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Wolfgang Loibl · Franz Prettenthaler
Editors

Economic Evaluation of Climate Change Impacts

Development of a Cross-Sectoral Framework and Results for Austria

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Karl W. Steininger · Martin König · Birgit Bednar-Friedl · Lukas Kranzl · Wolfgang Loibl
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Development of a Cross-Sectoral Framework and Results for Austria

This volume deals with the multifaceted and interdependent impacts of climate change on society from the perspective of a broad set of disciplines. The main objective of the book is to assess public and private cost of climate change as far as quantifyable, while taking into account the high degree of uncertainty. It offers new insights for the economic assessment of a broad range of climate change impact chains at a national scale. The framework presented in the book allows consistent evaluation including mutual interdependencies and macroeconomic feedback. This book develops a toolbox that can be used across the many areas of climate impact and applies it to one particular country: Austria.

"This study is a landmark, setting a new standard for the assessment of the impacts of climate change. It stands out for the comprehensiveness of its coverage of potential impacts across different sectors of the economy and its methodological innovations, including tracing climate impacts to economic endpoints."
Michael Hanemann, Professor of Economics, Arizona State University and Professor of the Graduate School, University of California, Berkeley

"This volume develops a consistent, bottom-up approach for a robust evaluation across the whole range of impact fields, acknowledging their macroeconomic feedbacks and budgetary implications."
Thomas Sterner, Professor of Economics, University of Gothenburg

"The lasting value of this book will come from the methodology with its frameworks, consistent toolbox and comprehensive integration, as well as the lessons learnt and shared, exemplified through application in Austria."
Roger Street, Director of UK Climate Impacts Programme, University of Oxford

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and Results for Austria

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Preface

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Chapter 6
Shared-Socio-Economic Pathways

Martin König, Wolfgang Loibl, Willi Haas, and Lukas Kranzl

Abstract Socio-economic pathways determine future climate impacts and costs thereof. Pragmatically, we have referred to a global reference socio-economic pathway (represented by SSP2 in the IPCC process) and derived figures for the core economic, demographic, land-use and (qualitatively) technological development in Austria, which again frame the sectoral development assumptions necessary to follow a scenario-based cost assessment approach.

In principal, trend projections and existing studies have been used to describe a single country, here applied for Austria, in 2030/2050 that is growing slowly in terms of population (0.27 % p.a.) and medium in terms of GDP (1.65 % p.a.) and in which forests, meadows and settlements expand in the north-east-south crescent—at the cost of arable land, within which further intensification will take place. Policy assumptions as well as technological change have been set to a medium path, at which risk zoning put forward, the EU integration 'muddles through' and no technological wonders are taken into account. A reference scenario might be regarded as least uncertain—which is not true—but we might expect more volatile developments to equilibrate over some decades.

The Austria we expose to climate change by 2050 is significantly different from nowadays: Its population is older and its public and private infrastructure density is higher—at least two factors that might influence future climate costs of inaction.

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6.1 Introduction

To assess the costs of future climate change in any specific country, we have to know for which type of future we carry out this assessment—climatically as well as socio-economically. The socio-economic development is structuring every countries development in various ways: It steers the building of infrastructures, drives land-use, accelerates or slows down technological development and influences the demographic features of migration and natural population growth/ageing of society et cetera.

While we have an overview of how vulnerable we are right now, we have the task to define societal vulnerability for the future to detect how much assets and which values we might expose to climate change.

We need to define the future national setting with respect to all climate sensitive assets and activities based upon these assets.

If we do so for a single country like Austria, we have to choose a top-down approach: Global trends will determine single country developments in a globalised world and set the frame, in which national policy and societies develop and how decisions are taken in future.

For example, global economic growth will allow a more prosperous Austria to invest in its infrastructure, which would alter the value of assets exposed to climate change impacts. Strong global population growth and poles apart or more convergence for global wealth will indirectly—via migration—impact on demographic structures in Austria, leaving us with different age distributions and sensitivities for heat waves. Global markets will steer the demand for certain agricultural or wood/timber products giving raise to land-use changes in Austria.

The IPCC has made significant progress in integrating socio-economic and climate scenarios and changed the mode of scenarios development from the sequential approach—first raising emission scenarios as driver for climate models and sequentially afterwards having climate impacts—to a more integrated and parallel approach, in which socio-economic development is not just steering global emission pathways but also—via different vulnerabilities—climate impacts, adaptation challenges and capacities. (cf. Moss et al. 2010)

That is why we will briefly look at the state of art for the developments of global shared socio-economic pathways, since these do matter not only for global greenhouse gas developments, but also for many factors that determine the sensitivity and exposure of people and assets in a single country. And we define our reference scenario along these assumptions taken for the global level.

To allow for range of potential future vulnerability, we have established 'diminishing' as well as 'enhancing' SSP scenario trends, wherever this was possible: E.g. for demographic as well as for economic developments plausible ranges are given in both directions leading for example to enhancing vulnerability for the demographic scenario, which results in high shares of people >65 years.

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6.2 Global Socio-Economic Pathways

The IPCC has started an intensive process to develop five possible scenarios for world development in the twenty-first century as a basic set. In principal, the main variables are population and (convergent or divergent) economic growth in the major global markets, technological development, degree of globalisation/regionalisation (i.e. mainly global work share and trade interdependence), efficiency of governance and institutions with investments in future infrastructure and population (e.g. education) reducing vulnerability of societies by sufficient access to fresh water and clean energy or leverage of adaptation capacity through education (cf. O'Neill et al. 2012).

The principal difference of these new global scenarios is that they are applicable not only for the assessment of GHG emissions (as the so-called SRES scenarios were cf. Nakicenovic and Swart 2000) but also for analysing vulnerability and thus allowing hints on potential costs caused by climate change or shocks by extreme events (Fig. 6.1).

If we take a look at the five SSP narratives, we see that a global shift towards more sustainability like in SSP1 would mean that global GHG emissions would decrease. A reduction of resource consumption would also result in higher adaptation capacity, e.g. water resources would remain accessible for many people and a further spread of regenerative energy would foster self-sustaining communities with potentially much lower vulnerability. Consequently, both—adaptation and mitigation needs—would be reduced in such a world.

In contrast, SSP3—the fragmentation scenario—would leave a world of non-cooperating economic blocks with some accelerating economic growth while others fall behind. Resource depletion would be high in an SSP4 world while population grows quickly. All this would lead to high challenges for both—adaptation and mitigation.

Fig. 6.1 The effects of SSPs on mitigation vs. adaptation challenges, O'Neill et al. (2012)

Yet, signals in both directions occur. Sustainable pathways come up in many parts of the world. Many of them rise bottom-up and are led by communities (Patt et al., transition towns) while others are driven by governments. In contrast to that, many global agreements (UNFCCC and Millennium Development goals) have not yet been met. Thus a likely mix of trends may result in the SSP2 reference scenario.

The core difference between the SSP4 and SSP5 worlds is disparity in welfare on a global level. While the conventional development/SSP5 argues for a convergence in economic development of transforming and developing countries in the long run, the inequality scenario/SSP4 postulates a further divergent economic growth in different world regions resulting in a rather small global elite and a vast majority of poor and vulnerable people with limited access to infrastructure, clean water and energy.

The striking difference for these two scenarios is a look at the different challenges they produce: While mitigation would be the key challenge in the conventional development/SSP5 world as a majority of world population would pursue a resource- and GHG emission intensive (and thus unsustainable!) pathway, the inequality scenario/SSP4 would create a vast majority of people remaining in poverty and—with respect to climate change—at high vulnerability, since their capacity to adapt would be very limited. In such an unequal world, the small global elite less affected by climate change might be less interested to introduce effective mitigation measures addressing the global scale quite easily while the poor majority would face climate change without being able to adapt. Consequently, the adaptation challenge in such a world would be very high.

In summary, we can expect the following trend: On the one hand, some economies in transformation countries as well as in developing countries will be catching up in terms of economic growth; on the other hand numerous countries will be left behind. Even for the ones catching up quickly, the additional national welfare is mostly gained by a rather small elite that is either controlling the natural resources (cf. Angola or Nigeria as an example) or gaining the advantages of foreign investments.

As a consequence, we refer to a reference/SSP2 world when we derive a shared socio-economic pathway for Austria. The core narrative—referring to O'Neill et al. (2012) for such a world is as follows:

6.2.1   Global Economy

A global economy that continues to grow with fluctuating growth rates between 0 and 4 % seems a reasonable assumption as 'reference': While recent trends show a slow recovery of the industrialised world after the global economic financial crisis in 2008/2009, also BRIC countries grow slower than expected. The technological progress will be significant in some fields like propulsion technology and efficiency as well as for renewable energy, but independence from fossil fuels is not expected until 2050. As a result of slowly declining demand and new exploration (especially

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in the Arctic) we expect a gradual global increase in energy prices until 2030 and an exponential growth only after 2030.

6.2.2 Global Population

The global population growth will be slower as formerly forecasted. Still, growth rates particularly in developing countries will remain high for a while. Thus, we can expect around 9 billion people around the globe in 2050 and declining global population due to ageing and a much faster demographic shift in most parts of the developing world as expected towards the end of this century. This is in line with more recent demographic studies (e.g. UN 2005) which expect that many developing countries are approaching the demographic shift (of a society with pre-industrial high birth rates but progress-triggered decreasing death rates) much faster as most industrialised countries did during the industrialisation era. In fact, decreasing birth rates show much less retention with decreasing death rates in recent industrialised societies, thus expecting less population growth.

6.2.3 Shared Policy Assumptions

There is no global consensus on ambitious mitigation policies. No huge transition towards a decarbonised economy occurs—neither at global nor at European or Austrian level. The achievements of the Millennium Development Goals are yet delayed leaving many people in developing countries without access to freshwater, sufficient food and energy. Vulnerability of people in developing countries will thus further increase which leads to an increase in migration within countries but also towards Europe.

6.3 Reference Scenario Assumptions for Austria

The global SSP2 as 'intermediate' scenario is selected as framing condition for the shared socio-economic pathway that we determine for our cost assessment in Austria. Shared socio-economic as well as shared policy assumptions relevant for Austria are in line with global SSP2 and shape the socio-economic conditions for the cost of inaction assessment. For demographic, economic and technological developments, we deliver country-specific plausible ranges (diminishing ← reference → enhancing), which are compliant with a global SSP2. It is important to note that 'fixing' the socio-economic conditions does not mean that there are no ranges for sectoral assumptions on their specific development. Some examples are:

- Forestry sector: The COIN reference SSP delivers as key assumptions the share of forests in Austria for the forthcoming decades and the world market price signals for timber as framing conditions, while the sector would raise the asset developments for certain (vulnerable) tree species (most adverse and most beneficial development plus best guess) within the forested land and assumptions for the development of the sawing industry in Austria and thus the import ratio for certain timber.
- Health sector: the COIN SSP delivers the share of >65 year old people (plausible range) for the forthcoming decades plus key assumptions on urban sprawl while WP6 (health) has to combine the key assumptions (e.g. share of >65 people living in non-air-conditioned flats in urban heat islands in 2030/2050) and how the development of climate sensitivity of older people in future will be to get to its exposure scenarios.
- Energy sector: the COIN reference SSP delivers the range for the price level of main energy carriers in 2030/2050, while sector energy would have to derive the energy mixes for 2030/2050 taking this overall energy price level as one boundary condition.
- Agriculture sector: the COIN reference SSP delivers the share of agricultural land use in 2030/2050 as well as world market prices for grain (ranges) plus assumptions on the level of subsidies (SPA for EU integration) while WP3 (agriculture) would derive the developments for certain (vulnerable) crop production until 2030/2050. Agriculture might be a more complex example, since crop production can be changed on a yearly basis and could thus react quickly (autonomous adaptation to climate change or changing demand/price signals). Thus the crop assets are the least fixed ones in the COIN asset exposure scenarios.

6.3.1   Shared Policy Assumptions

6.3.1.1   The EU (Dis)Integration

The future operation, intensity and budget of common EU policies, is explicitly important for the sectors agriculture (Common Agriculture Policy, CAP), energy (TEN-E), water (e.g. WFD) and transport and mobility (TEN-T policy) as well as to some extent also for ecosystem services and biodiversity (nature protection policy, e.g. protected areas like Natura2000).

As we have seen in early February 2013, the EU has reached consensus on its periodical financial framework 2014–2020 with slight decreases (960 billion euros compared to 995 billion euros for the last period 2007–2013). This agreement could be regarded as symptomatic for the EU (dis)integration. Trends in further integration especially for financial market control mechanisms and the European Stability Mechanism (ESM) are discernible. These trends might indeed empower

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the EU to control national budgets and to intervene in countries that are using ESM budgets.

However, since national budgets are under pressure as austerity policy prevails, we see the divergent trend of pooling less national resources on other formerly important fields of common European policy. Coherence funds as well as the budgets for CAP, TEN-E and TEN-T will most likely shrink or will at least be frozen. For all these shares of the EU budget, the national interests are diverging. E.g. France, Germany and also Austria want further protection of their farmers from major cuts in EU subsidies (via CAP), so that the CAP share will decrease to a lesser extent as many experts suggest.

To keep it simple, we expect a 'muddling through' of the EU for the coming decades. All COIN-relevant EU budgets will thus be projected as frozen to the amount of the last multiannual financial framework 2007–2013. This means in fact that

- subsidies for farmers will face a net real decrease according to the inflation rate
- major TEN-T projects will be prolonged, some might be cancelled due to budget constraints
- the share of EU protected areas (Natura2000) will remain at status quo.

6.3.1.2 National Policies

Especially for the impacts of climate-triggered natural disasters like floods, mass movements and avalanches, a rigorous risk zoning and centralisation of spatial planning policy at higher (provincial or federal) scale has to be taken into account. The degree to which this will take place until 2030/2050 is hard to project, but some proxies might be drawn from the major (national-scale) flooding events that took place in eastern Austria 2002 and western Austria in 2005.

National policies have gone through a learning process considering climate change as an issue. The ratification of the NAS in Austria could be regarded as major milestone in that respect, but we are not approaching adaptation yet as its implementation is still pending.

But the adaptation learning curve experienced will influence not only the pertinent national adaptation policies (i.e. planned adaptation, which is excluded from the COIN assessment), but will also trigger autonomous, individual adaptation, since public sector activity will inevitably foster private sector engagement for adaptation as particular tools for adaptation or at least risk management (cf. eHORA) will be available. All this will trigger public perception and policy implementation e.g. in terms of risk management for natural disasters.

E.g. after the major flood events in 2002 und 2005 the following water policies have been pushed forward:

- EU floods directive initiated by Austria

- Adjustments in the Austrian water law
- Adjustments in the Austrian law on hydraulic structures.

This indicates 'reactive' learning after natural disasters.

Pragmatically we will acknowledge a 'reactive' learning curve within public administration and policy development that is taken up by the private sector and thus lead to:

- More rigorous risk zoning
- More centralised spatial planning at provincial and federal level.

6.3.2 Demographic and Economic Development

6.3.2.1 Demographic and Economic Growth Assumptions

Demography is one of the key parameters that determine both biophysical and economic developments. Thus number of people and their age structure are highly relevant for consumption levels and patterns (transport, buildings, food/agriculture etc.), sensitivity of population (human health), size of labour force, dependency ratio with its financing implications for pension funds and education and so on.

According to the 2011 forecast of Statistics Austria population will still grow in future. In 2011 8.4 million people lived in Austria. For 2030 there are 9.0 million people and for 2050 9.3 million people expected (central projection; Hanika 2010). The age structure will shift towards an increased share of older people: Compared to 18 % share in population of 65 and over in 2011 this group will account for 25 % in 2030 and for 28 % in 2050. This rises the average age of population by about 4 years between now and 2050. For details on long-term assumptions for fertility, mortality and migration see Hanika (2010).

The SSP for economic development refers to Schiman and Orischnig (2012). In their economic long-term model for Austria's public finances, economic growth is driven by level of employment, its endowment by capital and technical progress. Projections are based on the central demographic projection of Statistics Austria (consistent with 'middle-of-the-road'). They state: 'Overall, the average annual trend growth is projected to be 1.65 % over the whole period (2012–2050). This increase is almost entirely accounted for by its increments of productivity, while labour input is stagnating [and capital stock only slightly increasing from 2030 onwards]'.

For both time slices, we deliver three possible scenario pathways. The 'diminishing' scenario reproduces less population and GDP growth due to less employees while the enhancing scenario reproduces a higher population, thus employee and GDP growth. In fact, the diminishing (i.e. less growth) scenario reproduces less assets, less people explicitly vulnerable to heat waves et cetera. On the other hand, one might argue that a growth scenario (here the 'enhancing' scenario as it 'produces more vulnerable people at critical age, more exposed

Table 6.1 Key economic projections for 2030. Sources cf. below

2030	Diminishing	Reference	Enhancing
Population (no.)	[a]	[b]	[c]
Total	8,926,000	9,013,000	9,385,000
<20 years	1,720,000	1,721,000	1,881,000
20 to <65 years	5,106,000	5,117,000	5,275,000
≥65 years	2,101,000	2,162,000	2,229,000
GDP growth (%)	[d]	[e]	[f]
National level	1.49 %	1.65 %	1.82 %
Employees (no.)	[g]	[h]	[i]
Total	3,443,000	3,450,000	3,557,000

[a]Statistik Austria low life expectancy projection (see also http://www.statistik.at/web_de/statistiken/bevoelkerung/index.html, cf. Hanika 2010)—midyear
[b]Statistik Austria central projection—midyear
[c]Statistik Austria growth scenario projection—midyear
[d]Based on footnote "e"; growth rate has been reduced by 10 %
[e]Schiman and Orischnig (2012) average growth rate over the whole period 2012–2050
[f]Based on footnote "e"; growth rate has been increased by 10 %
[g]Based on footnote "h" but reduced in proportion to change in population group 20 to <65 between central to low fertility scenarios
[h]Schiman and Orischnig 2012 with their assumptions on unemployment and part time work
[i]Based on footnote "h" but increased in proportion to change in population group 20 to <65 between central to growth scenario projections

assets' et cetera) calls for setting higher discount rate as the future generation has more welfare and financial power. It is thus hard to have a clear specification, which growth pathway is in fact more/less challenging in terms of climate impact costs (Tables 6.1 and 6.2).

6.3.2.2 Key Price Signals

Global market integration for energy and agricultural commodities is almost complete and world market price developments dominate supply and thus land-use shares of crops.

Simplifying the assumptions on key price signals, we opted for an evaluation of global market price projections by IEA, FAO and OECD rather than acknowledging the effect of climate change on domestic prices. This is an implicit mistake, which is due to the necessary sequential set up of (1) the climate and socio-economic scenario framework, (2) sectoral assessments and quantification of direct impact and (3) macroeconomic assessment and indirect effects (including altering price signals).

Table 6.2 Key economic projections for 2050, Sources cf. below

2050	Diminishing	Reference	Enhancing
Population (no.)	[a]	[b]	[c]
Total	9,113,000	9,334,000	10,456,000
<20	1,714,000	1,717,000	2,186,000
20 to <65	4,958,000	4,980,000	5,414,000
≥65	2,440,000	2,634,000	2,856,000
GDP growth (%)	[d]	[e]	[f]
National level	1.49 %	1.65 %	1.82 %
Employees (no.)	[g]	[h]	[i]
Total	3,435,000	3,450,000	3,751,000

[a]Statistik Austria low life expectancy projection (see also http://www.statistik.at/web_de/statistiken/bevoelkerung/index.html, cf. Hanika 2010)—midyear
[b]Statistik Austria central projection—midyear
[c]Statistik Austria growth scenario projection—midyear
[d]Based on footnote "e" growth rate has been reduced by 10 %
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[i]Based on footnote "h" but increased in proportion to change in population group 20 to <65 between central to growth scenario projections

Table 6.3 Energy and C reference scenarios from

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Thus price signals for agricultural goods are important as they trigger the crop selection, shifting towards more demanded agricultural goods. Price signals for energy commodities will alter supply and demand in any given country. All this triggers sector sensitivities significantly: Different crops as well as different energy supplies lead to divergent sectoral climate sensitivities.

The assumptions for economy-wide average energy and CO_2 price development are depicted in Table 6.3 and are grounded on the assumption that even for reaching an A1B emission pathway, mitigation measures are inevitable and would require mechanisms for carbon pricing that lead to according increases in energy and CO_2 emission credit prices. This implies that current climate mitigation policies are carried forward without neither attenuation nor intensification. By this, the definition of 'inaction' in terms of mitigation must be seen as relative to current action rather than absolute.

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Table 6.3 Energy and CO_2 prices in 2010 prices, after IEA WEO (2010): current policy scenario; reference scenarios from the project EISERN

	2010	2020	2030	2040	2050
Primary energy price (EUR/MWh)					
Coal	7.11	9.36	9.95	10.65	11.38
Gas	18.25	29.73	34.16	37.60	41.48
Oil	29.69	46.59	55.06	61.41	68.61
CO_2-Price (t CO_2)	15.84	21.60	26.64	33.84	41.04
Electricity wholesale price (EUR/MWh)	45.56	53.85	57.78	63.25	68.50

It is essential to stress that climate change could add on global food market prices. While climate change will most likely deepen the disparities in the global distribution of food, since most adverse effects (mainly losses in ecosystem services) will prevail in subtropical and tropical regions, cereal world market prices could rise by a maximum of 20 % under certain SRES scenarios (cf. Parry et al. 2004).

The price signals for agricultural products are hard to be projected and there is no forecast available how the price for wheat or soybean will develop over the next decades.

Uncertainty stems from various sources, where climate impacts on global yields is one among others. Nevertheless, corn markets are influenced heavily by the way that agricultural and energy markets will integrate, or in other words: How strong (and legally binding) the agrofuel mandate will be played in future. It is very likely that due to increasing demands as regards the global demographic development and the demand for agrofuels, we will face much higher volatility of the corn market (cf. Diffenbaugh et al. 2012). During the last four decades of the twentieth century, the prices decreased basically due to intensification and extension of arable land overcompensating the increasing food (and not yet energy) demand.

During the decade 2000–2010 we see the market becoming very volatile as shown by the index curves in Fig. 6.2. This depicts the increasingly complex influence on the market by energy (agrofuel) demands, increasing world population and impacts of climate change (mainly droughts in North America, Australia and Europe). On top of that, policy interventions in producer countries tend to protect their consumers by channelling more harvest shares on their domestic markets, which leads in the end to less supply on the global food market and increasing world market prices.

However, according to OECD/FAO forecasts for the most important agricultural commodities until 2020, we see almost no significant trend which would justify putting a certain index to the price development. There is only one commodity—vegetable oil—for which we see a clear increasing price level throughout this decade.
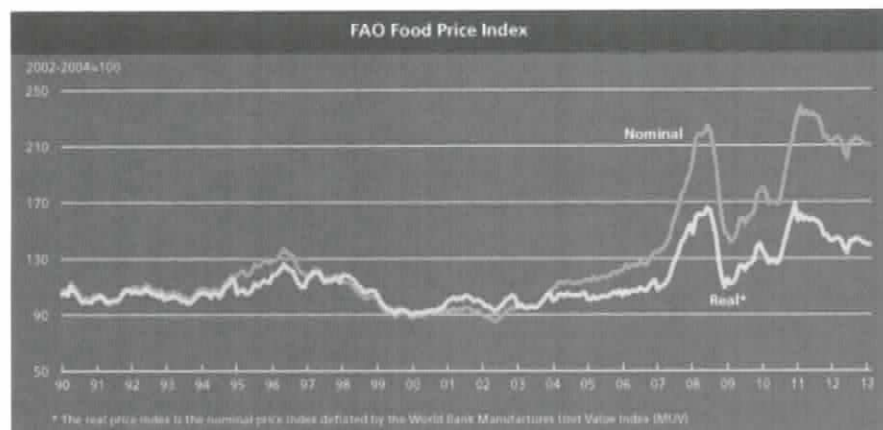
Fig. 6.2 FAO food price index since 1990, online source of FAO http://www.fao.org/worldfoodsituation/wfs-home/foodpricesindex/en

Consequently and as a best guess, we extrapolate 2020 agricultural goods prices to the decades after, acknowledging that the market will presumably be very volatile as it was in recent years. But the decreasing trend of agricultural goods prices has stopped and this has been acknowledged by the recent FAO outlooks to which we refer.

Under the assumption that the Common Agricultural Policy (CAP) would shrink in its financial intervention power (cf. above), we assume that world market prices would strike through on national food markets almost without a buffer. So, the means to decouple the EU internal market from the global market will be much less powerful in future decades (Table 6.4).

6.3.3   Land-Use Change

For the land-use change scenario, we stick to the reference scenario, because mapping ranges as giving ranges is neither possible on the existing data nor would it be easy to depict those ranges in an applicable way.

The land cover map reflects the kind and intensity of land-use. Land cover mapping is based on the European CORINE Land Cover project (http://www.umweltbundesamt.at/umwelt/raumordnung/flaechennutzung/corine/). Land use projection refers to the land use class shares and concentrates on settlement areas, carried out using population, employment and housing projections.

The map in the book is depicted in grey scale. A coloured image can be found on the web-site, accompanying the book (http://extras.springer.com) or on the Environmental Agency Austria's—CORINE website listed above. The spatial and the land use classes—especially those addressing settlements—are shown rather coarse
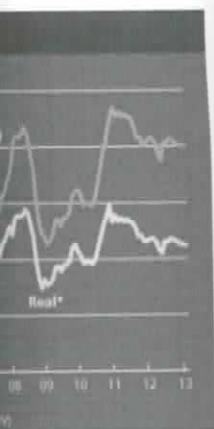
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Table 6.4 Real prices projected for 2020

Agricultural commodity	2020 Price in EUR/t or EUR/hl (for ethanol and biodiesel)
Wheat	178
Coarse grain	150
Rice	365
Oil seeds	354
Protein meals	242
Vegetable oils	805
Raw sugar	302
Beef and veal	3,547
Pig meat	1,894
Poultry meat	1,937
Sheep meat	2,629
Butter	2,762
Cheese	3,032
Skim milk powder	2,534
Whole milk powder	2,659
Whey powder	726
Casein	6,237
Ethanol	49
Biodiesel	106

Source: OECD-FAO Agricultural Outlook 2011; exchange rate 1.35 has been applied for USD/EUR

in Fig. 6.3. As a large part of Austria is covered by mountain and thus forested, the large settlements are concentrated in the plane areas in the north-east-south 'crescent' of Austria, shaped by Pleistocen glaciers as well as the Danube and further in some wider Alpine valleys along the rivers Rhine, Inn, Salzach, Enns, Drau, Möll, Glan, Lavant, Mur and Mürz.

For COIN this CORINE land cover subset has been intersected with the Austrian NUTS-3 regions to allow a more detailed spatial relation of sector-related land uses to different exposure patterns using tabular statistics.

The following map depicts the land use intensity with respect to housing and settlement area through population density per km^2 which allows identifying the population exposure variation to climate change effects and the related hazard risk through NUTS-3 regions. The darker gray (dark red to purple) shades show a higher population and thus settlement density (Fig. 6.4).

6.3.3.1 Assumptions on Future Land Use Change

The prior land use change and population change observations allow the following assumptions on trends. Two directions in spatial development can be identified: peripheral rural regions are expected to continue losing population and thus
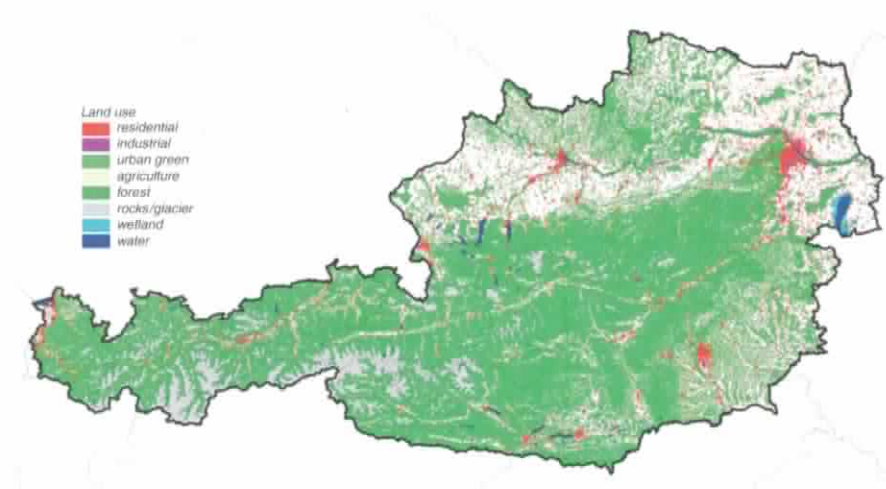
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Fig. 6.3 CORINE Landcover 2006, Environment Agency Austria (2014)
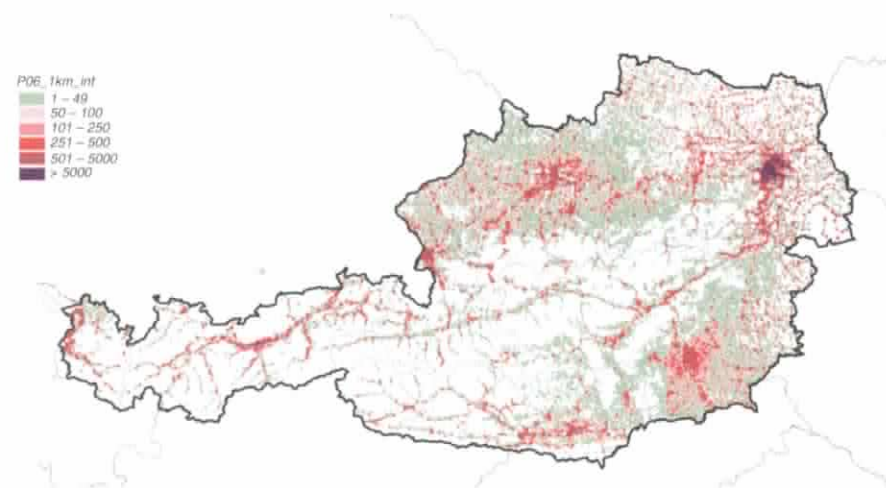

Fig. 6.4 Population distribution per km^2 2010, AIT—spatial allocation of population numbers related to CORINE land use distribution based on Statistik Austria population data

economic attractiveness, liveability and social cohesion (The reasons refer to their demographic structure and to migration patterns more or less triggered by economic expectations). Central regions with larger core cities are usually prosperous areas with migration surplus and growing businesses, all demanding additional building land.

6.3.3.2   Settlement Area

Settlement areas in rural peripheral regions with less economic activity will remain more or less as they are. As less people will be living in these areas, more houses will stay unoccupied or will be, in best case, occasionally used as holiday homes by the children of those living there before or rented out as guest houses during holiday seasons. Buildings in bad condition can be expected to be demolished. Buildings in areas which have been observed to be affected by natural hazards (floods, avalanches) will occasionally get abandoned.

Settlements in rural areas in attractive landscapes with higher touristic potential will grow—new houses will be built for guest accommodation or as holiday homes. In areas where no sufficient residential land is available, pressure to policy makers will turn up, to zone new building land. If there is no land available in areas which are free of risk to be damaged through climate induced natural hazards, areas judged to let expect little natural hazard risk may be zoned as new building land.

In urbanised regions pressure on land consumption will increase due to in-migration (either from the national periphery or from the European periphery which are both less prosperous). Settlements in urban and peri-urban areas are expected to grow because of housing demand from increasing population numbers, increasing household numbers (which still grow, even when population declines, because of decreasing household size) and because of increasing economic activities due to the establishment of new businesses or enlargement of existing ones demanding additional commercial area and related land uses like logistics, parking lots, transportation network and technical infrastructure supply. Depending on planning policy guidelines one can expect either densification with controlled growth in sub-centres or urban sprawl in the outskirts of the cities. Decline of climate comfort in densely populated and thus densely built up urban cores leads again to an urged trend of households which can afford single family homes to move to the city outskirts building houses in green environment and fresh air with sufficient nocturnal cooling.

The website accompanying the book contains a figure which shows regions in red where population numbers are expected to grow causing a growing settlement area and those regions in blue where population numbers will shrink leading to less growth pressure in those settlement areas. The grow-areas are all capital regions of Austria's provinces while the shrinking areas are those in less prosperous Alpine valleys like mountainous Carinthia, mountainous Styria and in the north-western peripheral region of Lower Austria (the "Waldviertel") and finally some parts of the southern Burgenland.

The following Table 6.5 gives an estimation of a "reference scenario" (REF) for further settlement area growth. The change rates are based on the changes between 2001 and 2010. Till 2020 the change rates are assumed to remain stable. For the decade 2021–2030 the change rates are reduced by 50 %. For the decades 2031–2050 the change rates are reduced to 25 % assuming declining building land demand due to a saturation of population numbers, household size averages and

Table 6.5 Building and transportation infrastructure land: absolute number, change rates and estimations for 2020–2050, Statistik Austria—ÖROK Scenarios, AIT

Building land and transportation infrastructure (km²)				Growth 2001–2010		Reference scenario 2030	Reference scenario 2050
Province	2001	2009	2010	2011	Absolute (km²)	Relative (in % of 2001)		
Burgenland	264	312	315	317	51	19	412	453
Kärnten	361	393	397	399	36	10	458	481
Niederösterreich	1,147	1,291	1,304	1,309	157	14	1,584	1,694
Oberösterreich	711	789	797	806	86	12	947	1,006
Salzburg	216	229	229	230	13	6	250	258
Steiermark	694	788	792	794	98	14	968	1,037
Tirol	270	297	299	302	29	11	349	368
Vorarlberg	117	121	122	126	5	4	130	133
Wien	191	196	194	194	3	2	200	206
Austria	3,971	4,416	4,449	4,477	478	12	5,299	5,622

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The projections show a slight saturation of settlement area growth after 2030 because of the saturation in population growth and thus economic activity increase. Until 2030, a 20 % increase of settlement area can be expected, till 2050 a 28 % increase can be expected (base year 2010).

The numbers above are target numbers derived from the ÖROK scenarios (see Hiess et al. 2009a, b). A further disaggregation into smaller regions is necessary to allow considering the regional variation of socio-economic trends. The following section documents the way how the projections have been carried out for the NUTS3-regions.

As the households are the major drivers for change in residential areas, projections of household numbers (Hanika 2010) are used as proxy for estimating the additional demand for settlement area for housing: From 2010 till 2030 an increase of 12.5 % can be expected, till 2050 the increase will results in 20 % since 2010. The increase will vary between stagnation in some NUTS3-regions and growth till 2030 of up to 25 % and till 2050 of up to 40 % (e.g.in the Vienna region outside the core city). The increase of household numbers in the cities will not require the same increase of building land but will be substituted to a certain extent through densification.

Growing household numbers represent just a part of the growing apartment numbers—a certain additional amount refers to second homes, holiday homes, reconstruction demand as well as a turnover demand for migration, renovation etc. (Windisch 2005). The reference household projections refer to the ÖROK household projections till 2030 (Hanika 2005) and the households' main residences projection 2011–2030 (Hanika 2010). The housing projections have been extended for the reference scenario till 2050. Therefore the regional growth rates for the decades till 2050 are taken from growth rates for decade 2021–2030 and have been reduced by the factor 0.8 assuming less apartment surplus for the future. Only for Vienna no reduction was considered, otherwise the apartment surplus share would have been reduced from 12.5 % (in 2011) down to 4 % which is assumed to be too low. Now the surplus share shrinks only to 6.7 %.

The remaining building land increase is due to increase of area demand for public infrastructure, for production, logistics, services and retail as well as for transportation infrastructure. To estimate the demand for building land for business development, the change in workplace numbers were used as proxy. As no workplace numbers are available but employee projections, we assume with some uncertainty (considering static employment ratios and neglecting changes in commuter patterns) that the workplace numbers will follow the workplace demand estimated through demographic projections and related employment quotas. Employee numbers (Kytir et al. 2010) have thus been taken as a further proxy to identify new workplace demand as new demand for business development area. From 2010 till 2030 some workplace increase of up to 4 % can be expected for the provinces Lower Austria, Vorarlberg and Vienna, till 2050 an increase ranging between 3 and 16 % can be expected for the provinces Lower Austria, Tiyrol,

Vorarlberg and Vienna. The NUTS-3-specific change rates show much more variation—e.g. up to 26 % in Vienna's outskirts.

Workplace increase projections are not available in detail for Austria. But there are projections based on NUTS-2 regions for EU27. An available projection comes from the PLUREL project (www.plurel-org.eu) based on GDP-projections of the NEMESIS economic model using energy price expectations to project GDP- and population up to 2025 (Boitier et al. 2008). These NUTS2-projections were taken to extend the 2010–2020 trend till 2050. The growth rates were reduced by a factor of 0.982 to achieve the 4.25 million workplace total as defined by the reference scenario. The NUTS2 workplace numbers were disaggregated to NUTS3 regions based on the 2010 shares of the NUTS-3 entities on the NUTS-2 regions.

Then the housing and workplace change ratios were taken as final proxy for extrapolating the urban fabric land use classes. The following Table 6.6 presents the numbers for built up land distinguished as CORINE landcover classes CLC 11 (urban residential) and CLC 12 (industrial, commercial, transportation infra-structure) for 2010, 2030 and 2050.

6.3.3.3 Agricultural and Forest Area

A study carried out by Alterra (Pérez-Soba et al. 2010) on land use change in Europe predicts a quite strong abandonment of agriculture in Western Europe's more marginal mountainous areas.

In peripheral rural regions, the share of arable land is expected to decline due to lacking cultivation, given up by prior farming families now commuting to nearby industrial or service centres for work or leaving the rural areas to move to urban regions for better education, better working and better living conditions. Some land will be first transformed into grass land used as pastures or fodder resource for cattle (or sheep in high mountain areas) by nearby farmers and will later evolve into forested area.

So, agriculture is quite under pressure loosing on the one hand arable land, transformed into residential and commercial land in prosperous, easy to be culti-vated central regions and on the other hand leading to abandoned areas—both affected by climate threats endangering harvest volume and thus income. Climate and market conditions lead also to changing crop cultivation shares—e.g. increas-ing crops for biofuel production, sensitive to drier and hotter climates, and decreas-ing food crop shares as far as EU Biofuel policies may influence the biofuel cultivation shares.

Haberl et al. (2003) have estimated changes in land use due to policy response of agricultural, forestry production till 2020. A TREND scenario extrapolates effects of current common agricultural policy CAP into the future. In the GLOB (global-isation) scenario, agricultural subsidies and market regulations will be reduced leading to a concentration on agricultural products which can be produced in Austria competitively. No additional biomass production is assumed here. In the MAX (maximum liberalisation) scenario, the highest possible increase of biomass

Table 6.6 Settlement area projections for NUTS3-regions, Processing: AIT based on CORINE Land Cover classes 2006: Urban residential, industry (incl. commercial, transportation infrastructure), and Statistik Austria projections for households, apartments and workplaces (ÖROK Scenarios)

NUTS-3	Urban-residential 2006	Industrial 2006	Urban-residential 2030	Industrial 2030	Urban-residential 2050	Industrial 2050
AT111—Mittelburgenland	3,778	30	4,387	37	4,604	38
AT112—Nordburgenland	10,074	512	11,958	634	12,774	640
AT113 Südburgenland	7,744	251	8,814	311	9,126	314

Table 6.6 Settlement area projections for NUTS3-regions. Processing: AIT based on CORINE Land Cover classes 2006: Urban residential, industry (incl. commercial, transportation infrastructure), and Statistik Austria projections for households, apartments and workplaces (ÖROK Scenarios)

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AT111—Mittelburgenland	3,778	30	4,387	37	4,604	38
AT112—Nordburgenland	10,074	512	11,958	634	12,774	640
AT113—Südburgenland	7,744	251	8,814	311	9,126	314
AT121—Mostviertel-Eisenwurzen	10,288	620	12,086	768	12,814	774
AT122—Niederösterreich-Süd	15,097	1,451	17,622	1,796	18,582	1,812
AT123—Sankt Pölten	7,873	304	9,225	376	9,756	380
AT124—Waldviertel	14,237	227	15,877	281	16,176	283
AT125—Weinviertel	13,468	232	15,795	287	16,729	290
AT126—Wiener Umland/Nordteil	23,295	1,705	28,967	2,111	31,922	2,129
AT127—Wiener Umland/Südteil	15,620	3,201	18,512	3,963	19,727	3,997
AT130—Wien	19,387	3,620	22,527	4,569	23,935	4,653
AT211—Klagenfurt-Villach	13,627	1,136	15,833	1,424	16,624	1,445
AT212—Oberkärnten	7,815	134	8,980	168	9,358	171
AT213—Unterkärnten	6,929	208	7,852	261	8,092	265
AT221—Graz	15,072	1,536	17,688	1,903	18,708	1,921
AT222—Liezen	5,388	287	5,990	356	6,083	359
AT223—Östliche Obersteiermark	10,022	1,170	10,707	1,450	10,525	1,463
AT224—Oststeiermark	13,116	206	15,744	255	16,942	258
AT225—West- und Südsteiermark	10,425	380	12,344	471	13,150	475

(continued)

Table 6.6 (continued)

NUTS-3	Urban-residential 2006	Industrial 2006	Urban-residential 2030	Industrial 2030	Urban-residential 2050	Industrial 2050
AT226—Westilche Obersteiermark	5,555	825	6,016	1,022	5,982	1,032
AT311—Innviertel	10,368	219	12,702	271	13,859	273
AT312—Linz-Wels	17,780	3,547	21,113	4,385	22,526	4,420
AT313—Mühlviertel	9,911	1	12,563	1	14,022	1
AT314—Steyr-Kirchdorf	7,400	343	8,802	424	9,406	427
AT315—Traunviertel	11,183	114	13,291	141	14,193	142
AT321—Lungau	1,395	1	1,664	1	1,783	1
AT322—Pinzgau-Pongau	8,708	64	10,619	81	11,551	82
AT323—Salzburg und Umgebung	10,181	632	12,275	798	13,238	812
AT331—Außerfern	2,862	29	3,575	37	3,951	38
AT332—Innsbruck	9,059	413	11,037	523	11,984	534
AT333—Osttirol	2,354	120	2,787	152	2,969	155
AT334—Tiroler Oberland	6,106	64	7,713	81	8,589	83
AT335—Tiroler Unterland	11,348	123	14,265	156	15,827	159
AT341—Bludenz-Bregenzer Wald	6,162	95	7,546	118	8,226	119
AT342—Rheintal-Bodenseegebiet	10,811	398	13,402	494	14,721	499
Total km²	354,448	24,198	420,279	30,108	448,456	30,443
Change factor, 2006 = 100 %	100.0	100.0	118.6	124.4	126.5	125.8

Table 6.7 Land cover s

Urban and infrastruc-
ture area

Cropland, gardens

Grasslands (in use)

Alpine grasslands
(in use)

Forest, woodland

Natural areas, rivers,
lakes

Unused Alpine pastures

Grassland (unused)

Grassland succession

Old field succession

[a]Haberl et al. (2003)
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Table 6.7 Land cover shares: 1995, 2008, scenarios 2020, reference scenario (reference), 2030

	1995 (km²)	2008 (km²)	TREND 2020 (km²)	MAX 2020 (km²)	GLOB 2020 (km²)	Reference 2030 (km²)
Urban and infrastructure area	3,967	4,360	5,191	5,191	5,191	5,300
Cropland, gardens	14,670	26,449	13,614	14,436	11,664	13,700
Grasslands (in use)	11,131		9,898	9,077	7,295	7,500
Alpine grasslands (in use)	8,525	8,552	8,616	8,616	5,773	6,500
Forest, woodland	38,400	36,343	39,375	39,375	42,014	42,500
Natural areas, rivers, lakes	7,164	7,622	7,164	7,164	7,164	6,500
Unused Alpine pastures	–	–	–	–	3	25
Grassland (unused)	–	–	–	–	757	757
Grassland succession	–	–	–	–	420	420
Old field succession	–	–	–	–	736	736
	83,857[a]	83,326[b]	83,858[a]	83,859[a]	81,017[a]	83,938[c]

[a]Haberl et al. (2003)

[b]Environment Agency Austria—BEV numbers

[c]AIT-estimation

production is assumed—a scenario which considers the possible impact of agricultural markets' liberalisation. Table 6.7 presents the numbers from Haberl et al. (2003), adds the observation numbers for 2008 and reference scenario numbers located between the TREND and the GLOB scenario, taking the settlement and infrastructure area from the estimations shown above. The total area numbers are varying slightly due to estimation and rounding errors.

The numbers are rough estimates based on available statistics and sources.

The areal change for non-urban land use classes is presented below. The maps give some hints on the regional differences in change of agricultural area. The numbers per NUTS-3 regions will serve as basis for the disaggregation of the changes in agricultural/forestry land cover sub-classes. Intra-regional details on patterns and shares are subject to sectoral investigations (Figs. 6.5, 6.6 and 6.7).

6.3.4　Technology and Innovation Path

In contrast to the other parts of the SSP, technological development is strongly sector specific, e.g. in terms of the breeding progress in the agricultural sector or in terms of cost-reduction of certain renewable energy technologies like photovoltaics. On the other hand, there are relevant aspects like technological progress in material science or in computing and communication technologies which have strong cross-sectoral characteristics. In this frame it is not possible to identify all
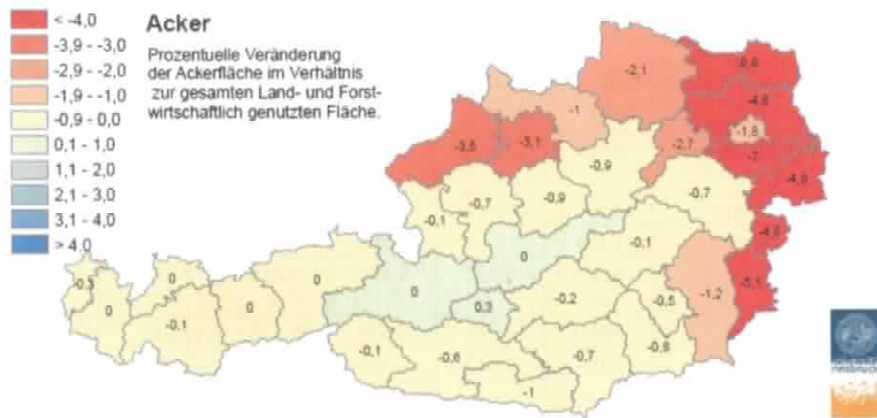
Fig. 6.5 Change of arable land 2011–2020, Rüdisser et al. (2011)
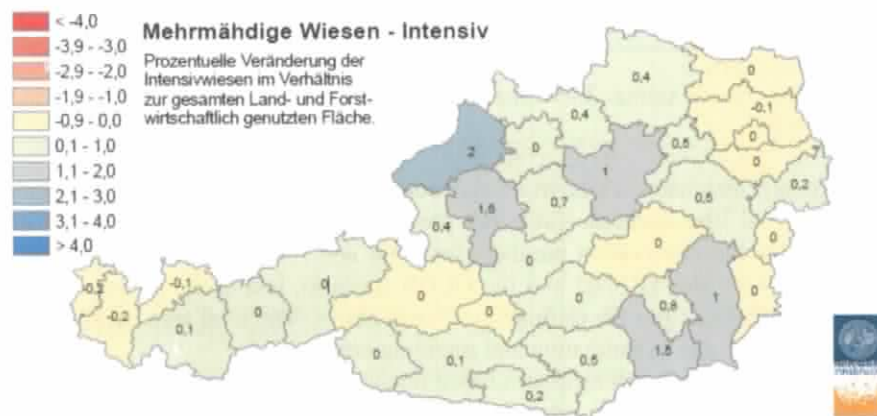

Fig. 6.6 Change of intensive grassland 2011–2020, Rüdisser et al. (2011)

relevant cross-sectoral technologies, to investigate the impacts of these technologies on the different sectors and to develop well based scenarios for the development of these cross-sectoral technologies.

Therefore, we suggest three basic qualitative storylines which are compliant with the definition of the three scenarios:

- Enhancing: Compared to the technological developments of the past years and decades, the technological development significantly decreases. No major progress is achieved and the innovations mainly refer to small improvements of single components.
- Reference: Remarkable, steady progress is achieved for single technologies, however, with no principle major change on the overall structure and efficiency of material use and sector specific technologies. No new technological
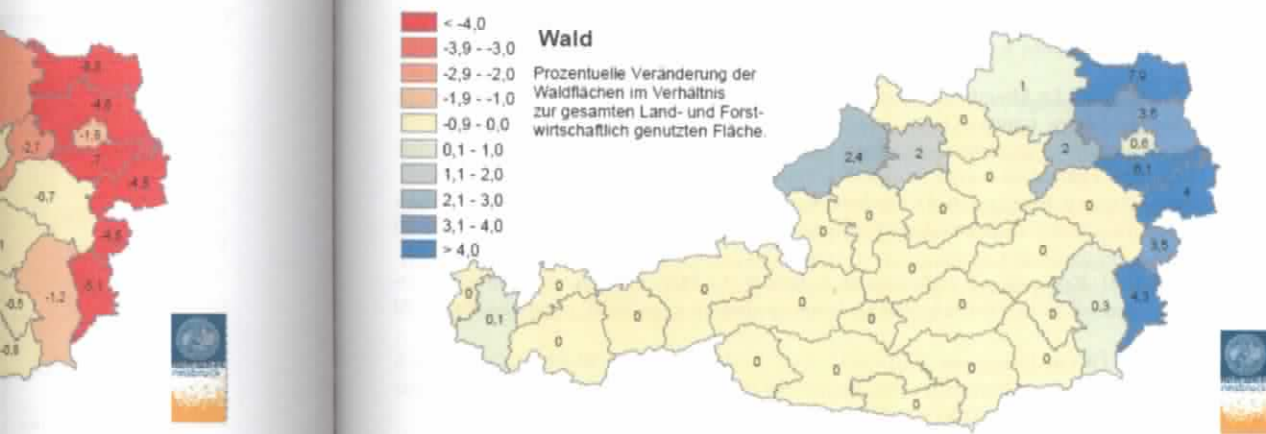
Fig. 6.7 Change of forest area 2011–2020. Rüdisser et al. (2011)

revolutions take place (compared to the technological revolutions in computing, telecommunication or internet which occurred in the last decades). This refers both to cost decrease of innovative technologies and development of new materials, components and technology systems.

– Diminishing: Substantial technological development occurs, in particular in material science (with corresponding impact e.g. on energy storage systems), computing and telecommunication. This technological development has a considerable impact on the sector-specific technologies. However, no "wonders" occur (i.e. nuclear fission still is not applied broadly and of course the physical laws of thermodynamics are still in place). The (even substantial) technological development does not lead to discontinuous jumps in the availability and cost structure of technologies. For pragmatic reasons, even in this storyline we do not consider wild cards (although we know that unexpected technology development may happen).

6.4 Uptake by Sectoral Assumptions

In part III's sectoral assessments and their socio-economic assumptions, various parts of this SSP have been uptaken. Some important ones are:

- Demographic scenario (age structure): uptaken by health chapter
- Demographic scenario (total population): uptaken/aligned by natural disasters and catastrophe management
- Land-use scenario: uptaken by agriculture, forestry, construction and buildings as well as urban green chapters
- Economic growth assumptions and key commodities price assumptions: uptaken by macro-economic, agriculture and energy chapters
- Technology/innovation pathways: uptaken by energy chapter.

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