Three Scenarios for Land-Use Change:

A Case Study in Central Europe

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Acronyms

CAP	Common Agricultural Policy
EAGGF	European Agricultural Guidance and Guarantee Fund
EC	European Community
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FRG	Federal Republic of Germany
GATT	General Agreement on Tariffs and Trade
GDP	gross domestic product
GDR	German Democratic Republic
IIASA	International Institute for Applied Systems Analysis
OECD	Organisation for Economic Co-operation and Development
UAA	utilized agricultural area

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Introduction

Land-use change has been identified as a major driving force for global change. Understanding past and future impacts of changes in land use and land cover is central to the study of environmental change and its human driving forces and impacts. To assess the social, economic, and environmental consequences of land-use change, comprehensive information on future land-use patterns is required.

The study presented in this paper is part of the Regional Material Balance Approaches to Long-Term Environmental Policy Planning Project at the International Institute for Applied Systems Analysis (IIASA). This project aims at studying the flow of four heavy metals (cadmium, zinc, lead, and arsenic) with particular focus on soils. The combination of load, soil characteristics, land use, and land management, including plant types grown and agrochemical applications, determines the fate of stored heavy metals. Heavy metals may further accumulate in the soil or they may be remobilized and enter the food chain via plant uptake or via groundwater. Land use and land management have an impact on the load of heavy metals because certain agrochemical inputs (phosphate fertilizers, sewage sludge, manure) contain heavy metals as impurities. Certain land-management practices also influence the soil characteristics that determine whether heavy metals accumulate or are available in their mobile form.

The project area (*Figure 1*) includes the northern part of the Czech Republic (Bohemia and Moravia), southwestern Poland (Upper and Lower Silesia), and most of former East Germany (Sachsen, Sachsen-Anhalt, Brandenburg, and Thüringen). The project area covers about 180,000 km^2, parts of which are highly industrialized and densely populated. Extensive atmospheric impact of pollutants from coal burning and other industrial activities has resulted in chemical deterioration of soils. Heavy metals have accumulated in the soils over the past few centuries. In spite of this pollution in certain areas, the project area as a whole is important for agricultural production, with half of its land use devoted to agriculture. *Figure 2* presents a map of the main land-use categories in the project area. In 1992, utilized agricultural area (UAA) accounted for 10 million hectares (54% of total land area), with nearly two-thirds of UAA used as arable land and the remainder used

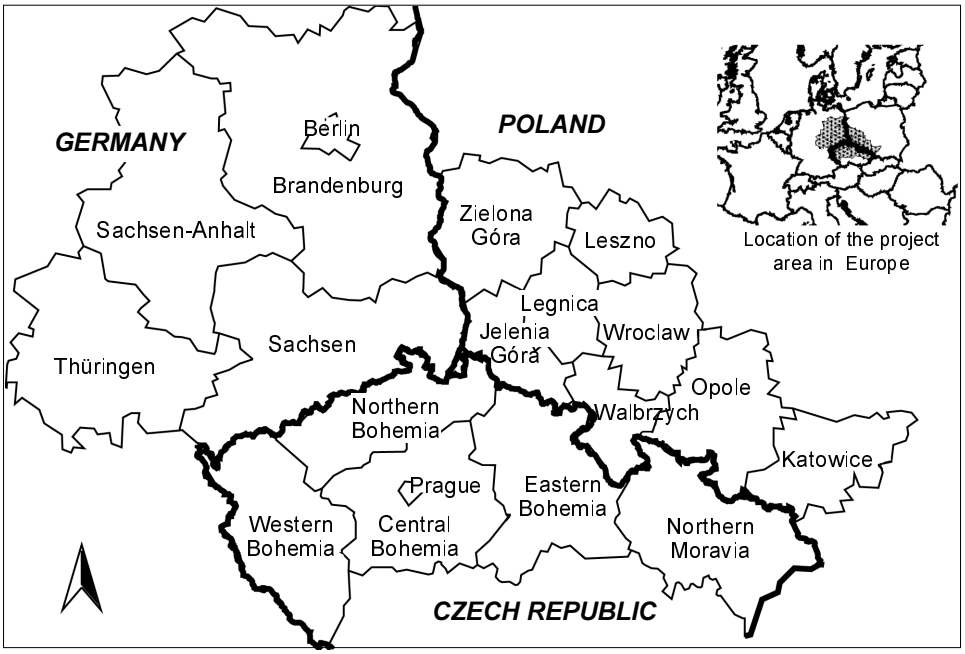

Figure 1. Project area of the IIASA Regional Material Balance Approaches to Long-Term Environmental Planning study.

as grassland or meadows. Six million hectares (32%) are covered by forest and the remaining 2.5 million hectares (14%) fall into the category "other land," which consists mainly of urban and mining land.

Land-use scenarios have been developed to help assess possible effects of accumulated heavy-metal pollution in the region. Because future land use and agriculture are highly uncertain, we have developed three radically different scenarios, all of which are possible but not equally probable. The first scenario (increase in wooded area) anticipates liberalization and abolition of subsidies in the agricultural sector and increases in demand that are too small to enable farmland in marginal areas to remain competitive. Large areas will be taken out of production and turned into forest or used for other nonagricultural purposes. Scenario 2 (alternative agricultural products) assumes a shift from food production to nonfood production, mainly biofuel, and incentives for extensification of agricultural production. The third scenario (Europe as food exporter) foresees increasing demand and rising world market prices for agricultural products, triggered by increasing wealth combined with environmental constraints in China and Southeast Asia.

This paper describes these three scenarios, which were constructed for the period 1995–2050. Section 2 presents the factors that influence land-use development

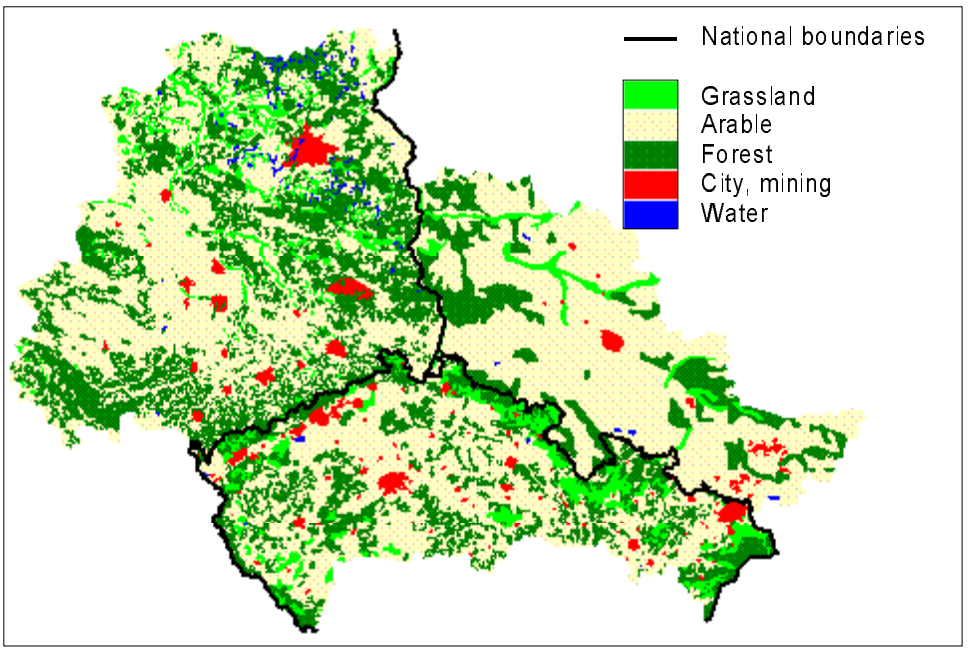

Figure 2. Main land-use categories in the project area.

and describes historical land-use changes in Europe and the countries of the project area. Developments in the agricultural sector, which are considered to be of particular importance for land-use changes in the European context, are discussed in Section 3. The discussion includes recent developments in Poland, the Czech Republic, and Germany, but also trends in the Common Agricultural Policy (CAP) of the European Union (EU) and possible impacts of global agricultural markets on European agriculture. Section 4 presents a general introduction to scenario construction; introduces the goals and key questions for the three scenarios constructed for the project area of this study; and presents, discusses, and compares the three scenarios. Conclusions are presented in Section 5.

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Development of Land Use in Europe and the Study Area – Key Factors and Trends

Transformation of land results from a complex set of interactions. To obtain information on future land use for a particular region, the factors acting as driving forces must be identified and their relative importance evaluated. *Box 1* presents a comprehensive summary of the most important factors that influence land-use change. An analysis of these factors provides basic information for developing scenarios of future land use for a particular region. The importance of a given driving force varies depending on the study region. Among the factors that are especially important in Europe are agriculture, forestry, market developments, environmental conditions, social context (including the history of a region), and policies related to land-use planning. Of these factors, agricultural policy, including forestry, is of particular importance for land-use change in the EU context (e.g., Lee, 1991; Jansen and Hetsen, 1991). Subsidy schemes have greatly influenced both internal markets and international markets where surplus production is sold. In addition, the expansion of urban area and land used for infrastructure will probably become increasingly important, but how urban development will take place depends largely on how land-use policies develop.

Land-Use Change during the Past 30 Years

An analysis of land-use change in Europe over recent decades is an important basis for discussing likely land-use changes in the project area. The general trend during the past three decades in Europe has been a decrease in agricultural land, both arable and grassland, and an increase in forest and "other" areas, mainly urban areas and infrastructure (see *Figures 3* and *4*).

Germany's agricultural area has decreased by 11% over the past 30 years, mainly due to a decrease in permanent pasture. Agricultural area has mostly been converted to land in the "other" land-use category, while afforestation has been

Box 1. Factors influencing land-use change.

1. Former land-use structure and change
2. General economic environment
   - GDP share (agriculture, forestry, industry, other)
   - Share in employment (agriculture, forestry, industry, other)
   - International market developments (esp. in agriculture and forestry)
3. Agriculture and forestry
   - Percentages of GDP and of employment in agriculture/forestry
   - Production structure
   - Size of farms/forests
   - Ownership structure
   - Policies (subsidies, taxes, agricultural pricing policies, special short-term measures, incentives for afforestation, environmental incentives, etc.)
   - Forestry/farmland use (commodity production, recreation, protected areas)
4. Environmental conditions
   - Climate, topography, soil characteristics, water availability
   - Environmental pollution (acidification or other pollution load)
5. Social context
   - Demographic factors (population density, migration, etc.)
   - Markets for agricultural and forestry products (local and international)
   - Traditional land use
   - Attitudes and values (toward the landscape, cultural heritage, and nature conservation)
6. Policies related to land-use planning
   - Development plans
   - Legal frameworks (land-use planning, land-use policy)

marginal. In Poland and Czechoslovakia (as of 1993, the Czech and Slovak Republics) agricultural land has decreased by 7% during the same period.[1] Poland has had a comparatively large increase in forested area (13%), while Czechoslovakia's "other" land use has increased substantially (34%). For comparison, in the EC-9 countries UAA has decreased by 14% (15.4 million hectares), and forest and "other" land use have increased by 17% (5.7 million hectares) and 41% (9.6 million hectares), respectively.

The forested area in Europe has increased by 10% (15 million hectares) since 1961 due to afforestation of surplus fields and drainage of wetlands. For the EC-12, the forested area has grown by 18% (9 million hectares) since 1960 (*Table 1*). This average increase differs substantially from country to country, however. Although

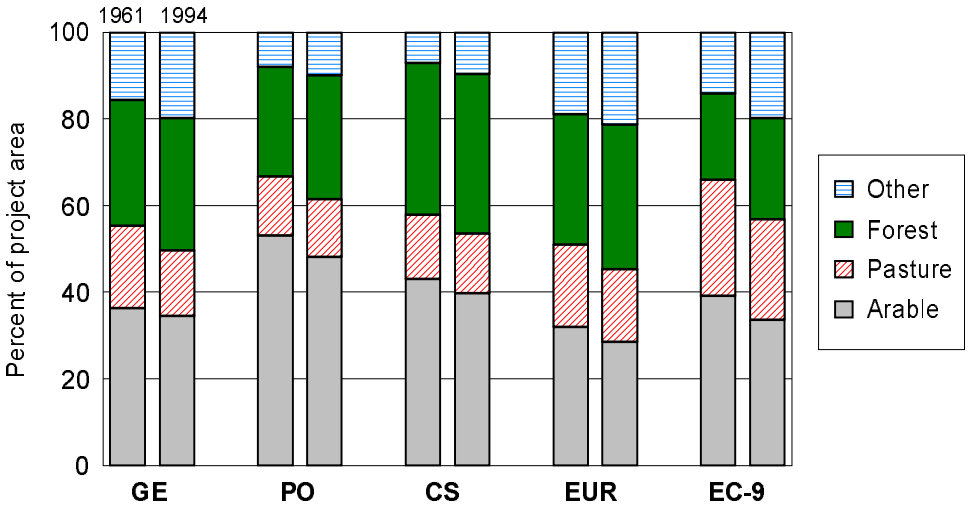

Figure 3. Land use in 1961 and 1994. Abbreviations: GE = Germany; PO = Poland; CS = Czechoslovakia (1961) and the Czech and Slovak Republics (1994); EUR = Europe; EC-9 = European Community (9 countries).

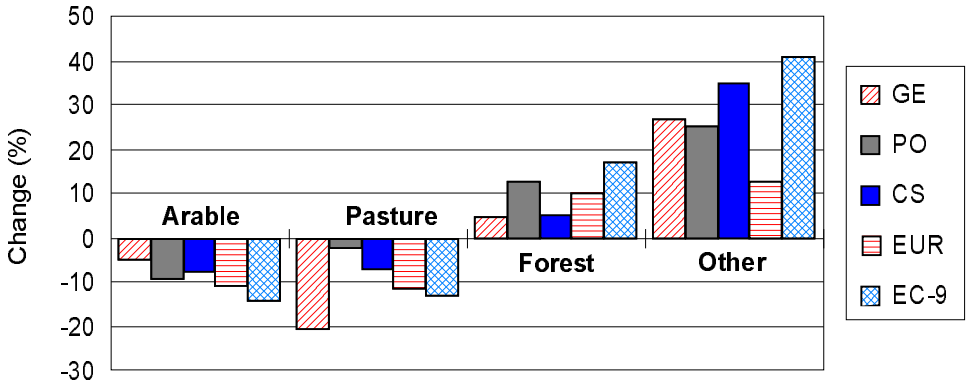

Figure 4. Percentage change of land use between 1961 and 1994. See *Figure 3* for explanation of abbreviations.

Table 1. Forested area in 1961 and 1992 (1,000 ha).

Country/region	1961	1992	% increase, 1961–1992	% of total land area in 1992
Germany	10,210[a]	10,412	2.0	30
GDR	2,955	2,983[b]	0.9	28
Czechoslovakia	4,400	4,618[c]	5.0	28
Poland	7,750	8,772	13.0	37
EC-12	49,313	58,127	18.0	25
Europe	143,000	158,000	10.0	33

[a] FRG and GDR.
[b] Figure given is for 1990.
[c] Czech and Slovak Republics.
Abbreviations: FRG = Federal Republic of Germany; GDR = German Democratic Republic; EC-12 = European Community (12 countries).
Source: *FAO Production Yearbooks* for the years cited.

the total forested area has increased, the area of exploitable forests has remained relatively unchanged since the 1950s. The area of unexploitable forests has increased because some areas have been designated as reserves and because of wood production outside economically accessible areas. This reflects the Europe-wide trend toward increased importance of environmental and recreational benefits of forests. In general, future forest management is likely to place more emphasis on multifunctional management of woods, including commodity, protective, social, and cultural functions.

The area of land in the "other" land-use category has increased by 10% in Europe since the 1950s. For the EC-9 countries the increase has been much higher (41%). This land-use category consists mainly of urban, suburban, or commercial areas, as well as land used for infrastructure purposes or strip-mining. This increase is primarily connected to the decrease in agricultural land. Once agricultural land is taken out of production, the pressure to develop it increases, particularly when the land is close to urban areas. Only a policy that aims at avoiding low-density urban development can halt this trend. Converting farmland to urban area is an irreversible process. Regional development plans often favor high-density urban development to minimize the spread of built-up area. If, as expected, there is strong economic growth in the region, the pressure for urban development will be significant in densely populated urban areas.

3

Agricultural Development in the European Union and the Countries of the Study Area

Trends in the Common Agricultural Policy

After the Second World War, European agricultural policy generally aimed at achieving food self-sufficiency – a goal it has successfully accomplished. Yields per hectare have increased considerably over the past 30 years. Europe now faces overproduction of most of its agricultural products on the one hand, and high support costs for agriculture on the other (Williams, 1994). In 1996, half of the EU's budget was allocated to the European Agricultural Guidance and Guarantee Fund (EAGGF) Guarantee Section and was spent on the CAP. About two-thirds of this expenditure went toward price intervention (EC, 1997). In addition to the growing demand within the EU to cut agricultural spending (in favor of structural funds[2]), the General Agreement on Tariffs and Trade (GATT) required less market intervention in the EU's agricultural sector.

The reform of the CAP, agreed on in 1992, has been the most substantial change in the Policy's history. The reform package was essential to a GATT settlement on agriculture. The price-support mechanism for production has been significantly reduced in favor of direct aid for producers, independent of levels of production. In this context, incentives are provided for afforestation, environmental conservation measures, "set-aside" of agricultural land, land management for public access and leisure activities, and more extensive forms of crop and livestock production. Although EU support for agriculture has undergone many changes – most recently from production-related to area-/animal-related support – the overall goal is to reduce subsidies radically, which is essential to eastward expansion of the EU. In 1996, the EAGGF Guarantee Section budget made up 50% of the general EU budget, down from over 60% in 1988. This reduction was a result of the development

of other common policies and a determination to curb agricultural spending (EC, 1997).

A European Community (EC) report on agricultural policy for the twenty-first century (EC, 1994) recommends further reform of the CAP along the lines of the 1992 reform:

> The fundamental approach is to separate more clearly two aspects of agricultural policy, that of economic efficiency on the one hand, and that of social and environmental measures on the other. ... With the introduction of direct income support a clearer separation of the responsibility for internal market unity and for competition on the one hand, and the responsibility for more localized social and environmental aims of agricultural policy on the other, is possible. Whereas the responsibility for the former should remain at the Community level, the principle of subsidiarity endorsed in the Maastricht Treaty of the European Union suggests that the responsibility for the latter should be allocated to Member States. [EC, 1994, p. xvii]

The report further argues that fulfilling these recommendations would increase the EU's "flexibility toward trading partners and new entrant states" (EC, 1994).

In addition to the CAP reform, which has had a direct effect on agriculture, there are also policies under discussion that may affect agriculture indirectly. Preconditions for agricultural production may change considerably due to changes in other policy areas – for example, through an energy policy that emphasizes energy from biofuel. Agriculture may also be affected by changes in attitudes and values concerning the landscape. Besides being perceived as a source of marketable products, the landscape is becoming increasingly important for functions relating to cultural heritage and visual amenities, and as a source of recreation. Wealthy societies, in particular, seem prepared to pay for these value-laden aspects of the landscape.

Until recently "conventional wisdom" held that large amounts of agricultural land in Europe would be taken out of production over the coming decades (Lee, 1991; Brouwer and Chadwick, 1991; Williams, 1992). Reduced price support for production would mean that large amounts of agricultural land would no longer be profitable and would be taken out of production (as long as no other support schemes intervened). This decrease of agricultural area would not be distributed evenly over the continent but would focus on marginal areas. Marginal land is a relative concept that is related to soil quality and to the land's organization, productivity, and actual production (Jansen and Hetsen, 1991). Because consumption in Europe is unlikely to rise, major decreases in agricultural area would be avoided

only if there were a strong increase in demand for agricultural products on the world market.

Impacts of Global Agricultural Markets

Recent discussions on trends in agricultural world market developments have suggested that Europe's export potential may grow due to significant increases in world demand for agricultural products. The basic feature of these projections is an anticipated strong import demand for agricultural products in the fast-growing economies of Southeast Asia and China. Rising meat consumption due to increasing wealth in these countries will mainly drive the increase in demand for grain.

Because of its large population, developments in China are of particular importance. Despite anticipated yield increases, production is not expected to keep pace with rising feed and food demands (FAPRI, 1997; Rosegrant *et al*., 1997; Brown, 1995; OECD, 1997). Increased demand offers opportunities for major grain exporters. Whether the increases are large enough to pose a threat to world grain supply or food prices is a matter of discussion. Although Brown (1995), for example, expects increases in food prices, many authors and institutions assume less drastic developments:

> China's increased imports pose no threat to world grain supplies or food prices . . . . It does seem likely, however, that China will become a more important player in world grain markets as an importer in the coming decades. Exporting countries, especially those dealing with wheat and maize, will undoubtedly be the beneficiaries of these trends in the short run. [Rosegrant *et al*., 1997]

The extent to which EU countries can benefit from growing import demand in the developing world depends not only on the amount of the demand increase, but also on the EU's potential to compete in market-oriented production with other major grain-exporting countries (the USA, Canada, Australia, and Argentina). In its Agricultural Outlook 1997–2001, the Organisation for Economic Co-operation and Development (OECD) anticipates that the EU will not benefit from growing food markets until 2001:

> Because of the increasingly binding restrictions on the use of export subsidies, the growing markets outside the OECD region are captured almost entirely by producers and traders in countries with market oriented production. Thus, while exports of cereals, dairy products and/or meat by countries in North America and Oceania are expected

> to grow strongly over the medium term, those of the European Union are stable or shrinking. [OECD, 1997]

The FAPRI World Agricultural Outlook for the present until 2005 (FAPRI, 1997) expects an increase in the EU's wheat exports after 2001, when world prices will be high enough to enable the region to export without being constrained by GATT commitments.

World agricultural outlooks are subject to major uncertainties, even for short-term projections. Among these uncertainties are the extent and speed of growing import demand in Asia. Furthermore, the evolution of cereal production in developing countries is difficult to predict. Uncertainty exists concerning the amount of additional land that can be brought into production and the yield increases that are possible. Any changes in these assumptions could have major impacts on medium-term trends. It is currently impossible to foresee the future of the former Soviet Union. Even though the significant production and export potential of some of the countries, such as Kazakstan and Ukraine, is not expected to be realized for some years, these countries may play a more important role in the future.

The aspects of these discussions on agricultural world market developments that are relevant for this study are whether there is future export potential for Europe, how large it will be, and the extent to which the countries of the project area of this study will be able to make use of any eventual export opportunities. The last of these raises the question of how the countries of the project area will compete within Europe.

Recent Developments in the Project Area

The countries of the project area dealt with in this study are among the Central European countries currently undergoing major economic and social transitions. The current economic and political frameworks are very different in each of these countries. The future direction of agricultural policy in all three countries is still very much under discussion. The general trend is toward integrating their policies into EU policy; after approximately 2005 or 2010, agricultural policies in the Czech Republic and Poland may be consistent with EU policies.

With Germany's unification, the EU's CAP was introduced into eastern Germany. Unlike current agricultural policies in Poland and the Czech Republic, the CAP is still considerably regulated by subsidies, quotas, and special programs providing income for farmers. The most important of the special programs is the set-aside program, which subsidizes farmers for not cultivating their land. Participation in the set-aside program is high in eastern Germany, where in 1994 an average of 14% of the agricultural land was set aside.

Table 2. Trade of agricultural and food products between the Czech Republic and Poland and the EU in 1994 and 1995 (million ECU).

	Czech Republic		Poland	
	1994	1995	1994	1995
Exports to EU	435	635	1,106	1,249
Imports from EU	614	867	1,168	1,354
Balance	–179	–232	–62	–105

Source: EC, 1997.

Since the implementation of a market economy in Poland and the Czech Republic, most subsidies have been removed and farmers in these countries have experienced severe economic pressure with only small compensation payments. After a strong decrease, production increased again in 1995. That year, in both countries on average 20% of a farm's gross income stemmed from subsidies, which was still low compared with the EU standard of nearly 50% (Lukas, 1995).

In all three countries the importance of agriculture in terms of gross domestic product (GDP) and employment contribution has decreased. Despite a decrease since 1989, the share of agriculture as a percentage of GDP is still high compared with West European countries. In 1995, the agricultural share of GDP amounted to 6% in Poland, 5% in the Czech Republic, and 10% in eastern Germany, compared with 1% for Germany as a whole, for example.

In eastern Germany, the number of people employed in the agricultural sector has shrunk dramatically, from 825,000 in 1989 to 150,000 in 1996 (full- and part-time agricultural employment; Harenberg, 1997). In the Czech Republic, the share of employment in the agricultural sector decreased from 12% in 1988 to 6% in 1996; in Poland it decreased from 30% in 1988 to 25% in 1996 (WIIW, 1997). Whereas the Czech Republic's share of employment in the agricultural sector is comparable to that of West European countries, Poland still has a very high rate of employment in this sector. By combining employment and GDP, it becomes obvious that Poland's labor productivity in the agricultural sector is very low.

The rapid liberalization of foreign trade revealed the low competitiveness of the countries undergoing transition. The Czech Republic and Poland's negative trade balance with the EU is increasing. *Table 2* shows the trade balance of agricultural and food products for Poland and the Czech Republic. In 1995, imports from the EU exceeded exports to the EU by 105 million ECU in Poland (compared with 62 million ECU in 1994) and by 232 million ECU in the Czech Republic (compared with 179 million ECU in 1994).

A major difference between the three countries is the structure of ownership. Under the communist system in Czechoslovakia and the German Democratic

Republic (GDR), over 90% of the land was managed by cooperatives and state farms; in contrast, in Poland 76% of the land was privately owned. This is correlated with the size of farms. In the GDR and Czechoslovakia, average farm sizes were large compared with those in Western Europe, amounting to 4,500 hectares and 8,000 hectares, respectively; the average private farm in Poland is less than 6 hectares. Whereas in eastern Germany and the Czech Republic, privatization is ongoing and farm sizes are being reduced, to be competitive Poland requires structural adjustments toward larger farming units.

In summary, the following key questions concern the agricultural sector:

- What is the future export potential for Europe?
- How much will agricultural land be reduced?
- To what alternative use will today's agricultural land (currently used for food production) be converted?
- What function will a landscape fulfill if it is no longer used for food production?
- How acceptable is a conversion of farmland to forest, urban, and built-up area?
- Will other land uses compete with agricultural production (especially increasing timber demand)?

These questions have played an important role in the construction of the scenarios.

4
Scenarios

Scenarios are indispensable tools for environmental projects that focus on large-scale, long-term interactions between economic development and environment (Clark and Munn, 1986; Toth *et al*., 1989). Scenarios have two particularly advantageous qualities: first, they provide a coherent framework for analysis of how various issues or sectoral developments impinge on one another and interact; second, they serve as a tool to foster creativity, stimulate discussion, and focus attention on specific points of interest. Both of these qualities are important in long-term studies and assessments. Scenarios are necessary for combining various sectoral fields and models, and for opening up a constructive analysis of future problems (see, e.g., Wack, 1985a, 1995b; Hesterberg *et al.*, 1992). In the case of long-term effects of accumulated toxic pollution, the principal focus of the Regional Material Balance Approaches to Long-Term Environmental Policy Planning Project, there is definitely a need for a broad and imaginative analysis of the risks of past, present, and future practices. Scientific knowledge must be integrated to look more closely into what types of development are risky and how they can be avoided. A scenario approach can be very valuable both for stimulating analysis and sorting out urgent research areas, and as a means of communication between scientists and policymakers.

Various Types of Scenarios

The scenario concept came into research via military and strategic gaming, but originates from theater (Becker, 1983). In futures studies, a scenario is a hypothetical sequence constructed for focusing on causal processes and decision points (Kahn and Wiener, 1967). It should be strongly emphasized that scenarios are hypothetical: they make an effort to introduce analysis of different "what if?" developments and should therefore be distinguished from forecasts. Moreover, scenarios may be quite different in various studies: they can focus on the development or a future state of the world, and they can be anything from a simple curve to a very detailed description of a future development or state (Anderberg, 1989). In futures

studies, two basic types of scenario approaches are used, namely, exploratory and anticipatory scenarios (France:Datar, 1975; Hall, 1977). In exploratory scenarios, one starts in the present and tries to project various trends into the future. In anticipatory scenarios, one starts by painting a picture of a future situation and then asks, How do we get there? or, How do we avoid getting there? This category is most often either normative (i.e., How do we reach a desirable future?) or contrasted (e.g., a solar or a uranium future society). Crisis scenarios, which are common in war gaming, can also be included in this category. Another differentiation can be made between methodological and informal scenario writing (Asplund, 1979). In the methodological approach, a certain method or model is used to ensure that it does not matter who constructs the scenario, as the input assumptions should lead to the same output. The informal scenario writing procedure differs from situation to situation and from author to author; however, this does not mean that an informal scenario is unstructured or lacks logical consistency. At larger scales, two methods are predominantly used to create different scenarios: (1) altering trends in key factors like population, energy use, or gross national product; and (2) altering developmental constructs, that is, changing assumptions about world dynamics such as trade, transport or labor dynamics, peace versus conflicts, etc. (Makridakis and Wheelwright, 1978).

Demands on a Scenario

A great diversity of methods can be used to construct scenarios, and many studies use a combination of approaches. Nonetheless, there are several demands that can be placed on a "good" scenario (Anderberg, 1989):

- The scenario must provide adequate information and explanations of the central assumptions on which it is built. Questionable, weak, or controversial points must be brought to light, not hidden.
- There must be a logical contiguity of events during the progression of the scenario through time and some consideration of historical experience. These considerations are important for making the scenarios as intelligible and acceptable as possible.
- There must be sufficient detail to allow for tolerable "performance" of the scenario. The detail requirement and the focus must, of course, be adjusted according to the purpose of the scenario project.
- The scenario must be easy to understand and follow. Concreteness should be encouraged to ensure that the scenario can be analyzed in practical terms.

In all these points, adaptation to the specific goals of a scenario project is implicit: a good scenario is one that fills its defined function (see, e.g., Brown, 1968; Wack, 1985a, 1985b). Furthermore, a range of scenarios should be considered and discussed. At the same time, it is important to reach a consensus among participants and users on the acceptability of the presented scenarios. Otherwise, the analysis could be dismissed as meaningless.

It should be remembered that scenario construction and analysis are mainly practical processes that depend on creative participation and inputs from different individuals as well as their knowledge and perspectives. This cannot be fully described and no attempt is made here to formalize a rigid methodology. Nonetheless, some basic guidelines can be put forward to facilitate the use of scenario approaches and make scenario studies and scenario presentations as useful and interesting as possible. Scenario analysis and construction should be viewed as means to inspire and focus creative thinking and to analyze possible problems and risks in an uncertain future. The value of scenarios is that they work as catalysts for such processes.

Land-Use Scenarios Constructed for the Project

Important factors influencing future land use and land cover may change considerably in the near future. This is particularly true for the agricultural sector in both the EU and the countries of Central Europe undergoing social and economic transition, but it is also true for agricultural world market developments. Discussing future land use and land cover by means of scenarios permits the incorporation of several paths of future development in those sectors relevant to land-use change. The time frame covered is from 1992–2050, with an intermediate step in 2020. Although the main goal has been to develop plausible scenarios for the project area of this study, to some extent the scenarios are relevant for all of Europe. Each scenario will be described qualitatively and quantitatively. Quantitative descriptions apply specifically to the project area.

The first questions to be asked in a scenario study are, What are the goals? and, What problems are to be focused on? Based on the answers given, interesting cases of development should be discussed and analyzed. When constructing land-use scenarios in this project, the goals were that the scenarios should

- be representative of a range of possible future developments, including some surprising, yet plausible, developments;
- be easy for outsiders and nonspecialists to understand and follow;
- provide enough explanation and arguments for “tolerable performance”;

- provide an appropriate framework for more detailed studies on long-term effects of pollution at various scales and make connections to the institutional framework, thus enabling analysis and discussion of policies in response to the scenarios.

The three scenarios presented here are primarily intended as framework scenarios for specialized studies focusing on different effects; the scenarios also provide a linkage to the agricultural and land-use-planning policy areas. The scenarios are *exploratory* and follow different trends based on diverging assumptions about policy development in Europe and in the individual countries. Scenarios 1 and 2 do not foresee any major changes in the basic structures of the food sector in Europe; Scenario 3 introduces radical changes in international food trade and the orientation of agriculture in Europe. The scenarios presented are *informal*, but are based on past development of land use. The experiences over the past 30–40 years in Western Europe clearly suggest that, even with radical restructuring of agriculture and urban and economic development, land-use changes occur slowly.

The scenarios focus on the development of basic land-use patterns and agricultural management in the study region. The quantitative presentation of the scenarios focuses on the state of basic indicators in the region and the geographical distribution of land use at three points in time: 1992, 2020, and 2050. To explain the changes in land use and in agriculture, forestry, and the energy sector – all of which influence land use and land management – certain developments are needed, both in the region and at a higher level (EU agricultural policy, international trade).

This study assumes that Poland and the Czech Republic will have full membership in, or at least associate status (including full market integration) with, the EU by approximately 2010. Within the EU the most uncertain factor is developments in the CAP. However, because scenarios are not intended to foresee future developments, but rather to serve as a framework for assessing possible future paths, the goal here is to present a range of the most likely developments. Therefore, the observed decrease in agricultural land during the past few decades (see Section 2) is expected to remain the main direction of land-use change in Europe (*Figure 5*). The extent of the decrease, however, will differ in the three scenarios.

A common feature of all three scenarios is a trend toward a more integrated world economy in the agricultural sector. With a few possible exceptions, most of the countries open their agricultural markets.

With continued overproduction (in relation to markets) in the EU and assuming only small changes on the demand side and no other support for agricultural production, farmland will decrease considerably. Until the Central European countries enter the EU, market forces and competition – particularly with EU countries – will drive farmland decrease. The first two scenarios describe two different paths for

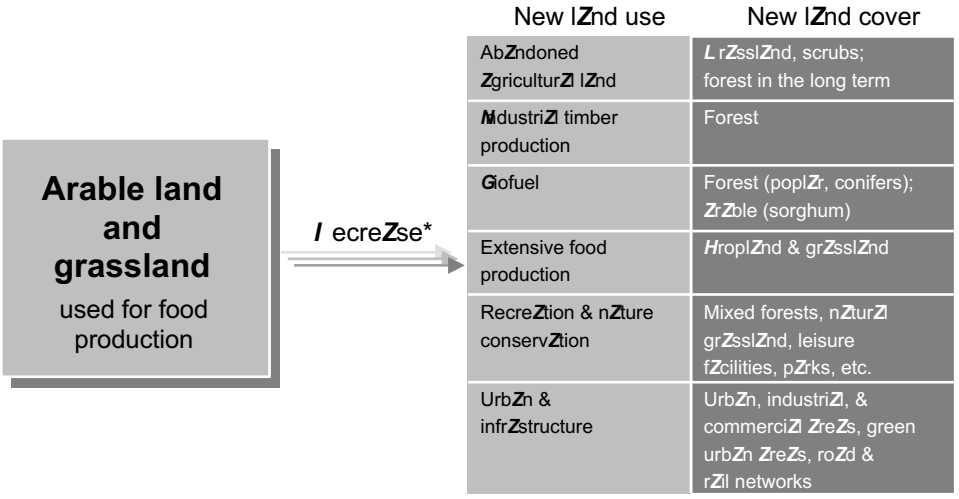

Figure 5. Likely direction of land-use and land-cover changes in Europe.
*The extent of the decrease is different for each of the three scenarios constructed in this paper.

dealing with surplus agricultural land and development of rural areas in general. In contrast, the third scenario assumes an increase in demand for agricultural products on the world market that will enable Europe to export without further subsidizing its agricultural sector.

In summary, Scenario 1 is inspired by the need to reduce public spending on agriculture because of overproduction; Scenario 2, by recent initiatives to extensify agriculture and support environmental measures; and Scenario 3, by recent discussions on possible dramatic changes in the agricultural world market.

Scenario 1: Increase in Wooded Area

The basic feature of Scenario 1 is a major withdrawal of subsidies for the agricultural sector. In this scenario, increases on the demand side are not large enough to enable farmland in marginal areas to remain competitive and there is no policy interest to preserve agricultural land or keep the land open. The result is a decrease in the price of agricultural land in marginal areas and subsequent abandonment of farmland. Individual farmers now have two possibilities. From an economic point of view, the most lucrative solution is to sell farmland for conversion to urban land. This is an opportunity for farmers in densely populated areas. Where relatively inexpensive agricultural land is available, urban development will be more and more extensive and will include recreational areas consisting of landscape parks, small

forests, nature conservation areas, etc. (This is similar to the development in large parts of the northeastern USA). Consequently, Scenario 1 assumes a significant increase in land in the "other" land-use category. In more remote areas where there is no need for urban development, the farmers' final response to an unprofitable farm will be to afforest their land. (This has long been a relatively common and profitable practice for farmers leaving agriculture in forested areas in Scandinavia.) The afforestation is viewed as desirable by the authorities from both a recreational and an economic point of view. In the context of the EU it is considered unlikely that large amounts of agricultural land will lay fallow. To alleviate the economic strain, subsidies are available to afforest farmland.

One incentive for afforestation is an increase in demand for industrial roundwood in the near future. Nilsson *et al.* (1992) analyzed supply-and-demand balances for industrial roundwood in Europe assuming three different scenarios (a no-decline scenario, an air-pollution-induced forest decline scenario, and a forestland expansion scenario). All scenarios foresee a roundwood deficit by 2010, with the EEC-9 being the region with the most serious potential deficits, largely because roundwood demand is expected to grow strongly there. Poland and the Czech Republic have a long-established tradition of forest management and an important wood and pulp and paper industry. Therefore, the conversion of farmland to forest is strongly encouraged, primarily for securing raw materials for the long-term needs of an expanding forest industry. However, with increasing wealth in the region, the protective, social, and cultural functions of forests gradually become more important. The socioeconomic consequences of this scenario include a further decrease of employment in the agricultural sector. The gap in wealth between rural and urban areas widens.

In terms of land cover, this scenario means a conversion of agricultural land (arable land and grassland) to forest, either by active afforestation or by natural succession to the climax forest. The type of forest grown (deciduous, coniferous, or mixed) will depend on the type of management chosen. Land-cover conversions will have significant environmental consequences. Changes may occur in local climate, plant and animal species, hydrological conditions, and soil properties (including dependent functions like accumulation or release of nutrients and pollutants). The direction of change (of soil properties in particular) depends to a large extent on the type of forest grown and management practices.

Scenario 1 foresees a 35% decrease in farmland by 2050 compared with the present (*Table 3* and *Figure 6*). Forest area and "other" land use increase by 33% and 61%, respectively, compared with their areas in 1992. Consequently, the overall land-cover pattern in 2050 is quite different from that in 1992. Whereas in 1992 more than half of the land was used for agriculture (54%), by 2050 forest is the most important land use (42%) and 22% of the total area accounts for "other" land

Table 3. Scenario 1 (increase in wooded area): Development of land use in the project area (1,000 ha).

Land-use category	1992	2020	2050	Change, 1992–2020	Change, 1992–2050
Agriculture	1,0073	7,555	6,547	–2,518 (–25%)	–3,526 (–35%)
Forest	5,924	7,405	7,879	1,481 (25%)	1,955 (33%)
Other	2,587	3,624	4,157	1,037 (40%)	1,570 (61%)

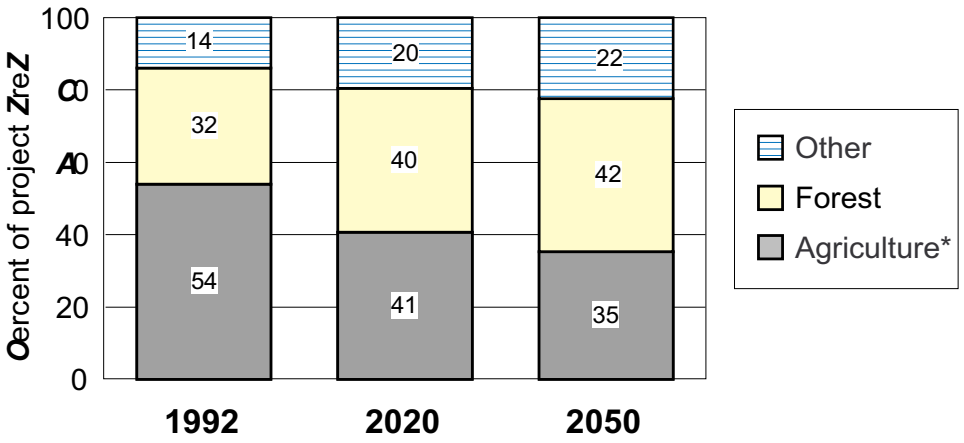

Figure 6. Scenario 1 (increase in wooded area).
*Food production only.

use. Large parts of the forest (or, better, "wooded area") are multifunctional, serving recreational or nature-conservation purposes in addition to timber production. Part of the increase in wooded area may also be due to abandonment of agricultural land.

As discussed above, the conversion of agricultural land to forest will not be distributed evenly over the project area, but will be concentrated on marginal agricultural land, such as farmland with poor soils or disadvantageous topography. Furthermore, those areas that already have a high share of forest land are more likely to increase their forested area than those with a low share of forest land, simply because forestry-related know-how is more likely to be available in an area with an established forest sector.

Scenario 2: Alternative Agricultural Products

This scenario introduces two possibilities for using "surplus" agricultural land. First, farmers are viewed as countryside managers responsible for conserving the rural landscape and are compensated for fulfilling this task. Second, a shift to non-food agricultural products, namely, biofuel and plants for the chemical industry, is encouraged. Unlike in Scenario 1, farmers in Scenario 2 receive subsidies.

Scenario 2 also introduces a more liberal economy into the most productive parts of the agricultural sector. However, major political goals are to keep the land open, to avoid uncontrolled spread of urban development, and to prevent undue dependence on imports of agricultural products from outside Europe. To reach these goals, means are provided for farmers to shift their production and sources of income. This means subsidies for the agricultural sector, particularly during the initial phase. However, the subsidies stem mainly from regional development and environmental funds and only partly from agricultural funds. On the one hand, these programs emphasize biological and more extensive forms of food production, tourist and recreational activities, and preservation of landscapes for their nature-conservation or aesthetic and cultural value. On the other hand, in accordance with the assumed changes in energy policy, the introduction of biofuel and the use of crops by the chemical industry are encouraged. Afforestation of surplus agricultural land takes place, but to a much smaller extent than in Scenario 1.

In Scenario 2 there is minimal conversion of land cover in the region but a major change in land management. *Table 4* and *Figure 7* summarize the results for Scenario 2, suggesting a 15% decrease of agricultural land by 2020 and a 25% decrease by 2050. Three-fifths of the agricultural area is afforested, the remaining area is categorized under "other" land use. Consequently, by 2050 forest and "other" land use make up a greater share of the total land area than in 1992. Agriculture takes up 41% of the total land area, compared with 54% in 1992.

Even though the decrease of total agricultural area is moderate, there is a major change in agricultural products. By 2050, in addition to food production, alternative products (mainly biofuel, but also plants for the chemical industry) have been introduced. Regulations on fertilizer use are strict for ecological reasons; food production is rather extensive. A majority of the farmland is integrated into some kind of designated landscape area or nature reserves. Farmers often rely on additional income from tourist activities. The purpose of agricultural production is not only to produce food or alternative products, but also to preserve the cultural heritage of the landscape and to provide means for development in rural areas. Though subsidies are available for the agricultural sector, efforts are made to minimize them. The subsidies focus on energy policies that promote the economic competitiveness

Table 4. Scenario 2 (alternative agricultural products): Development of land use in the project area (1,000 ha).

Land-use category	1992	2020	2050	Change, 1992–2020	Change, 1992–2050
Agriculture	10,073	8,562	7,555	–1,511 (–15%)	–2,518 (–25%)
Forest	5,924	6,892	7,405	968 (16%)	1,481 (25%)
Other	2,587	3,130	3,624	543 (21%)	1,037 (40%)

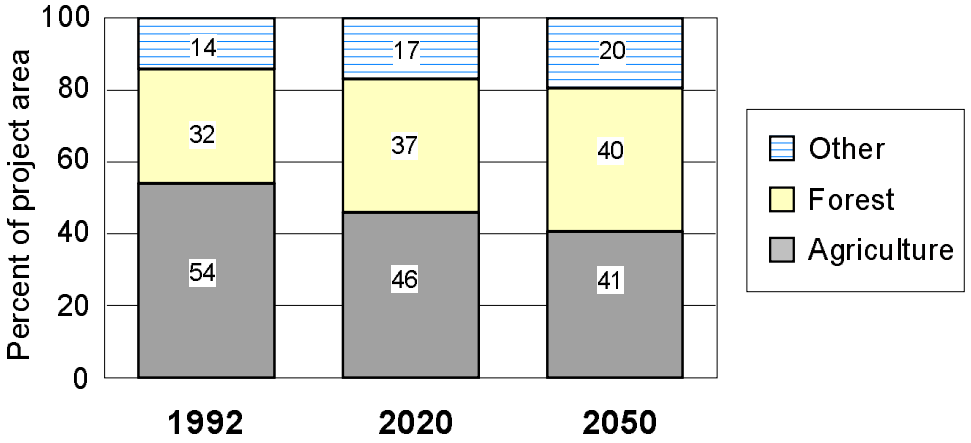

Figure 7. Scenario 2 (alternative agricultural products).

of biofuel on the one hand, and improve marketing strategies for individual farmers to ensure a market for high-quality products on the other.

Scenario 3: Europe as Food Exporter

Discussions on agricultural policy are currently conducted in the context of agricultural surpluses on the world market that result from significant financial support of domestic agricultural sectors by their national economies. International and national efforts aim at withdrawing these subsidies. As outlined in Scenario 1, ending agricultural subsidies without any compensation results in irreversible land-use and land-cover changes. This is particularly true for urban development, but to a large extent for afforestation as well.

However, agricultural policy must be discussed in quite a different light if there is a justified assumption that demand for agricultural food products will increase significantly in the near- or mid-term future. This will be the case if wealth and import demands rise significantly in large, densely populated countries or regions in Asia. Such a development may trigger a dramatic increase in world food prices.

In the past few years several studies have focused on China's long-term food prospects. Brown (1995) argues that China's dependence on food imports will increase starting in approximately 2010 or 2020:

> Countries that become densely populated before they industrialize inevitably suffer a heavy loss of cropland. If industrialization is rapid, the loss of cropland quickly overrides the rise in land productivity, leading to a decline in grain production. The same industrialization that shrinks the cropland area also raises income, and with it the consumption of livestock products and the demand for grain. [Brown, 1995, p. 12]

In China the production of grain was static from 1990–1994. During that period, production of wheat and corn increased slightly, but production of rice – which is concentrated in the south, where industrialization is most rapid – dropped by more than 8% between 1990 and 1994. If industrialization spreads to the central and northern provinces, as government policy is promoting, then production of corn and wheat may soon follow the same downward trend as rice.

Brown (1995) also argues that China might develop along the lines of Japan, South Korea, and Taiwan, all of which shifted from self-sufficiency to importing food as they underwent industrialization. Since 1985, imports have accounted for roughly 72% of consumption. For example, Japan's harvest area for grain peaked in 1955 at 5.1 million hectares. By 1994, it had shrunk to 2.4 million hectares, a decline of just over 50%. From 1950–1960, grain production rose more or less in line with consumption, then began its gradual long-term drift downward. Consumption, on the other hand, continued its rapid rise until the mid-1980s, generating an ever-widening gap between demand and supply.

It is obvious that a similar development in China, with a population projected to reach 1.5 billion in the next century, will have an effect on world production and prices of agricultural products. In 1994–1995 China's record grain imports made it the number two grain importer after Japan. Projected total imports of wheat, barley, rye, and rice in 1995–1996 will approach record levels. Domestic production in China is now estimated to supply just under 90% of its internal utilization (USDA, 1995).

In addition to China, other food-importing countries will increase their demand over the next decade, mainly as a result of population increases. Even if their grain imports are much lower than those of a wealthy country like Japan, they will be competing for a share of the overall grain supply on the world market. On the supplier side, currently only North America, Western Europe, and Australia and New Zealand are net exporters of grain (*Table 5*). In addition, demand for land

Table 5. Pattern of world grain trade, 1970–1990 (million tons).[a]

Region	1970	1980	1990
North America	+56	+130	+110
Western Europe	−22	−9	+27
Eastern Europe and Soviet Union	−2	−44	−35
Latin America	+4	−15	−10
Africa	−4	−17	−25
Asia	−37	−63	−81
Australia and New Zealand	+8	+19	+14

[a] A plus sign indicates net exports; a minus sign indicates net imports.
Source: Brown, 1995.

for production of other products like cotton, vegetable oil, and sugar intensifies competition.

These considerations suggest that the world grain market will soon change from a buyer's to a seller's market. Since the middle of this century, exporting countries seem to be competing for markets that are never large enough. Now it appears that we are nearing a turning point where scarcity of food products will replace current overproduction.

Folmer *et al.* (1995) discuss likely developments of the EU's CAP. One scenario assumes rapidly increasing global demand for food. In general, their arguments are similar to those of Brown, referring to a general population increase; a population increase combined with an increase in wealth in Southeast Asia; water scarcity, erosion, and other forms of land degradation; urbanization and industrialization competing with agriculture for land and water; and a lack of new yield-increasing technologies. Gardner (1996) also demands the preservation of agricultural resources in light of likely food scarcity in the near future. His main arguments for this preservation of resources are a general increase in demand for food products, an ongoing decrease of farmland per capita, and possible water shortages.

The OECD also discusses developments in the growing economies of Southeast Asia, especially China, and possible implications for agricultural commodity markets and world food security (OECD, 1995, 1996). The OECD's forecasts suggest good prospects for market-driven growth in world commodity markets over the medium term, with prices generally higher but possibly more volatile than in the past. Much of the projected strength in world commodity prices is due to rapid economic growth in non-OECD countries and growing imports, particularly in Asia. In the medium to longer term, China may require higher feed grain imports to sustain growth in the livestock sector. However, the OECD also forecasts lower import levels than those projected by some analysts.

The timing of the envisaged shift from current overproduction and low price levels to much higher prices for food commodities is very important. A study by the Food and Agriculture Organization of the United Nations (FAO, 1995) does not foresee these developments by 2010, although it agrees with many of the developments that are the basis for Scenario 3. For instance, it foresees a decrease of farmland per capita and a related high dependence of production increases on the growth of yields. It also foresees strong growth in the livestock sector and wealth and population increases in China. However, the FAO's general conclusion is that there will be no food shortage by 2010.

The relevance of such developments for Europe's agricultural sector is obvious. The liberalization of the agricultural sector envisioned by the CAP would occur without the loss of significant amounts of farmland and jobs. However, overproduction remains, as does the need to subsidize agriculture to keep it alive in the near- to mid-term future.

Scenario 3 assumes that by approximately 2010 a scarcity of agricultural products will stimulate intensive agricultural production in Europe. It also assumes that decision makers today are aware of this possibility. Consequently, unlike in Scenario 1, the aim is not a rapid withdrawal of support for the agricultural sector, but rather the preservation of the potential for agricultural production in Europe. For this purpose, a strategy similar to that in Scenario 2 is chosen; that is, alternative agricultural products are encouraged. A significant reduction of farmland like in Scenario 1 is not perceived as desirable in the framework of Scenario 3.

The basic feature of Scenario 3 is a considerable increase in demand for agricultural products by approximately 2010 that triggers an increase in world market prices, especially for grain. Until about 2010 the developments in Scenario 3 are similar to those in Scenario 2. The main goal is again to keep the land open and to avoid dramatic losses in employment in the agricultural sector to preserve the know-how for agricultural production. As in Scenario 2, until 2010 subsidies and political regulations are provided to shift agricultural production to alternative products (including biofuel, plants for the chemical industry, and high-quality food) and landscapes are preserved for their cultural and nature-conservation value. After 2010 the paths of development in Scenarios 2 and 3 diverge. The growing demand for agricultural food products smoothes the transition from subsidized farming to a free-market economy. All alternative agricultural products that still require subsidies are replaced with intensive food production. The full food production potential of the existing farmland is used.

Table 6 and *Figure 8* show how the assumptions of Scenario 3 translate into land-use changes. Overall, changes in land use are small. Farmland declines by 15% until 2050, forest area increases by 19%, and "other" land use increases

Table 6. Scenario 3 (Europe as food exporter): Development of land use in the project area (1,000 ha).

Land-use category	1992	2020	2050	Change, 1992–2020	Change, 1992–2050
Agriculture	10,073	9,065	8,562	–1,007 (–10%)	–1,511 (–15%)
Forest	5,924	6,674	7,047	750 (13%)	1,123 (19%)
Other	2,587	2,845	2,975	257 (10%)	388 (15%)

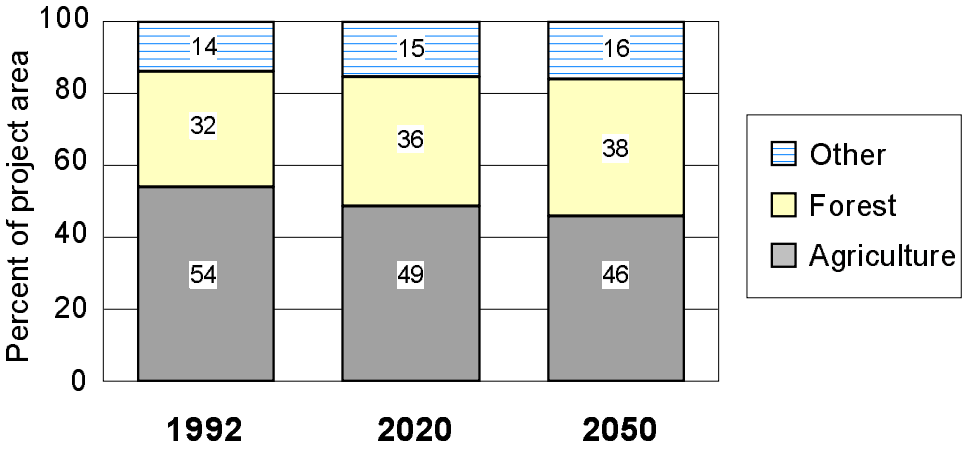

Figure 8. Scenario 3 (Europe as food exporter).

by 15%. There is a shift in agricultural production, however. In 1992 all farmland is used for food production. By 2020 approximately one-third of agricultural land is used for cultivating biofuel and other alternative agricultural products; another third is devoted to extensive agriculture; and the remaining third, to intensive agriculture. Some subsidies are still available for the agricultural sector. In 2050 the pattern changes again. World market prices for agricultural products are high enough to encourage production on all available farmland. As a result, most farmland is used for intensive food production within the frame of environmental regulations.

Comparison of the Three Scenarios

Figure 9 summarizes the changes in land use for the three scenarios. All scenarios assume a continuation of the trend toward a more liberal market in the food production sector. Whether this liberalization will result in declines in production and/or farmland depends on two main factors: future demand, mainly from outside Europe, and the type and extent of resources allocated to the agricultural sector. As

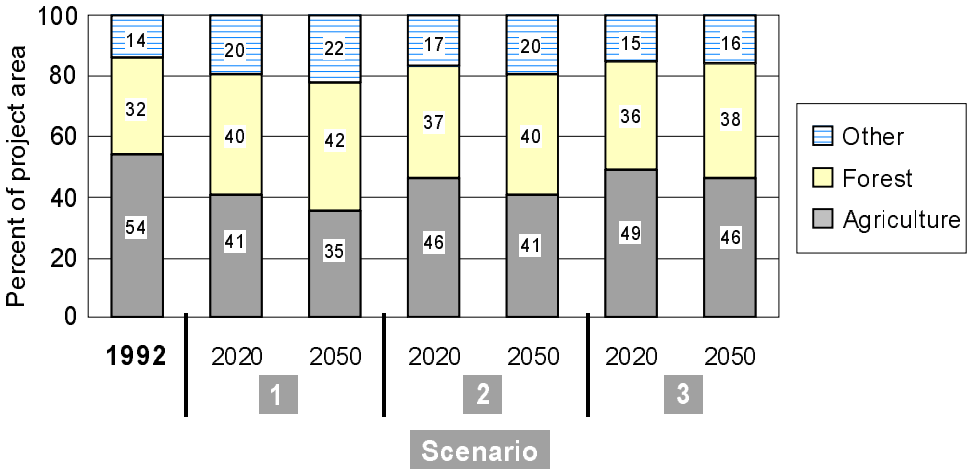

Figure 9. Comparison of the three scenarios. Scenario 1 = Increase in wooded area; Scenario 2 = Alternative agricultural products; Scenario 3 = Europe as food exporter.

in the past, these issues will determine the prospects for rural areas in economic and social terms. The three scenarios presented in this study explore the effects on land use of different assumptions for these issues.

Scenario 1 assumes declining state support for the agricultural sector and only small increases in future demand for food products. Consequently, the decrease in UAA is greatest in this scenario, amounting to 35%. Whereas in Scenario 1 the focus of agriculture is on food production, in Scenarios 2 and 3 the anticipated policy framework aims at rural development in general. Support for farmers is available for maintaining the landscape; fostering more extensive, ecological production; and introducing alternative agricultural products, such as biofuel or plants for the chemical industry.

The difference between Scenarios 2 and 3 is a change in the world market for agricultural food products by about 2010. Whereas Scenario 2 is in line with Scenario 1, Scenario 3 assumes an increase in the world market price of grain and other food products triggered by wealth and population increases in the developing world (in particular Southeast Asia and China). This increase is assumed to be large enough for Europe to emerge as a food exporter without state subsidies, producing on an area of farmland that is only slightly smaller than the current area of farmland. Until 2050, the decrease of farmland is 25% in Scenario 2 and 15% in Scenario 3. Unlike Scenario 2, by 2050 no further subsidies are required for the agricultural sector in Scenario 3.

Afforestation of marginal farmland occurs in all three scenarios. The extent differs, however. In Scenario 1 the share of forest in the total area increases from 32% in 1992 to 42% in 2050, an increase of 33%. In Scenarios 2 and 3 the increase amounts to only 25% and 19%, respectively. The principal reason for these different developments is the general economic situation of agriculture. Scenario 2 foresees means to preserve farmland. In Scenario 3, the agricultural market increases the value of farmland. In contrast, Scenario 1 assumes no protection for farmland and no important increases in demand for food commodities, but growing demand for timber products as well as other uses of forests.

Besides afforestation, agricultural land is also converted to "other" land use, mainly consisting of urban areas and infrastructure. The increase of "other" land is highest (61%) in Scenario 1 because of a lack of demand for farmland. Scenario 2 shows a 40% increase and Scenario 3 shows a very small increase of only 15%. For comparison, the increase in "other" land use in the EC-9 countries between 1961 and 1994 was 40% (see *Figure 4*).

5
Conclusions

The forces driving future land use in Europe include highly uncertain factors such as agricultural policy and international agricultural markets. The slow pace of land-use and especially land-cover changes necessitates long-term scenarios, which further increases uncertainties. Most economic projections, for example, are only considered reliable for periods of up to five years. Because of these uncertainties, however, discussions on future land use and its social, economic, and environmental consequences require scenarios. The three scenarios presented here describe contrasting paths of possible developments. The probability of each scenario is a matter of discussion and depends on which of the major driving forces behind the scenarios are regarded as most likely from our current perspective.

It seems that the developments of Scenario 2 (alternative agricultural products) are most likely in the EU. Farmers are a powerful group and it is unlikely that shock therapies such as those in Scenario 1 (increase in wooded area) will be possible. Such extreme changes could cause unacceptable large-scale bankruptcy and social unrest in some regions. The EU's capacity to produce food is also too valuable for such radical changes. Future prospects and development of rural areas are important political issues. A recent draft on the "European Spatial Development Perspective" defines the basic goals of the long-term spatial development of Europe as economic and social cohesion, sustainable development, and balanced competitiveness of the European territory. Though not introduced at a large scale, alternative agricultural products have already been encouraged by the MacSharry CAP reform of 1992.

It is difficult to foresee agricultural development in the transforming economies of Poland and the Czech Republic. The Czech Republic and to a lesser extent Poland currently seem to be following the path of Scenario 1. In the Czech Republic, liberalization of agriculture is a high priority. Consequences like production decrease, labor outflow, and decrease in farmland are accepted as unavoidable in the transformation process. Areas of marginal agricultural land are severely affected and the social burden there is high, but the general positive economic development

with a relatively low unemployment rate and an already low share of employment in agriculture facilitates this development.

The situation is different in Poland, where agricultural employment is much more important. Although the overall economic situation has improved with GDP growth since 1992, unemployment is very high, especially in rural areas. The Polish Peasants' Party is demanding greater support and protection for farmers. For all these reasons, it can be concluded that subsidies for the agricultural sector will be available more readily in Poland than in the Czech Republic. Another reason Scenario 1 is likely for Poland and the Czech Republic is the well-established (and successful) forest sector in both countries, which is likely to expand in the future.

Both the Czech Republic and Poland aim at becoming EU members as soon as possible. Their agricultural policies will then be superseded by the EU's agricultural policy. Hence, their current agricultural policies are likely to be relevant only for a short period. However, by the time they are EU members, the CAP will probably have undergone changes toward renationalization, simply because today's CAP will become too expensive. This means fewer regulations and subsidies from the EU and more national autonomy and responsibility for the agricultural sector.

To maintain the sustainability of soil resources in terms of ensuring multiple soil functions for future generations, it is important to avoid a significant increase in land in the "other" land-use category. A land-use change toward urban and built-up areas is in practice an irreversible change. Scenario 1 shows a high increase in "other" land because the price of surplus agricultural land decreases. Inexpensive land encourages urban and infrastructure development. Therefore Scenario 1 anticipates a 40% increase of "other" land use in the project area by 2020 and a 61% increase by 2050. In contrast, in Scenario 2 a major policy goal is to preserve farmland. Here, the increase in "other" area is more moderate, amounting to 21% by 2020 and 40% by 2050. Finally, Scenario 3 (Europe as food exporter), which assumes high demand for agricultural products, shows only a 10% increase by 2020 and a 15% increase by 2050.

Issues of global food security, which form the basis for Scenario 3, are expected to increase in importance. The possibility of global food scarcity will influence agricultural policies. Assuming that the developments of Scenario 3 take place, sustainable agricultural production and preservation of farmland will become essential goals. In light of these goals, the developments of Scenario 2 are preferable to those of Scenario 1: the shift in labor away from agriculture and major decreases in farmland seen in Scenario 1 are undesirable. However, if in the near future there are price increases in food commodities, as suggested in Scenario 3, the conversion of farmland to forest or built-up area will automatically be halted.

Notes

[1] On 1 January 1993, Czechoslovakia split into two independent countries: the Czech Republic and the Slovak Republic. Statistical data for the period before 1993 are for Czechoslovakia; data for subsequent years are for each individual country.

[2] Structural funds are large financial transfers to the poorer regions in the EU. The funds are explicitly aimed at encouraging greater economic and social "cohesion," which generally means convergence of per capita income levels.

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