings which had to be compensated, especially in the 1990s.



Graph 5. Development of population, housing and industry in Demmin (Mecklenburg-West Pomerania) 1996-2009 (source: Statistical Office of Mecklenburg-West Pomerania).



Graph 6. Development of population, housing and industry in Oberspreewald-Lausitz (Brandenburg) 1996-2009 (source: Statistical Office of Berlin and Brandenburg).



Graph 7. Development of population, housing and industry in Löbau-Zittau (Free State of Saxony) 1996-2009 (source: Statistical Office of the Saxony).

The development of the labour market and industrial sites in the areas can be connected to demographic change. With the reunification process, economy and population decreased. That is why the number of businesses also decreased. Nowadays there is almost no demand for industrial sites. A weak economy with mainly agriculture leads to a small job market, which is a specific characteristic of all three case study areas. Moreover, this has a strong influence on

the local population, because especially young people are leaving these areas, promoting the ageing process and the loss of labour supply.

Comparing the data on the development of land consumption by housing with the population development, it seems that there is no linkage between them. But looking at the qualitative results of this analysis there are interdependencies (Fig. 7).

The linkage between land consumption by housing and ageing is the so called ‘Remanence effect’ (Demuth et al. 2010). Older people stay in their homes or flats although their children have grown up and left. So they have much more living space per person than normally necessary and this living space is not accessible to larger households. Currently, this development is mainly hidden in the rural areas. But in the next years it will become more and more visible, as people get older. They will no longer be able to manage their house and garden. That is why abandoned houses and gardens will become more visible. Furthermore, there is a lack of successors or buyers to take on these houses. Municipalities and administrations know about the increasing problem of abandoned houses and the ageing process. Nevertheless the problem is not communicated openly. Both the masking of these problems and a lack of public funds as well as labour might be reasons that there are no statistics about the number of current and prospective abandoned houses.

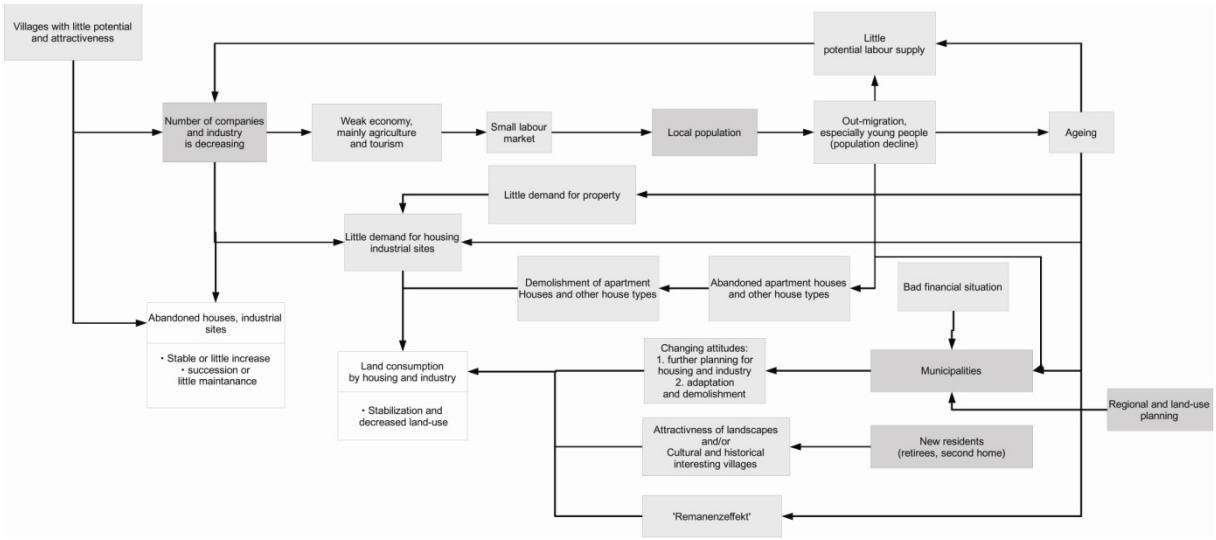


Fig 7. Interdependencies between population decline and ageing and other factors and their influence on the development of land consumption by housing and industry (constellation analysis) (source: own).

Another problem is the increased number of empty tenement buildings. In the 1990s some apartment blocks. As demand for these flats is mainly asked from older people, there will be no future for these houses. In the meantime they are mostly vacant, yet local authorities have to pay for the renovation and maintenance. Also other house types (single houses) are affected by abandonment, because of lack of demand, especially from younger people with good education who are leaving these areas.

As interviews with land registries showed, there is no call for new property in the case study areas. The demand for new and old houses as well as industrial sites has been decreasing since the mid-1990s. Previously, a lot of new industrial and housing sites had been developed. Nowadays a lot of these sites are unused.

Land consumption by housing not only depends on demographic factors such as population decline and ageing, but is also affected by the trend to an increased number of households (fewer children, more childless people, and single households). Furthermore there are factors such as a changing working environment and increasing space requirements, leading to a decreasing dwelling density. The development of industrial sites depends on the development of the economy in the area. Buying power as well as labour supply are connected with population decline and ageing. The result is a decreasing number of companies.

Most of the villages and their landscapes in the case study areas are less attractive and therefore have little potential for new and innovative developments (e.g. tourism, industry). In order to cope with demographic change, local authorities are adopting different strategies. Some are developing further planning for housing and industrial sites in order to attract investors. Others are trying to adapt to the ongoing changes, e.g. by demolishing abandoned houses. But the influence and scope of action of local authorities on their landscapes is restricted by their bad financial situation and by other actors who dominate the regions and their landscapes. Population decline and ageing are exacerbating both developments.

To sum up, land consumption in the case study areas is connected with demographic change and is leading to landscape change. Main aspects are:

- Land consumption by housing per day is low and decreasing in absolute numbers, but increasing per person (depending on population density and population decline),
- Apartment blocks and other dwellings are abandoned, but scarcely demolished,
- Industry is decreasing in general, industrial sites are abandoned,
- The analysis of land-use plans and their existence in municipalities of the case study areas showed that they quite often do not prepare such plans because there is no demand and inadequate funding,
- Municipalities and administrative districts have insufficient funds to tackle the demolition of vacant dwellings and industrial sites, because the population in these areas is declining, and there have also been reductions in subsidies, and incentives and
- Therefore the appearance of landscapes will change in the near future: abandonded residential buildings, gardens, industrial sites, brownfield sites and cleared wasteland.

Abandoned buildings and industrial sites which are no longer used provide the opportunity for revitalization and improving ecosystem services and functionality. Demographic change and its characteristic population decline and ageing are playing a major role for their development. However, although there is the potential for new developments, innovations are limited as funding for demolition and regional development is decreasing. Instead, a constant growth in land consumption in the case study areas is leading to a decreasing diversity of the ecological system. This has a strong influence on landscape resilience.

4. Discussion of the empirical results against the background of resilience theory

It is consensus that ecosystems and landscapes are continuously changing, with uncertain and unpredictable futures. Similarly, this can also be applied to human systems in general, and population development in particular. Some of the problems in ecosystem management stem from the failure to recognise that ecosystems and social systems are interlinked (FOLKE 2010). The development of landscapes and their population influences landscape resilience.

Using the panarchy concept, each element in a landscape hierarchy has its own adaptive cycle. Population development can be also seen as one element with its own adaptive cycle in a social system hierarchy. All these cycles interact with each other on different scales and at different rates building a ‘panarchy’ (Holling et al. 2002). The panarchy of cross-scale dynamics and interplay between a set of nested adaptive cycles helps to consider structures and processes in a dynamic fashion, to move away from a steady-state world where change is looked upon as an exception, to confront complexity and uncertainty, and move further into patterns and processes that you cannot directly observe and quantify with available data (Folke 2006). There is the possibility to regard driving forces over time on different spatial levels and their influence on a system such as landscapes. The concept of resilience is part of the overall concept and makes it possible to assess the stability of a system such as landscapes.

Adaptive cycles can be characterized by three dimensions: connectedness, potential, and resilience (Holling & Gunderson 2002). These changes in value depending on the phase of an adaptive cycle with four phases of development: the K-phase (conservation), the r-phase

(exploitation), the Ω-phase (release) and the α-phase (reorganisation) (Holling & Gunderson 2002). Holling and Gunderson (2002) explain these phases using ecological examples, but the concept is also used to describe social systems and their linkages to ecological systems (Folke 2006). Therefore the panarchy concept seems especially applicable to explain the effects of demographic change on landscapes and their socio-ecological resilience.

The sequence from r to K phase is a slow one during which connectedness and stability are increasing and 'capital' of nutrients and biomass is accumulated and sequestered (Holling & Gunderson 2002). The potential for other use is high. The system becomes overconnected and increasingly rigid. The actual change is triggered by agents of disturbance such as storm, fire, or disease.

The Ω-phase can also be called a phase of 'creative destruction'. This term was borrowed from the economist Schumpeter (1950 and reviewed in Elliott 1980 and (Holling & Gunderson 2002)). The accumulation of biomass and nutrients becomes increasingly fragile which means in system terms that the elements are overconnected. This leads to a release by agents such as forest fires, drought, and intense pulses of grazing.

The α-phase is one of reorganization, greatest uncertainty and greatest chance of unexpected forms of renewal as well as unexpected crisis (Holling & Gunderson 2002: 43). This involves the transient appearance or expansion of pioneer species and other opportunist organisms.

The reorganization phase is characterized by innovation and restructuring. This phase is typical for a society in times of economic recession or social transformation where new economic processes and policies are needed (Holling & Gunderson 2002).

Landscape change in the case study areas is caused by various driving forces, of which demographic change is only one. As already shown, land consumption is connected to population decline and ageing. But there are further aspects of landscape change which are linked to demographic change. These aspects are derived from expert interviews and data as well as document analysis:

- Intensification and mechanization in agriculture and livestock farming is increasing,
- A rapid development of renewable sources of energy (e.g. biomass production, wind energy),
- Landscape diversity is diminishing,
- Although FFH- and SPA-protection areas have induced new and further developments in establishing protection areas, the quality of these areas is decreasing,
- Decreasing number of actors of landscape development – concentration of land ownership and power,
- Nature conservation organizations are "leaving" these areas, their membership is decreasing and ageing,
- Decreasing numbers of people and especially of people who are interested in nature conservation and sustainability,
- Environmental administrations are ageing, with reduced numbers of employees, and limited influence,
- Population density is decreasing and
- Land consumption by housing and industry is not coming to an end, although there is the potential for revitalization.

The above-mentioned changes in the whole socio-ecological systems of landscapes are leading together with land consumption to changes regarding the resilience of landscapes in the case study areas.

In recent times the concept of resilience has gained a wide recognition in the literature. It has its origins in ecology through studies of interacting populations like predators and prey and their functional responses in relation to ecological stability theory (Folke 2006). The discovery of

multiple stable states in ecosystems in the 1960 and 1970s was first discussed by Holling (1973). This inspired social and environmental scientists to challenge the dominant stable equilibrium view (Folke 2006).

There are two views of resilience: it is understood as the capacity to absorb disturbances and still maintain function, or as the capacity for renewal, re-organization and development. Resilient socio-ecological systems hit by disturbances have the potential to create opportunities for innovation and development. In contrast, vulnerable systems will suffer from dramatic consequences even after small disturbances (Adger 2006).

Whereas ecological resilience is understood as the potential of ecosystems to maintain themselves in the face of disturbance, social resilience can be understood as the ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change. Social resilience is institutionally determined. Therefore it can be examined through indicators such as institutional change and economic structure, and also through demographic change (Norberg et al. 2008).

It is increasingly recognized that social and ecological diversity is an important requirement for long-term, sustainable functioning and development and for the resilience of socio-ecological systems (Norberg et al. 2008). Both are diminishing in the case study areas.

As already shown, landscapes in the case study areas are under pressure in various respects. Demographic change and its characteristics is one of them. Out-migration and the negative natural population development have different effects on landscapes. Depopulation is forming future landscape development in various ways which can be seen in the chosen case study areas. Actors in the case study areas do not have the capacity to influence the resilience of their landscapes. As population decline is projected to continue until 2030, leading to a loss of 50% of the population in comparison with 1990 population densities in the case study areas will decrease to a level where it seems almost impossible that resultant landscape changes will be terminated.

Demographic change is just one development which is not deliberately introduced by them. Further examples are the development of renewable sources of energy, the intensification of land-use, and the decreasing number of actors with a nature conservation background. Instead ongoing landscape changes in the areas are forced transformations, caused mainly by extrinsic driving forces. Because of the ecological, economic and social structures as well as low resilience in the case study areas, landscape systems are at a turning point. It is even possible that, with a regime shift, new landscape systems are emerging.

There are some data problems relating to the results of this study that should be mentioned. Data about land consumption by housing and industry in Germany has only been collected annually since 2001. Before this, it had been recorded only every four years. Moreover, a temporal and spatial comparison of these data inventories is limited as there are different stages of automating them. Finally, since 1992 old data from East Germany have been gradually converted to the West German system. This revealed some inconsistencies which were corrected. That is why apparent land-use changes are sometimes included which can distort the results. Nevertheless the quantitative data about land consumption show the general trend. Further investigations are necessary to obtain accurate data.

Fig 8. Abandoned apartment building constructed during the time of the former German Democratic Republic (GDR) for farm workers (source: own).

5. Conclusion: Linkages between Demographic Change and Socio-ecological Resilience of Landscapes

Demographic change is mainly an indirect force working on different spatial and temporal scales. Population decline in regions such as the chosen case study areas is primarily caused by migration related to disturbances such as the breakdown of industry and the labour market in the course of the unification process. Whereas the breakdown of the lignite mining industry is responsible for changes in Oberspreewald-Lausitz, intensification and mechanization in the agricultural sector together with deteriorating prospects on the labour market are mainly accountable for demographic changes in Demmin. In Löbau-Zittau the breakdown of industry altogether (textile, automobile industry, lignite mining, etc.) led to high unemployment. The extent of these changes is also supported by specific regional and local conditions.

As a result, daily land consumption by housing and industry is stagnating or decreasing in the case study areas. This seems to be positive for the ecological side of landscape development, but nevertheless the area used for housing and industry is increasing overall, and revitalization of land is seldom. On the other hand social resilience of these landscapes is affected by demographic change in a way that societal diversity (actors and institutions) is decreasing. Furthermore the social control through the rural society is weakened. Population decline and ageing will not come to an end in the coming decades. Especially the loss of young people and well-educated women is fostering this development. Just the ageing process will probably stop by 2060, when the baby-boom generation is reaching the age of 90 years. Birth attitudes cannot be changed regionally or locally. Therefore people in the case study area try to cope with the circumstances by adapting to the changes. With adaptive strategies, infrastructure programmes and subsidies for regions which are suffering from economic structural change, policy-makers are trying to initiate intrinsic developments. But unfortunately the long-term success is mostly not apparent.

Landscapes in the case study areas are vulnerable socio-ecological systems which are losing their resilience and therefore their adaptability. There are three possible opportunities for

development. Firstly, the regions can persist with the ongoing changes and stay in the same stage – which seems unlikely. Secondly, landscapes and their socio-ecological systems change to another stage which will be connected with either new opportunities or thirdly with a decline of the region. Landscapes will be more and more depopulated and with intensive land-use. They will be seen as regions which are functioning as areas for the agricultural production, providing resources in economic terms. Currently, it seems as there are few chances for new, innovative and sustainable developments. It is more likely that the current potential for such developments is ebbing away. In areas such as Demmin, where communities depend on landscapes and their ecosystems, resilience can be undermined by disturbances in the market system or environmental system (e.g. climate change).

Landscapes of the case study areas are in the α-phase, where resilience and connectedness is low and potential is still high. Low connectedness "… is associated with aggregated elements whose behaviour is dominated by outward relations and affected by outside variability" (Holling & Gunderson 2002). In contrast, "high connectedness is associated with aggregated elements whose behaviour is dominated by inward relations among elements of the aggregates, relations that control or mediate the influence of external variability" (Holling & Gunderson 2002). As the landscapes in the case study areas currently have high potential for innovations and new developments there are theoretically many opportunities to develop landscapes in a sustainable way. Nevertheless the danger that this potential will leak away is great. At this point, landscapes can change to less productive and organized systems or to very homogeneous, intensively used landscapes which are vulnerable to disturbances.

Landscape management strategies should shift from controlling change in systems which are regarded as stable to managing the capacity of landscapes as socio-ecological systems to cope with and adapt to changes (Folke 2006). Socio-ecological resilience of landscapes depends on the diversity of ecosystems and the institutional rules which govern social systems. As socio-ecological diversity of landscapes is currently dwindling it is necessary to stop this development using suitable management strategies.

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