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Climate change research in central and eastern Europe

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Abstract

Climate change presents both threats and opportunities to the nations and peoples of central and eastern Europe. National and international programs are directly addressing climate change, and other programs speak to natural resource and environmental quality issues that will have significant effects on vulnerability and adaptation to climate change. This paper explores examples of ongoing climate change activity in the region, setting a broad context for the subsequent papers in this volume of *GeoJournal*.

Introduction

During the years since the transition from communism beginning in 1989, environmental concerns and activities in the nations of central and eastern Europe (CEE) have germinated like dormant seeds in a parched land receiving welcome rains. Indeed, in some countries environmental issues were a major impetus for collapse of communist regimes – in Bulgaria, for example, protests against transboundary air pollution from Romania, protests against major water diversions, and the emergence of Ecoglasnost were important events in the transition. Decades of economic growth and industrialization at any environmental cost left nations and regions with a legacy of polluted and devastated regions as well as threats to human health. Collapse of uncompetitive industry now facing a global, unprotected market brought fortuitous improvement in air and water quality. Hundreds of environmentalist non-government organizations (NGOs) have been formed across CEE, many with sponsorship from or cooperation with well-known international NGOs. Local citizens and NGOs have urged serious enforcement of pre-1989 environmental law and encouraged formulation of newer and stronger statutes. The prospect of accession to the European Union (EU) provided impetus for nations to bring environmental monitoring and regulations into conformity with EU standards. International agreements and conventions have mobilized local scientific and environmental expertise in response.

In this paper, we look broadly at the status of climate change research and activity within CEE in the general context of environmental activities. Compliance with the United Nations Framework Convention on Climate Change (UN FCCC) is one unifying theme across CEE, as teams of scientists and officials mobilize to develop 'National Communications' and consider the mitigation of greenhouse gas emissions. Investigations into the potentials for and impacts of climate change included in the communications are more limited and variable in scope. In some nations, interdisciplinary research teams have undertaken studies of climate change, examining impacts in various areas of concern, such as water resources or agriculture. Often, researchers and organizations within nations work independently, producing limited studies of impacts in one domain. Within CEE there has yet to appear any complete integrated assessment at the national or regional level comparable to the national and regional assessments of climate change impacts that have been undertaken in other nations, such as Canada, the U.K., and Australia.

We begin by reviewing the current state of knowledge of potential climate change impacts in CEE, drawing upon studies at the global and continental levels, as well as perspectives from local CEE researchers. We then examine CEE activity within major international climate change programs and scientific collaborations. Other environmental activity may affect the way in which CEE nations are able to adapt to or mitigate adverse impacts; thus we address some examples relevant to climate change assessment. After a nation-by-nation summary, we conclude by suggesting some focal elements of future research in CEE, based on potential regional collaboration.

We do not maintain that CEE is a geographical region unified in its environmental, social, economic and political conditions. On the contrary, we recognize very great differences in all dimensions. However, we do argue that all these nations share some common challenges and opportunities– some visible, some elusive–that are relevant to climate change assessment and planning for its impacts. Among the challenges are:

(1) Multiple issues exist in the transition from totalitarian regimes and centrally planned economies to democratic regimes and open market economies. Changing political systems include environmentally important dimensions of

central command and control vs. local environmental management and initiative; changing economic systems have universally faced some degree of initial collapse, with different degrees of restructuring in progress. The transition is not a singular process but multi-layered, complex, and subtle;
(2) Initial economic collapse led to substantial, but inadvertent, improvement in air, water and soil quality due to less industrial pollution and chemical fertilizer use, as well as decreased energy use. Thus most CEE nations have already met UN FCCC goals for GHG emissions, and forecast growth in many cases poses little challenge in continuing to meet these standards;
(3) Negative environmental impacts have emerged as well: urban sprawl, collapse of public ex-urban transport, increase in private vehicle ownership, traffic jams, poverty (particularly among the elderly and ethnic minorities), collapse of publicly funded health care, stripping away of environmental resources for survival (e.g. illegal forest cutting), mindless consumerism, and increase in waste generation;
(4) Euphoria at the beginning of the transition was followed by disillusionment. Exigencies of day-to-day survival, unemployment, crime and corruption diverted attention from local and global environmental issues;
(5) CEE nations share a common history of the organization of government planned scientific research, with elite national scientific academies as core institutions, teaching universities with more limited research opportunities and less contribution to national scientific knowledge and policy, and degree-awarding ministry-affiliated and industrial sector research organizations that duplicated academies in areas of applied research. The segmented nature of this research structure when combined with the stress of increasingly limited support has raised rather than lowered walls between institutes and organizations, as all compete for scarce funding among themselves and with NGOs;
(6) For institutions responsible for environmental data, provision of that data to outsiders has become a means for raising funds, thus limiting access of the public and interdisciplinary researchers to environmental data, ranging from basic weather and hydrologic measurements to more sophisticated air and water pollution analyses. Sometimes the proprietary treatment of environmental data is, in terms of availability, the same as the status of data as a national secret prior to 1989;
(7) There is a persistence of old mind sets, such as having environmental laws 'on paper' but by-passing them in reality for the sake of expediency. For example, environmental impact assessment (EIA) is still evolving (Cherp, 2001a, b).

On the other hand, the nations of CEE also share important encouraging elements:
(1) New doors have opened to international collaboration on global and regional issues such as global change. Opportunities are greatest for the EU accession countries, but more limited elsewhere;
(2) The necessity of raising research funds has been accompanied by the freedom to explore new research agendas and break free from centralized control. This makes possible the opportunity for interdisciplinary synergism;

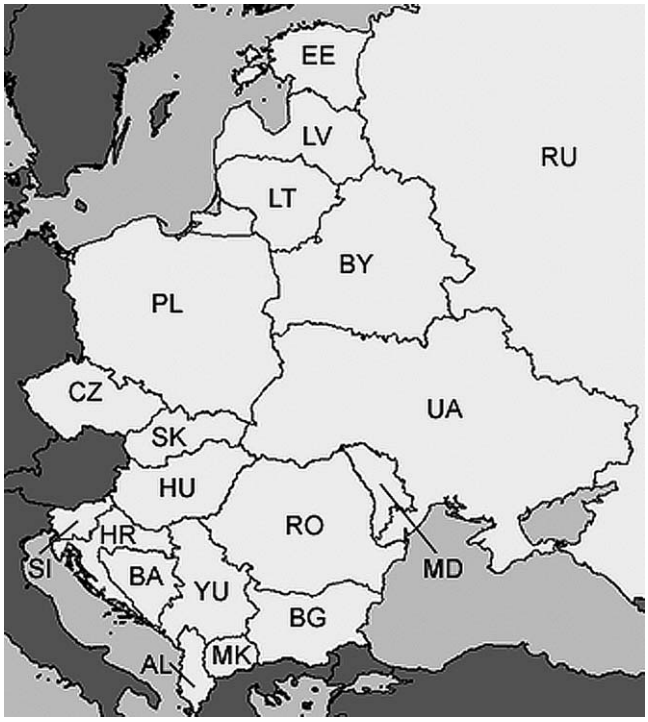

Figure 1. The former socialist countries of central and eastern Europe. For a key to country codes, see Table 1.

(3) Scientists now have the freedom to address controversial environmental issues and to share their perspectives publicly;
(4) Civil society is developing across a spectrum of activity, resulting in increasing public involvement in environmental issues and the founding of multiple NGOs dealing with the environment. However, these local environmental NGOs also compete among each other for scarce resources;
(5) Capacity to work on national, regional and global research agendas is strong; and
(6) There are the beginnings of acknowledgement that, accession to EU not withstanding, nations in CEE recognize regional concerns. Examples include the V4 (Visegrad Group, 2000; Hungary, Poland, Czech Republic, and Slovakia) and the Baltic Assembly (2003; Estonia, Latvia, Lithuania).

Of course, there are notable exceptions in CEE to many of these commonalties as individual nations seek their own new paths or work toward conformity with EU and international standards, beginning from significantly different structural and geographic affinities to western capitalism and political systems (contrast Albania or Belarus with Slovenia or Hungary). The many institutional legacies common across the CEE may not be as apparent as the geographical and geopolitical differences, but we argue that the commonalties present salient factors in understanding, anticipating and eventually dealing with climate change impacts.

Our strategy in this paper is to review existing documents from archives and the internet as basic information sources to supplement our own experiences in CEE. We limit our comments largely to the nations other than the Russian Federation in the region (Figure 1). The internet has

Table 1. ISO 3166-1 Alpha-2 country codes for Central and Eastern Europe

AL	Albania
BA	Bosnia-Herzegovina
BG	Bulgaria
BY	Belarus
CZ	Czech Republic
EE	Estonia
HR	Croatia
HU	Hungary
LT	Lithuania
LV	Latvia
MD	Moldova
MK	Macedonia (FYROM)
PL	Poland
RO	Romania
RU	Russian Federation
SI	Slovenia
SK	Slovakia
UA	Ukraine
YU	Yugoslavia[1]

Source: ISO (2003).
[1] New codes for Serbia and Montenegro had not been specified by the time of publication.

evolved as a major source of information dissemination only late in the post-1989 transitional decade. Thus many earlier environmental reports are only available locally as printed documents. Fortunately, some of this local and ephemeral literature on the legacy of environmental problems is summarized for the CEE countries in the former Soviet Union by Mnatsakanian (1992). For other CEE nations, there are multi-national surveys edited by Carter and Turnock (1993, 1996, 2002; see also Turnock, 2001, 2003).

One of the most comprehensive archives of environmental documents on CEE from the pre-internet era (Mnatsakanian, 2000) is located in the Environmental Sciences and Policy program at the Central European University (CEU), a post-communist international graduate institution in Budapest. From the end of the 1990s decade, the internet provided much information, although there are certainly many documents in each nation that are only accessible to those physically present. Our work is limited to information available in CEU archives, the internet, internationally accessible library resources, and our own experience. In tables, we use the Alpha-2 country codes of the ISO (2003) for brevity (Table 1). Finally, we treat future climate change largely from the viewpoint of impacts resulting from globally increasing greenhouse gas (GHG) emissions and the climate scenarios that derive from such a reality. Our hope, of course, is that the UN FCCC will be effective in dampening future climate change through conscious human action.

CEE countries are among the world's thirty most CO_2-intensive economies, including Ukraine, Bulgaria, Russia, Romania, Estonia, Belarus, and the Czech and Slovak Republics (European Commission, 1999). However, collapse of industry in the 1990s decreased aggregate energy use and GHG generation. Addressing the challenges of energy efficiency and mitigation of future GHG emissions drives much of the climate change agenda in and for CEE, and many studies of potential impacts and adaptation evolved in the context of GHG mitigation issues (EEA, 2002).

For people in CEE, the prospects of climate change may seem remote in terms of contemporary environmental and other problems (O'Connor et al., 1999). Indeed, there is a large and growing literature on environmental stress in Europe (Stanners and Bourdeau, 1995; EEA, 1998, 2003a) and in CEE (Carter and Turnock, 1993; Jansson and Stålvant, 2001). Thus it is important to note that there are more immediately pressing environmental exigencies in CEE and that impacts of climate change there, as elsewhere, occur in the context of existing environmental stress.

Scenarios of climate change

Most investigations draw upon Intergovernmental Panel on Climate Change (IPCC) scenarios for future trajectories of GHG emissions and on atmospheric general circulation models (GCMs) driven by the relevant parameters. The status of GCMs has improved over the past decade, and increasingly, transient coupled ocean-atmosphere models with aerosols are available as well as $2\times CO_2$ models. Parry (2002) addressed the question of appropriate selection of scenarios for impact assessments, and the IPCC Data Distribution Center makes available results from eight GCMs (IPCC-DDC 2003). Liszewska and Osuch (2003; this volume) illustrate several of the major climate scenarios for CEE.

In general, climate models show relatively consistent patterns of warming over CEE, with a general pattern of wetter conditions in the North versus drying in the South. The models reviewed differ significantly in how they render topography, and in details. There are also some regional differences in the direction of precipitation changes. In addition, the models differ in their ability to replicate baseline conditions; some replicate temperature better; others model precipitation with greater accuracy (Liszewska and Osuch, 2003, this issue).

Climate change and impacts

Climate change scenarios are used to suggest or model impacts on environmental and society. Studies of this nature covering CEE have been undertaken in many contexts, including vulnerability and adaptation assessments at the continental level as part of the IPCC process and European environmental assessments. At the national scale, the U.S. Country Studies Program (USCSP), the 'National Communications' to the United Nations Framework Convention on Climate Change (UN FCCC), and studies done independently, particularly for specific impact categories or within specific sub-national regions (or both), develop more locally-relevant issues and scenarios. In the subsequent sections, we move down scale from international to continental to national analyses of climate change impacts.

The IPCC Process

The IPCC process involves three working groups (WG)–WG-1 deals with climate processes and change; WG-2 examines vulnerability to climate change, impacts and adaptation potentials; and WG-3 addresses mitigation of climate change (IPCC, 2003). In addition to quinquennial reports from the working groups (plus a synthesis volume and summary for policy makers), the IPCC produces special, technical and methodological reports. In the early IPCC process, few participants from CEE were involved, with the exception of Russia (Table 2). In more recent activities, a greater number of CEE countries have been represented as authors or review editors.

One of the IPCC special reports was a regional assessment of climate change (Watson et al., 1997), including a chapter on Europe (Beniston and Tol, 1997), which was based on the IPCC's Second Assessment Report (SAR; IPCC, 1996a–c). Two individuals from CEE participated in the European analysis. The authors of the regional assessment used these definitions:

> *"Vulnerability" is the extent to which climate change may damage or harm a system; it is a function of both the "sensitivity" of a system or structure to climate and the opportunities for "adaptation" to new conditions. Sensitivity is defined as the degree to which a system will respond to a change in climatic conditions (e.g., the extent of change in ecosystem composition, structure, and functioning, including primary productivity, resulting from a given change in temperature or precipitation). The responses may result in either beneficial or harmful effects. Adaptation is defined as adjustments in practices, processes, or structures in response to projected or actual changes in climate. Adjustments can be either spontaneous or planned, reactive or anticipatory. In some cases (e.g. for many ecosystems), options for planned or anticipatory adaptation may not exist. Adaptations can reduce negative impacts or take advantage of new opportunities presented by changing climate conditions* (Watson et al., 1997, Section 1.1).

The climate scenarios used were those of the SAR, with environmental and socio-economic data from the mid-1990s. All of the countries considered in this paper were part of the European assessment. The IPCC regional assessment began with a brief review of the geography, ecology, society and economy of Europe, noting particularly the large differences within Europe on all accounts. It then turned to regional patterns of temperature change, noting significant warming in the post 1970s period, with greatest future warming in winter and at higher altitudes, and a decreasing diurnal temperature range. Precipitation increased in northern Europe, while decreasing in southern areas. Concerning future climate, using the SAR GCM results, the assessment stated:

> *Most GCM-based projections for the European region indicate that there may be an overall increase in winter annual temperatures (IPCC 1996, WG I, Figure 6.32) and that this increase could be larger in boreal latitudes than in mid-latitude Europe. The diurnal temperature range, according to the model used, is 2.5–4.5 °C for northerly latitudes, compared with 1.5–4.5 °C for southern Europe. The range of summer temperatures forecast by the different models is larger than for the winter period, but the upper limit of the range is about 4.5 °C increase in a 2×CO2 climate for southern and northern Europe.*
>
> *Projected precipitation patterns are more uncertain. Most models show an increase in precipitation for Europe as a whole as a consequence of a higher content of water vapor in the atmosphere. Winter precipitation in high latitudes of Europe may increase by as much as 20% (IPCC 1996, WG I, Figure 6.32), according to most models. Rainfall during the summer months may remain unchanged in many parts of Europe. Some models show decreases in the Mediterranean region and in central and eastern Europe, though others show increases; in northern Europe, most models suggest an increase in summer precipitation. There is much uncertainty associated with future precipitation trends, however; for instance, GCM simulations incorporating the aerosol effect provide conflicting evidence for future precipitation trends in parts of Europe, compared with greenhouse-gas-only simulations* (Beniston and Tol, 1997, Section 5.2.3).

The general impacts of climate change in Europe as suggested by the IPCC study are listed in Table 3. Clearly, all CEE countries have a stake in climate change, but the issues will be different from sub-region to sub-region. The report notes the importance of anthropogenic effects on environment separate from and potentially confounding climate change impacts, especially with regard to ecosystems, forests, and hydrologic systems. New agricultural opportunities may be created in northern parts of CEE, whereas drought may be a threat for summer crops in southern CEE. Adaptation strategies (crop selection, production technology) could offset these threats. Rivers in central Europe could become ice-free as a result of warming. With regard to water, the study notes:

> *GCM-based analyses for the European continent (IPCC 1996, WG II, Table 10-1) give a range of possible responses of river runoff in a warmer global climate–from decreases in some regions (e.g., Hungary, Greece) to increases in other regions (United Kingdom, Finland, Ukraine); these estimates are a function of precipitation, evapotranspiration, and soil moisture projections in the different GCMs. The uncertainties of climate model results, however, remain very large in terms of hydrological forecasting, particularly at the regional scale. This limitation is particularly critical for water management practices in the future because water resource impacts occur at the local scale, not at regional or larger scales* (Beniston and Tol, 1997, Section 5.3.3.2).

The study also notes the potential for greater severity of floods due to increased rainfall when soils are saturated and

Table 2. Participation of CEE scientists in selected IPCC activities (as authors and review editors)

IPCC Study	AL	BA	BG	BY	CZ	EE	HR	HU	LT	LV	MD	MK	PL	RO	RU	SI	SK	UA	YU
SAR WG1															20				
SAR WG2								6					3		10				
SAR WG3															2				
REG-EUR					1											1			
TAR WG1					1			1					2	8	22	1	2		
TAR WG2			1										4		8		1		
TAR WG3								1					1		2	2		1	
CEWCE			1		1								1						1
SR LULCF															3				1
Totals			2		3			8					11	8	67	4	3	1	2

SAR WG1 (*Climate Change 1995: The Scientific Basis*; IPCC 1996a)
SAR WG2 (*Climate Change 1995: Impacts, Adaptations, and Mitigation of Climate Change*; IPCC 1996b)
SAR WG3 (*Climate Change 1995: Economic and Social Dimensions of Climate Change*; IPCC 1996c)
REG-EUR (*IPCC Special Report on The Regional Impacts of Climate Change, Europe*; Beniston and Tol, 1997)
TAR WG1 (*Climate Change 2001: The Scientific Basis*; IPCC 2001a)
TAR WG2 (*Climate Change 2001: Impacts, Adaptation, and Vulnerability*; IPCC 2001b)
TAR WG3 (*Climate Change 2001: Mitigation*; IPCC 2001c)
CEWCE (*IPCC Workshop on Changes in Extreme Weather and Climate Events*; IPCC 2002)
SR LULCF (*IPCC Special Report on Land Use, Land-Use Change And Forestry*; (Watson et al., 2000)

earlier snowmelt occurs. Some CEE coastal countries will face the longer-term threat of sea-level rise. Several studies of the costs of sea level rise in Poland were noted. Persistent summer anticyclones could increase low level air pollution, especially in cities. There may be heat wave and other health effects, such as increases in allergies and vector-borne diseases could occur. Some work on integrated assessment was noted, citing studies of the economic impacts of climate change (from western European countries).

IPCC TAR

The IPCC's *Third Assessment Report* (TAR) conclusions about climate change in Europe were largely parallel to those in the 1997 regional analysis (Cramer et al., 2001). The TAR noted these climate conditions:
(1) Warming occurs all over Europe, greatest in southern and northeast;
(2) Winters warm more in continental eastern Europe;
(3) Summer warming is greater in southern Europe;
(4) Contemporary ten percent probability cold winters disappear;
(5) Present ten per cent probability warm summers are exceeded every year;
(6) Greatest model agreement is for southern winters;
(7) Precipitation has modest increase in northern Europe and decrease in southern Europe;
(8) Most of Europe is wetter in the winter, except the Balkans;
(9) Summer rain increases in the North, decreases in the South;
(10) There are differences in magnitude, even sign, of precipitation change;
(11) Heat waves, intense precipitation episodes and strong wind events are likely; and
(12) Sea level rise, while occurring, will have different impact in northern areas due to eustatic elevation changes.

Specific conclusions about climate impacts in Europe in the TAR included:
(1) Climate change will exacerbate pressure on water resources and water management;
(2) Ecosystem change will occur, including northern and upslope migration of communities;
(3) Potential for increased agricultural yields could be realized in northern Europe but be threatened by water shortages in southern and eastern Europe;
(4) High costs will occur in the insurance industry due to floods and coastal effects;
(5) Tourism could be negatively affected by summer heat in the South and less winter snow;
(6) Risks to human health will occur; and
(7) There is high adaptation potential in human systems but lower potential in natural systems.

These conclusions, particularly the last, did not differentiate relatively wealthy western Europe from CEE, although the report did note that more adverse affects could occur in poorer parts of Europe (Cramer et al., 2001).

The U.S. Country Studies Program

The U.S. Country Studies Program (USCSP) was announced at the 1992 UN Conference on Environment and Economic Development (The Rio Conference) to provide assistance to developing and transitional countries to assess GHG emissions and mitigation, to examine vulnerability to climate change, and, for some countries, to develop national climate change action plans, an activity closely related to the subsequent process of national communications to the UN FCCC (USCSMT, 1999; Table 4). The USCSP involved a consortium of ten U.S. agencies with overall direction from the Department of Energy. Although the major thrust of the USCSP was greenhouse gas mitigation and energy efficiency, elements of the activity included an assessment of vulnerabilities and adaptation options in eight potential

Table 3. IPCC Regional Assessment for Europe: Executive Summary (Beniston and Tol, 1997, p. 92; http://www.grida.no/climate/ipcc/regional/092.htm; reproduced by permission of the Intergovernmental Panel on Climate Change).

Climate Change. Climate model projections suggest a general increase in temperature, greatest in northerly latitudes. Precipitation changes are considerably more uncertain, but one could expect generally wetter conditions in the north, drier conditions in the south, and increasingly drier conditions from west to east. Winter precipitation may be greater than today, while summer precipitation is likely to decrease.

Sensitive Regions. As water is one of the main integrating factors for many environmental and economic systems in Europe, currently sensitive areas in terms of their hydrology include ▪ **central and eastern Europe** [authors' emphasis]. A changing climate is likely to enhance water-related stresses in these already sensitive regions.

Vulnerability and Potential Impacts Hydrology, Snow and Ice, Water Supply and Demand

- Evapotranspiration will increase in a warmer climate, with potential reductions in water availability; however, the response of hydrological systems depends on the distribution of precipitation (highly variable, as suggested above) and storage capacity.
- Many regions in the southern and interior parts of Europe could experience a general decrease in runoff, though the change in runoff may range between -5% and +12%.
- More droughts could be expected in southern Europe, and the potential for winter and springtime flooding could be greater in northern and northwestern Europe. However, this pattern is not the same for all general circulation models (GCMs).
- Intrusion of saline waters into coastal aquifers and the expected reduction in precipitation could aggravate the problem of freshwater supply in some areas.
- Snow and ice are likely to decrease in many places, with consequences for the timing and amount of runoff in river basins, as well as winter tourism.
- Demand for water could increase in summer. Supply could decrease, though there may be regional differences in which storage capacity plays an important role.
- Pollution is a major stress factor for many European rivers, and a decrease in discharge would increase pollutant concentrations, leading to reductions in water quality.
- Current national and international policies and practices for water resources management will be put under stress by climate change.

Ecosystems

- With the exception of parts of Scandinavia and the Russian Federation, Europe has few genuine natural ecosystems. Natural ecosystems generally are confined to poor soils and are fragmented and disturbed; consequently, they tend to be more sensitive to climate change than agriculture, which occupies the most fertile soils.
- The reaction of European ecosystems to global change is difficult to predict because there are a number of interactions and feedback loops between increasing temperatures, decreasing availability of soil water, and increasing carbon dioxide (CO2) concentrations.
- Increasing CO2 concentration increases the productivity of plants with C3 metabolism under laboratory conditions (for most agricultural plants, except maize and millet). However, many other factors come into play under field conditions, such as water and nutrient stress, increased respiration losses, and interactions between species. Therefore, the overall change in productivity can only be predicted if these interacting environmental conditions are taken into account. Many studies indicate that CO2 increases alone may have relatively little impact under field conditions.
- The forests in many parts of Europe are affected by high deposition rates of nitrogen. Their productivity is not only a function of climatic factors but of the change in nitrogen deposition, which can both act as a fertilizer and cause disturbances to many processes within the ecosystem.

Agriculture

- Crop mixes and production zones will be redistributed, and the use of water, fertilizers, herbicides, and pesticides will shift with them.
- Conflicting demands for water—for instance, between irrigation and domestic supply in southern Europe—will need to be taken into account.
- Changes in potential production translate in a complex way to farmer incomes and food prices, depending on technology, farmer adaptation, world markets, and agricultural policies.

Coastal Zones

- Sea-level rise will place additional stress on coastal zones already stressed by other factors (urbanization, coastal developments, pollution, etc.).
- The level of impact will depend on the adaptation capacity (e.g., the ability of systems to move inland) and policies of individual countries (e.g., trade-offs between lands that are not considered important and those that need to be protected).
- Sensitive zones include areas already close to or below mean sea level (such as the Dutch and German North Sea coastlines, the Po River delta, and the Ukrainian Black Sea coast), areas with low intertidal variation (such as the coastal zones of the Baltic Sea and the Mediterranean), and coastal wetlands.
- Changes in the nature and frequency of storm surges, particularly in the North Sea, are likely to be of considerable importance for low-lying coastal areas.

Other Infrastructure, Activities, Settlements

- Energy. Changing hydrology will impact those energy and industrial production sectors that depend on water for cooling. There is a potential for increased energy demand related to cooling in summer, and decreased energy demand related to heating in winter. Such changes would lead to shifts in peak energy demand.
- Urbanization. Infrastructure, buildings, and cities designed for cooler climates will have to be adjusted to warmer conditions, particularly heat waves, to maintain current functions.

Health

- While there are fewer heat-related deaths in Europe than in some other parts of the world, the risk of heat-related deaths would probably increase with summer warming. The risk of cold-related deaths would probably decline with winter warming. It is not clear what the net change in risk would be for Europe.
- Warmer temperatures will exacerbate summer air pollution episodes and their health impacts in many cities.
- Some vector-borne infectious diseases will have the potential to extend their range; the adaptation capacity of individual countries will depend on their level of environmental management, public health surveillance, and health care.

Table 4. CEE participation in the Country Studies Program and the vulnerability/adaptation assessment (USCSMT, 1999, p. 75)

Country	National Action Plan Support	Vulnerability/Adaptation Topics
Bulgaria	*	Agriculture, forestry
Czech Republic	*	Agriculture, forestry, water
Estonia		Agriculture, forestry, water, coasts
Hungary	*	*(no vulnerability study)*
Poland		Agriculture, water, coasts
Romania		Agriculture, forestry, water
Slovak Republic		Agriculture, forestry, water
Ukraine	*	Agriculture, forestry, water, coasts

impact categories. In the CEE countries, only four were addressed: agriculture, forestry, water resources, and coastal areas.

For the USCSP, vulnerability meant "the physical and economic impacts of climate change" and adaptation was defined as "what steps countries could take to respond to the physical impacts of climate change" (USCSMT, 1999, p. 73). Results of the vulnerability analyses were mixed, both within and among countries (Table 5). A major source of uncertainty derived from the mix of GCMs and scenarios used; sometimes the scenarios differed not only in magnitude but direction of climate change.

In general, it was anticipated that climate change would alter ecological zones with concomitant change in distribution of forest species in both altitude and latitude. Agricultural impacts were mixed, with some opportunities for yield increases and changing crop combinations. Threats to water resources include lower summer flows and potentials of flooding. For countries with coastal assessment, loss of land would result in economic losses. Overall, the vulnerability assessments in the USCSP covered only seven of the nations considered in this paper and lacked uniformity in use of GCM scenarios and methodologies. Thus it is impossible to generalize across CEE or sub-regions from the USCSP. A special journal issue resulting from a 1995 conference on climate change vulnerability and adaptation, sponsored by the USCSP, included examples of climate change research in CEE (Dixon, 1997). Other publications from the USCSP include articles (e.g. Smith and Lazo, 2001), books edited by Smith et al. (1995, 1996) and by Lenhart et al. (1996), plus a special journal issue on water (Strzepek and Biswas, 1996).

European Environmental Assessments

The first European Environmental Assessment ("The Dobris Assessment"; Stanners and Bourdeau, 1995) examined a wide range of environmental issues in Europe, including environmental hazards. However, climate change was a minor issue. In the second European environmental assessment (EEA, 1998), climate change was also briefly addressed:

> *European annual mean air temperatures have increased by 0.3–0.6 °C since 1900. Climate models predict further increases, above 1990 levels, of about 2 °C by the year 2100, with higher increases in the north of Europe than in the south. The potential consequences include increases in sea level, more frequent and intense storms, floods and droughts, and changes in biota and food productivity. How serious these consequences will be depends partly on the extent to which adaptation measures are implemented in the coming years and decades* (EEA, 1998, p. 14)

Most of the second assessment's discussion climate change focused on GHG mitigation. Concerning CEE, the assessment stated:

> *In Eastern Europe, carbon dioxide emissions from fossil fuel use fell by 19% between 1990 and 1995, mainly as a result of economic restructuring. Energy use for transport fell by 3% in CEE over this period and by 48% in the NIS. Industrial energy use fell by 28% in CEE and by 38% in the NIS. Energy intensities in CEE are about three times higher than in Western Europe and in the NIS probably five times higher, so there is considerable potential for energy savings. In a baseline "business as usual" scenario, energy use in 2010 is expected to be 11% lower than in 1990 in the NIS, and 4% higher than in 1990 in CEE* (EEA, 1998, p. 14).

The third European assessment (EEA, 2003) gives special attention to CEE (and the newly independent countries). It also addresses climate change in a more comprehensive manner, with considerable attention to impacts. Those of concern include:
(1) Hydrological changes, including decreased flows in the southern CEE countries and increasing flood risk;
(2) Threats to mountain areas, including less snow, loss of glaciers, and risk of avalanches, rockslides, and landslides;
(3) Coastal flood and erosion risks;
(4) Soil erosion, salinization, and loss of peat;
(5) Agricultural and forest impacts, which could be positive if moisture is not limiting;
(6) Migration of ecosystems and loss of biodiversity;
(7) Economic impacts from environmental changes and impacts in the insurance industry;
(8) Positive and negative changes in tourism destinations; and
(9) Largely negative human health impacts.

The third assessment notes the potentials within the EU and in conjunction with other nations for emissions trading and joint implementation of GHG mitigating activities (EEA, 2003). Joint Implementation is a mechanism under the Kyoto Protocol in which an Annex I country could receive credit for emission reductions through support of projects that reduce net emissions in another Annex I country. Emissions trading and joint implementation of GHG mitigation projects are discussed in this volume (Ürge-Vorsatz and Szeszler, 2003, this issue) and related literature (e.g. Babiker et al., 2002; Evans, 2003).

Table 5. Summary of CEE vulnerability/adaptation assessments in the U.S. Country Studies Program (authors' summary based on USCSMT 1999)

Sector	BG	CZ	EE	PL	RO	SK	UA
Agriculture	Largely − without CO_2 fertilization	Yield + with greater variability	Largely − with fertilizers	Largely + with disease risks	Largely + with increased yields	Largely + for winter wheat w/ fertilizers	Mixed, varies by region, most +
Forestry	Species change w/ stress at low elev.	Species change, some − at low elev.	Variable with species change		Species change & growth − at lower elev.	Species change w/ increase in biomass	Uncertain, varies by GCM used
Water		Largely − especially in small basins	Largely + with rising ground water	Largely − quantity & quality; flood risk	Largely − but only one GCM used	Largely − for surface, ground-water	Uncertain, varies by GCM used
Coasts			Major land and economic losses	Land loss with some protection possible			Land and economic losses

'National Communications' to UN FCCC

Nearly all of the CEE countries have submitted at least one 'National Communication' to the UN FCCC. These reports are intended to have a section on climate change impacts and potentials for adaptation. As a whole, the CEE communications cover a wide range of impact categories (Table 6), but no country reports on all of them. For some countries, impact analysis at the national level is at a beginning stage; for others it is more mature. In no country is there an analysis that could be viewed as a national integrated assessment, such as those undertaken in EU countries, Canada, USA and Australia. The review that follows builds from the latest communications submitted (UN FCCC, 2003).

Beginning in the Balkans, *Albania*, one of the latest nations to undertake a national communication process, has one of the more comprehensive impact analyses. For Albania, the major negative impacts involve coastal impacts of sea level rise (with related impacts on coastal populations and tourism), threats to hydroelectric production from decreased runoff, and increased drought risk. Positive impacts in the energy sector are related to lower heating requirements and potential increases of solar energy (Albania, 2002).

In contrast, *Bulgaria's* third communication (Bulgaria, 2002), a report particularly strong on GHG mitigation, does not include impact categories beyond those examined in the previous Country Studies Program. Mixed impacts in agriculture and negative impacts on forests are anticipated. Surprisingly, impacts of sea level rise on the Black Sea coast are not addressed. The possibility of impacts on water resources is mentioned but not investigated.

Croatia anticipates increase in both temperature and precipitation, although present precipitation trends are negative (Croatia, 2001). The Croatian report suggests adaptation in agriculture could overcome deficits in soil moisture and take advantage of a longer growing season. As in Albania, major negative coastal impacts would occur with higher sea levels.

Slovenia, like Albania, was one of the latest nations to submit its first communication (Slovenia, 2002). The breadth of impacts considered makes its report almost a primer in impact assessment. However, most of the areas treated are considered only in generality, with notable exceptions of hydrology and agriculture.

In central Europe, The *Czech Republic's* third communication (Czech Republic, 2001) is, like the Bulgarian communication, strong in GHG mitigation and energy efficiency measures, but has a wider scope on impact assessment. Decreasing runoff and change of runoff seasonality is expected. The Czech report notes possible negative ecological impacts of increasing temperature of fresh waters. This report has, compared to others, a more comprehensive discussion of direct and indirect effects of climate change on agriculture, albeit without model prognostications of yield changes (with mixed impacts in the Republic).

The *Slovak Republic's* communication (Slovak Republic, 2001) addresses a narrow range of impacts, but with sophisticated modeling and comprehensive consideration of adaptation alternatives. Hydrological, agricultural and forestry impacts are analyzed; important seasonal and spatial differences are noted.

The *Polish* third communication (Poland, 2001) is surprisingly weak in its treatment of impacts in comparison to its Country Studies Program reports and the level of national climate change impact expertise. Sea level rise is mentioned; agricultural issues are more fully explored (mixed impacts); and, like the Czech communication, impacts on water quality are briefly considered. One additional category not addressed by other communications is shortened periods of icing in rivers.

Table 6. Impact assessment issues in national communications to UNFCCC

	AL	BG	CZ	EE	HR	HU	LT	LV	MD	MK	PL	RO	SI	SK	UA
Report Number	1	3	3	3	1	3	2	3	1	1	3	2	1	3	1
Year	2002	2002	2001	2001	2001	2002	2003	2001	2000	2003	2001	1998	2002	2001	1998
Temperature	+	+	+	+	+		+		+	+	+	+	+	+	
Precipitation	−	+/−	−	+	+		+/−		+/−	−	+	+/−	+/−	+	
Surface Water	−		−	+	−				+/−	−	+/−	?	−	−	−
Ground Water	−			+	−				+/−					−	
Sea Level Rise	**N**			**N**	**N**		**N**	**N**			?		n		**N**
Agriculture	m, n	m	m	m	p				m	n	m	p	m	p	p
Forests	m	**N**	**N**	**P**	n				n	n		n	n	m	+/−
Terrest. Eco.							**N**								
Mountains													n		
Soil s									**n**	**n**					
Hydro power	**N**												n		n
Energy	**P**												p		
Health	**N**				n				n				n		
Population	n														
Tourism	m												n		
Biodiversity					m		**N**			n			n		
Marine ecosys.					?		**N**						n		
Water quality			n				n				n				n
Wetlands							n								

Key: +, increase, −, decrease; +/−, scenarios disagree on direction; **P**, significant positive impact; p, modest positive impact; m, mixed impact; n, modest negative impact; **N**, significant negative impact; ?, impacts expected but uncertain. Temperature and precipitation trends reported only where GCM scenarios were utilized.

The *Hungarian* communication (Hungary, 2001) emphasizes the risk of recurring drought and has a major analysis of drought phenomena in the country. Although drought impacts are considered, other elements of impact analysis are not explicitly defined.

In east-central Europe, *Moldova's* first communication (Moldova, 2000) has a useful description of the current status of environment and stresses that would be affected by climate change. The report very nicely maps the changing geographic distribution of ecological zones (northward and becoming more arid). As scenarios progress through time, water resources at first decrease, then increase. The report notes the likely persistence of existing water stress.

Romania's communication is one of the two oldest of those available (Romania, 1998), thus one might expect its impact analysis to be less well developed than those coming later. Agriculture received the greatest attention and modeling, followed by forests. Possible water impacts were mentioned but not analyzed.

The *Ukraine* communication is of the same vintage as that from Romania (Ukraine, 1998). Negative impacts in coastal areas and for hydroelectric production and water quality were noted; agricultural impacts were largely positive whereas those for the forest sector were mixed.

In the Baltics, *Estonia's* report identified mixed impacts in agriculture, but significant possibilities for forest biomass accumulation (Estonia, 2001). Both ground and surface water would benefit from climate change, but sea level rise would impose large costs from both inundation and storm surges. The Estonian communication has particularly compelling graphics. *Latvia's* communication (2001) also identified sea level rise as a major threat, but unlike Estonia, no cost estimates were reported. This report did not use GCM projections, but has important observations about existing climate trends (warmer) and impacts of contemporary human activity on land use and land cover. In general, this impact analysis is an early stage. In *Lithuania*, impact analysis is also at its infancy, except in the area of ecosystems and wetlands, both of which could experience negative impacts (Lithuania, 2003).

In comparing the reported climate changes and impacts determined to be important, the results are not always consistent from one country to its neighbors. These differences are rooted in (1) the relative level of sophistication in national impact assessment; (2) differences in climate scenarios used; and (3) differences in judgments about impact significance. For example, in the agricultural sector, consideration of CO_2 fertilization differed among countries.

The 'National Communications' are not necessarily a reliable indicator of national capability to undertake impact assessment. In some cases, for example Bulgaria, the team simply did not include experts in many impact areas that could have contributed. Staneva et al. (2000) illustrates the breadth of national expertise available in that country. In other countries, such as Poland, considerable national research in various impact categories was not included. It is clear that dominant local expertise sometimes helped to drive the impact categories addressed – examples include crop-climate modeling expertise in Bulgaria, Moldova and Romania. For some areas, such as the Baltics or Balkans, impact assessment could be enhanced by in-

ternational collaboration rather than each nation 'going it alone.'

None of the 'National Communications' brought together issues of extant environmental stress, the major social and economic transitions occurring, and the impacts of climate change in an integrated analysis. In contrast, the economic transition was very much part of GHG mitigation issues. In most countries and impact categories, the sophistication of impact modeling was far below that of the energy and mitigation analyses; notable exceptions in some countries were ecosystem, agricultural, hydrological and sea level impact assessments.

Using the 'National Communications' as a broad overview of the region by local researchers, some generalities emerge. All countries reporting coastal impacts express great concern about the consequences and (where estimated) costs of sea level rise. Agricultural impacts are mixed, but most issues can be addressed by mitigation measures and many examples of gains are cited. Forests, ecosystems, and biodiversity are widely threatened. Over most of CEE, hydrological impacts are negative, in terms of flow, seasonality changes, flood threats, and water quality, all existing stresses that could become worse. Only Hungary addressed drought as a singular phenomenon, but threats to water resources and soil moisture were noted widely, suggesting that drought is widespread threat. Adaptation options are well understood over the region, but the financial means to implement them remains threatened by the relative poverty of the region.

Continent scale water analyses

Water resources have received particular attention at the European, national, and basin scale. The typical strategy in this research dimension is the development or use of a climate-driven hydrological model, calibrated and validated for a particular region (Kundzewiczi and Somloydi, 1997). The model is then driven by climate results from one or more atmospheric general circulation models (GCMs), typically those used in the work of the IPCC. GCM results could be used directly, but more common is use of changes from the baseline parameters (e.g. precipitation, temperature) applied to locally documented data. The challenges posed by climate change for water resource management in CEE occur in a context of other issues, including pollution, water supply and sanitation needs, flood management, irrigation, institutional and management dimensions, and financial and capacity building hurtles (Kundzewicz and Somloydi, 1997; Maziliauskas, 2000; Nixon et al., 2000; Prinz, 2000; Boschet et al., 2001; GWP, 2001; Kundzewicz, 2001; Guerrie and Delfino, 2002).

One of the earlier analyses of climate change impacts on European water was completed by Brouwer and Falkenmark (1989). They noted UK Meteorological Office simulations showing decreases in water availability in southern and Mediterranean Europe, with a suggestion that interannual variations could become even more important threats to adequate soil moisture. The authors recommended water conservation, recycling, improvements in irrigation technology, and drought-resistant crops as possible adaptations.

Table 7. Changes in Annual Runoff under $2\times CO_2$ (Strzepek and Yates, 1996, p. 88)

Country	% Change in runoff GFDL	GISS	UKMO
Albania	− 8.6	9.8	−33.1
Bulgaria	−14.7	0.7	−50.3
Czech & Slovak Republics	−7.4	0.9	−11.4
Former Soviet Union (W)	−9.9	12.3	− 0.9
Hungary	−12.6	3.7	−32.0
Poland	−8.3	− 2.5	− 2.0
Romania	−9.0	2.6	−34.0
Yugoslavia (former)	−8.5	6.5	−36.9

Strzepek and Yates (1997) assessed the impacts of climate change on European water resources using an annual temperature-precipitation index (Turc) with a half-degree spatial resolution from IIASA data (Leemans and Cramer: 1991). Results by CEE country are shown in Table 7. For central European countries (Austria, Albania, Bulgaria, Czech & Slovak Republics, Greece, Hungary, Poland, Romania, Turkey, former Yugoslavia), the analysis showed −6%, +5%, and −23% changes in annual runoff from the GFDL, GISS, and UKMO $2\times CO_2$ scenarios, respectively. Annual results for Poland and the Czech Republic were largely consonant with monthly water balance analyses; those for Ukraine differed significantly, with monthly analyses showing increased runoff compared to the decreases in the annual index. The authors concluded the annual index method could be useful for rapid analyses under conditions of limited climatological data availability.

Kertész and Mika (1999) documented increased warming and decreased precipitation in southeastern Europe, suggesting a general trend toward aridification, with declining ground water tables, land use changes, and potentials for soil erosion risk due to changing plant cover.

More comprehensive studies were completed by Arnell (1999). Arnell's work suggests a major decrease in runoff in southern CEE. Analyses were completed over a 0.5 degree grid, suggesting changes in total runoff and runoff timing by mid- and late-twenty first century. In general, runoff increases in the most northern areas, and decreases significantly in the southern under two GCM scenarios. This research appears to be very sensitive to spatial resolution in mountainous areas which are significant contributors to annual runoff. As Chang et al. (2003; this issue) suggest, finer spatial resolution yields different results, perhaps in relation to the necessary simplification of topography and climatic parameters in half-degree modeling resolution. The relationships between climate parameters and runoff is not linear with elevation, so flattening the landscape with low resolution models may be misleading.

Using the WaterGAP model (Alcamo et al., 2003), Henrichs and Alcamo (2001; see also Lehner et al., 2001) examined present and future water stress in Europe, defining stress as the proportion of water in a basin that is withdrawn in comparison to availability. Medium contemporary water

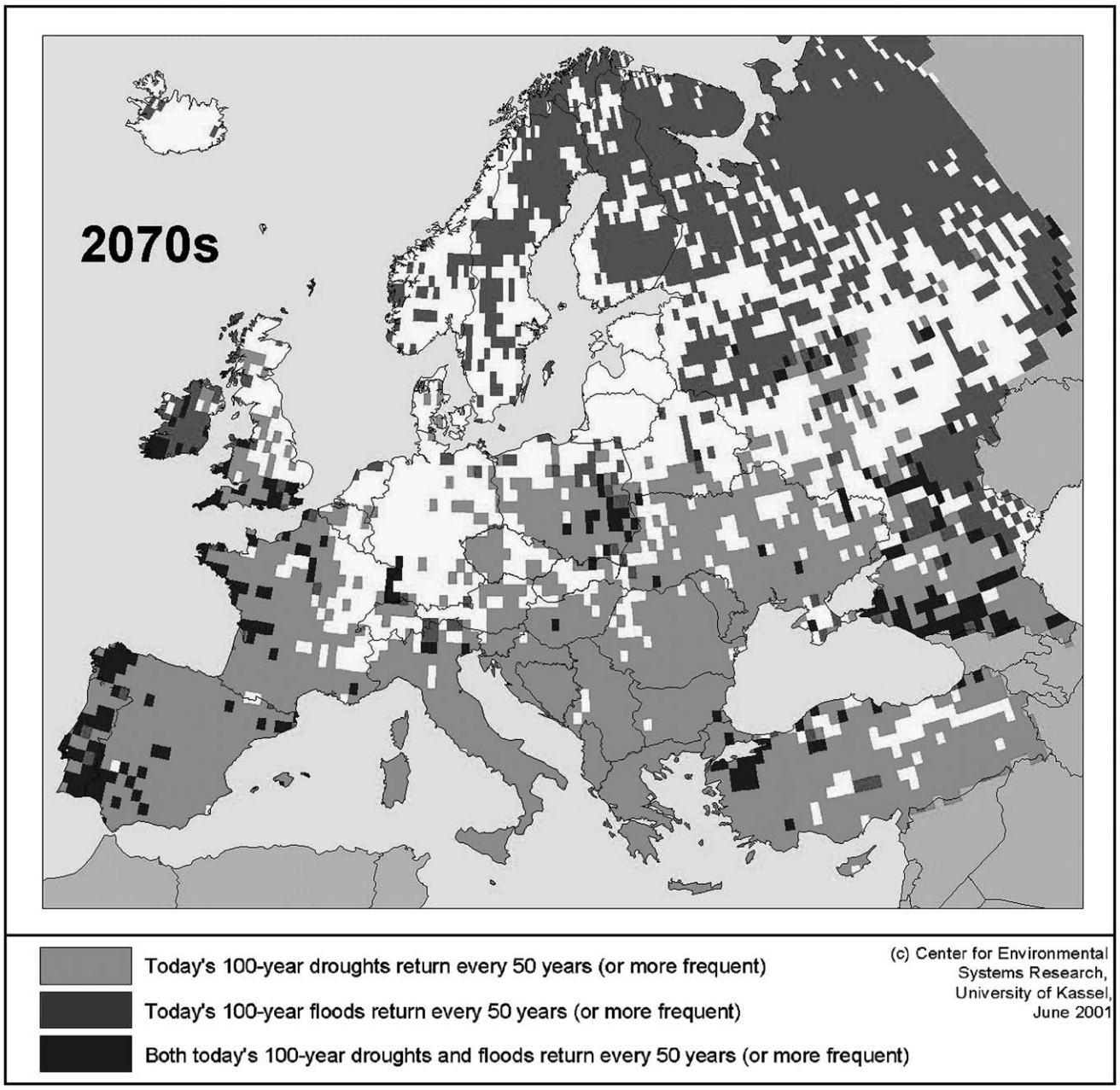

Figure 2. Changes in water resources in Europe – 2070. This page: Changes in Drought and Floods – 2070; Next page: Changes in Drought and Water Stress – 2070 (WaterGAP model; Henrichs and Alcamo, 2001; Lehner et al., 2001. © 2001 Center for Environmental Systems Research, University of Kassel. Reproduced with permission).

stress is already occurring in Poland and parts of Bulgaria, Romania, Ukraine and Moldova; severe stress in southern Bulgaria and much of former Yugoslavia. Climate change scenarios (ECHAM4 and HADCM3) show increasing water availability by the 2070s in the Baltics and northward, and decreasing availability in the central (ECHAM4) or southern (HADCM3) portions of CEE, with patterns somewhat similar to those derived by Arnell (1999). Using a scenario that assumes marked increase in thermal electric power generation and industrial water use across CEE, Henrichs and Alcamo (2001) project more than 50% increases in water stress throughout CEE, with a broad swath of countries (except the Baltic nations) having medium to severe water stress by the 2070s (Figure 2). These authors acknowledge, however, that the degree of change in stress is highly sensitive to socio-economic projections. WaterGAP may also be sensitive to simplification of topography.

At the national and basin levels, there have been a large number of studies of water resource impacts of climate change (for example, Kaczmarek, 1993, 1996; Dvorak et al., 1997; Liszewska and Osuch, 1997; Bürger, 2002, Chang et al., 2003). Most of these analyses addressed issues of river flow; some studied groundwater impacts; and others examine water supply issues. Few studies have addressed issues of water quality.

One example of research focused on climate change impacts on water quality was based on the Nitra River in the Slovak Republic (Carmichael et al., 1996). A com-

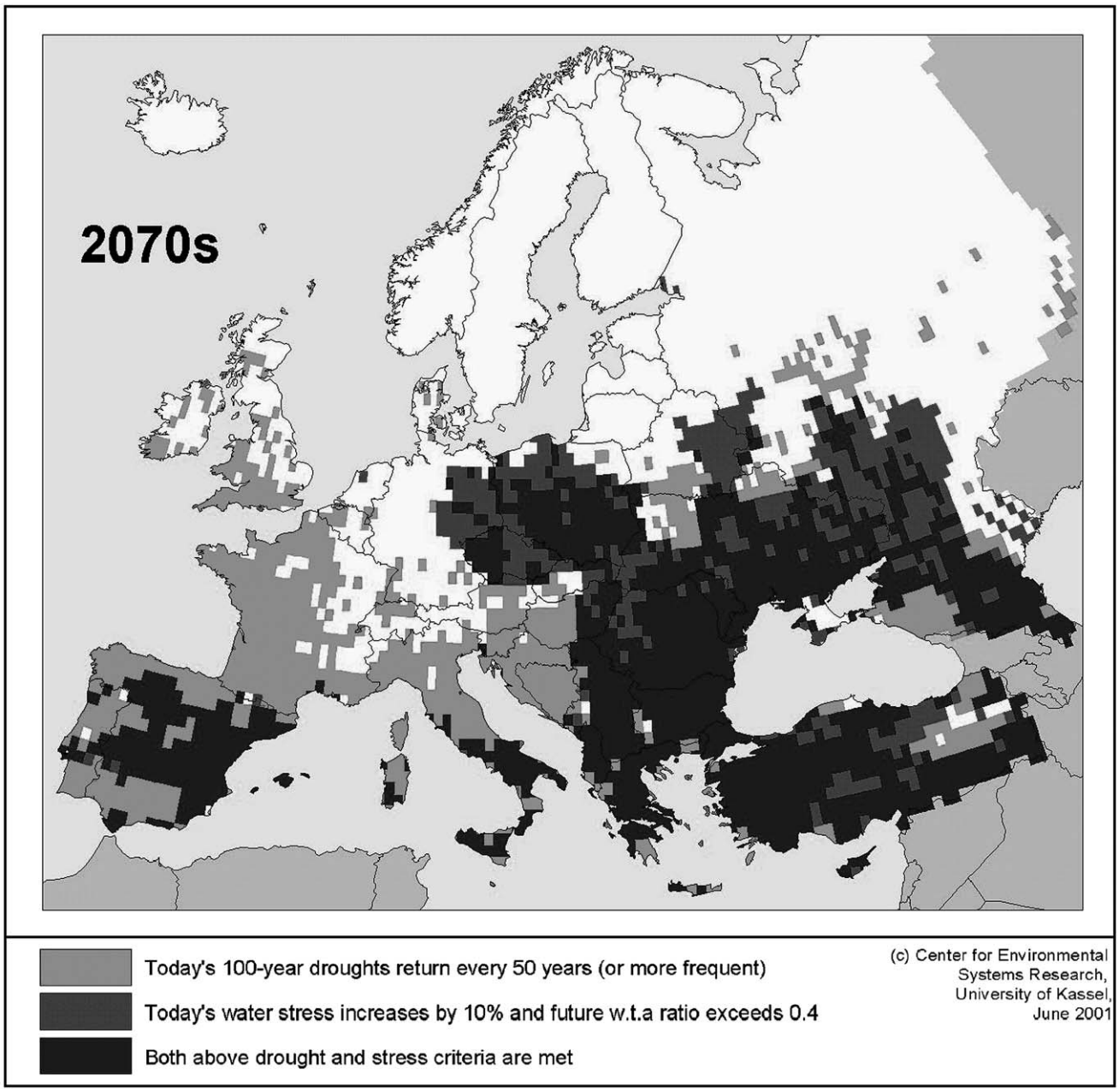

Figure 2. Continued.

bination of lower volume and warmer water decreases the ability of the river to assimilate pollutants, thus increasing treatment costs to maintain water quality. The River Environmental Knowledge and Assessment model (REKA) was built with collaboration of Carmichael, to address issues of maintaining or improving water quality in a Bulgarian basin under conditions of changing pollutant loading, land use, or climate change (Knight et al., 2002).

Agricultural impacts

Among the cascading impacts of changes in climate and water resources, agriculture and forestry have been, perhaps, the most studied in CEE. Olesen and Bindi (2002) reviewed research on climate change impacts on agriculture across Europe (including European Russia). Three of eight defined regions in Europe correspond with CEE as discussed in this article. Olesen and Bindi's Region 6 includes Poland and the Czech and Slovak Republics; Region 7 includes Hungary and the Balkans from Slovenia through Bulgaria; and region 8 includes European Russia and newly independent states from the Baltic and Belarus through Ukraine and Moldova. These regions are characterized by low and declining yields, low production intensities, and lower than anticipated yields based on agro-climatic considerations. In theory, increased CO_2 should increase yields, particularly in C_3 (e.g. wheat) versus C_4 (e.g. maize) plants. In the northern areas, growing seasons will be longer, whereas in southern areas higher temperatures will result in greater respiration and lower net growth, as well as early maturation. A summary of simulation studies suggests that the northern areas will have increased yields of all crops except sunflower, whereas in

the southern areas, soybean, potato and grape yields will increase by 2050, but grain maize and sunflower will have lower yields by 2050 and under double CO_2 conditions. In the south, wheat yields may increase by mid-century but will be lower under $2\times CO_2$. The "yield gap" between theoretically possible yields and real production in CEE is far greater than possible changes attributable to climate, so management issues (crop selection, production technology) become important adaptation strategies (Olesen and Bindi, 2002). Many of the studies done by CEE researchers on climate change impacts on agriculture are cited by Olesen and Bindi (2002), and two papers in this volume address agricultural issues (Corobov, 2003, this issue; Cuculeanu et al., 2003, this issue).

Coastal zones and wetlands

Studies in CEE have been made on the impacts of climate on sea and lake levels. For example, Zeidler (1997) suggested the potentials for great coastal damage and high costs in Poland. Recent work by Stanev and Peneva (2002) is another example of research in CEE addressing the sensitivity of sea level changes to atmospheric patterns. Here, the sensitivity of Black Sea to the North Atlantic Oscillation (NAO) and, more weakly, to the El Niño–Southern Oscillation (ENSO), is documented, with the suggestion that the water balance over the Black Sea basin will also affect salinity of the Aegean Sea and broader Mediterranean hydrology. Although the authors do not address application of future climate scenarios, the implication of their work is that GCM output could be used to project sea level changes in the Black Sea. Tran et al. (2003, this issue) also address the NAO and synoptic conditions over southeastern Europe contributing to drought.

Several of the USCSP reports and UN FCCC 'National Communications' address coastal issues, as noted previously. Prominent among them are Albania, Estonia and Ukraine (see also Kont et al., 2003).

Bulgaria, the Czech Republic, Estonia and Russia are among those countries whose wetlands are threatened by changing hydrological regimes that could encourage agricultural development of remaining wetlands. The need for buffer zones, sustainable use, and restoration were noted (Hartig et al., 1997).

CEE and international climate change, environment and scientific programs

CEE nations participate in a wide variety of international programs and activities, far beyond those reviewed here. Table 8 provides a summary of involvement; citations to specific programs are included in the table. In addition to the international programs, in every country environmental ministries, NGOs, scientific institutes, and researchers contribute directly or indirectly to climate change issues, by addressing climate policy and impacts, or by bringing understanding to existing and future environmental stresses.

International Human Dimensions Programme (IHDP)

IHDP is the human sciences organization parallel to the International Geosphere-Biosphere Program (IGBP) and the World Climate Research Program (WCRP). It is an international, interdisciplinary NGO with focus on human dimensions of global environmental change.

IHDP co-sponsors a nascent CEE regional network called SCENIC (Global Change **SC**ience in Eastern **E**urope and **N**ewly **I**ndependent **C**ountries), still in formative stages (START, 2003). The goal of this network is to bring together global change scientists from across CEE to develop collaborative research addressing common issues.

IHDP also supported the development of national 'human dimensions committees' through a program of small grants. In CEE, three countries have received support to review IHDP-related activities, two of which have designated national human dimensions committees: Bulgaria and Romania. In Bulgaria, 82 individuals and 22 organizations were identified as being affiliated with the National Coordination Center for Global Change, which was organized within the Bulgarian Academy of Sciences in 1997. In 2000, 66 Bulgarian projects related to climate change were identified, as well as 197 papers and reports in the areas of industrial transformation; global environmental change and human security; institutional dimensions of global environmental policy; land use and land cover change; biodiversity; climate change and risk management; public perception of GEC; human dimensions of GEC in mountain regions; coastal zones; water resource management and GEC; urbanization; health; data acquisition and integrated assessment; sustainable development; demographic processes and the environment; and vulnerability and impact assessment (Hristov, 2000).

In Romania, 69 specific projects related to IHDP activities were identified, along with 77 institutions working on issues similar to those listed for Bulgaria (Balteanu et al., 2002). We have found that neither the Bulgarian nor Romanian surveys are exhaustive; some relevant individuals and institutions were not included.

Researchers in Russia identified some 700 recent papers on IHDP related themes published between 1990 and 2001. Plans to establish a national human dimensions committee in 2003 were also reported to IHDP (Nikitina et al., 2001). IHDP also reported activities from national committees in Poland and the Czech Republic (IHDP, 2003).

International Geosphere-Biosphere Program

This international research organization on Earth systems, under auspices of ICSU (see below), is built around core scientific projects, all of which have global climate change dimensions,. Almost half of the CEE nations have national IGBP committees (Table 8).

UN FCCC

The United Nations Framework Convention on Climate Change secretariat administers the global program for GHG mitigation on behalf of the "Convention of the Parties".

Table 8. CEE country participation (*) in climate, environment and scientific programs

	AL	BA	BG	BY	CZ	EE	HR	HU	LT	LV	MD	MK	PL	RO	RU	SI	SK	UA	YU
Climate Change																			
IHDP			*											*			sc		
IGBP			*		*	*		*					*	*	*		*		
UNFCCC-A1			*	*	*	*	*	*	*	*			*	*	*	*	*	*	
UNFCCC-AB			92		92	92	95	94	92	92			94	92	100	92	92	100	
GEF/UNDP	2		1		3		4	5	4	2	2	3	8	2	5	3	2	3	
REC-CCP			*		*	*		*					*	*		*	*		
ICLEI-CCP					2			3		1			5	1	1	1		1	
Environment																			
SCOPE					*			*					*		*		*		
AGENDA-21	c	c	d	d	d	d	c	d	c	c	c	c	i	i	c	c	d	d	c
EEA	*		*	*	*	*	*	*	*	*		*	*	*	*	*	*		
ECNC					1	2	1	3					3	1	2	1	1	1	1
COB-NR			*	*	*	*		*	*				*	*	*	*	*	*	
MAB-BR		2	16		5+1		1	5		1			6+3	2+1	30		2+2	4+2	2
CEE-ILTER					*			*					*	*			*	*	
DIVERSITAS						c							c	c		NC	c		
IUCN			nm		gmn	n	n	mn		n	n		n	mn	gmn	m	nm	n	nm
NCSD				*	*	*		*	*	*	*		*	*		*	*	*	*
ICLEI	4	1	2		1	1	2	4		2			2	5	1		1	3	2
ECOLINKS			10+		+		4+	+				2	1+	12+			4	4	
GWP-CEE			*		*	*		*	*	*			*	*		*	*		
Scientific																			
HC-CBSS						*			*	*			*		*				
ICSU			*	*	*	*	*	*	*	*	*	*	*	*	*		*	ob	

IHDP: Human Dimensions Committees under IHDP; sc = Scientific Committee member (IHDP 2003)

IGBP: National Committee in the International Geosphere-Biosphere Program (IGBP 2003)

UNFCC A1: UNFCCC Annex1 country designation (industrialized nations; UNEP-FCCC 2002)

UNFCC AB: UNFCCC Annex B country designation (percent base year GHG reduction commitment; UNEP-FCCC 2002)

GEF/UNDP: Number of active climate change projects funded by GEF through the UNDP or IBRD (as of March 2003)

REC-CCP: Participation in the Regional Environmental Center for Central and Eastern Europe's Capacity for Climate Protection program (one of more local NGOs; REC 2003)

ICLEI-CCP: Number of member communities in the International Council for Local Environmental Initiatives Cities for Climate Protection Program (ICLEI 2003a)

SCOPE: National membership in the Scientific Committee on Problems of the Environment (SCOPE 2003).

AGENDA-21 National Sustainable Development Plan status as of 2002: i = implementation in progress; d = in development; c = components in place (UNDSD 2003)

EEA: Participation in the European Environment Agency (EEA 2003b).

ECNC: Number of representative organizations in the European Centre for Nature Conservation (ECNC 2003)

COB-NR: Convention on Biodiversity, availability of national report or plan (UNEP-GRID 2003)

MAB-BR: Number of biosphere reserves in the Man and Biosphere Program (UNESCO 2003); + indicates shared international reserves

CEE-ILTER: Participation in the Long Term Ecological Research network in CEE (LTER 2001)

DIVERSITAS: National Committee (NC) or existence of a contact point (c) in Diversitas (2003)

IUCN: Participation in the World Conservation Union (g = government, m = ministry, n = non-government organization(s) (IUCN 2003).

NCSD: Membership in National Councils for Sustainable Development (NCSD 2003).

ICLEI: Number of member communities in the ICLEI network (ICLEI 2003b)

ECOLINKS: Projects and (+) focal countries in the USAID Ecolinks activity (USAID 2003)

GWP-CEE: Participation in the Global Water Partnership, Central and Eastern Europe (GWP 2003a)

HC-CBSS: Participation in the Helsinki Commission, Governing Body of the Helsinki Convention (HELCOM 2003); Council of the Baltic Sea States member

ICSU: National academy of sciences participation in the International Council of Scientific Unions; ob = observer status (ICSU 2003)

Most CEE countries are listed in Annex 1, that is, they are industrialized nations committed to GHG reduction, and in Annex B, have committed to specific targets during the period 2008–2012 (Table 8). As noted, 'National Communications' report the status of this commitment as well as vulnerability, adaptation, and public involvement issues.

Global Environmental Facility (GEF)

Established by implementing agencies, the World Bank, the UN Development Programme (UNDP), and the UN Environment Programme (UNEP), GEF is the financial arm of the UN FCCC. Its "National Communications Support Program" assists nations in meeting UN FCCC report requirements (UNDP, 2003a).

The Global Environmental Facility is supporting a number of energy efficiency, GHG mitigation, and capacity building projects for meeting UN FCCC reporting requirements in CEE countries (Martinot and McDoom, 2000), in addition to a region-wide "Balkans Energy Efficiency Program (BEEP)" and "Capacity-building for Improving the Quality of Greenhouse Gas Inventories (Europe and CIS)". There were some 49 active GEF climate-change-related activities in CEE at the time of writing (Table 8).

In addition to the foregoing programs, the Greek program, "Capacity Building Program for the Balkans" is addressing GHG mitigation and energy efficiency through a series of workshops in, and collaboration with, selected institutions in Albania, Bosnia-Herzegovina, Bulgaria, FYROM (Macedonia), Romania and Yugoslavia. This program has goals similar to those previously mentioned, with focus on mitigation of GHG (DAC, 2002). An impacts component is less well developed.

Regional Environmental Center for Central and Eastern Europe

REC is a non-governmental organization based in Hungary. REC's climate change program, "Capacity for Climate Protection", has a goal of assisting nations in addressing issues of greenhouse gas mitigation and energy efficiency. The program, funded by international donor organizations, works with NGOs in constituent countries (Table 8).

International Council for Local Environmental Initiatives (ICLEI)

ICLEI is an organization supporting local communities in addressing sustainable development. Thirty one CEE communities participate in ICLEI (Table 8). One program within ICLEI is the "Cities for Climate Protection" initiative to address GHG emissions and air pollution (ICLEI, 2003b); fifteen CEE cities participate in the CCP program.

SCOPE

SCOPE (Scientific Committee on Problems of the Environment) is an international interdisciplinary program under ICSU (see below) devoted to environmental issues and related policy concerns. Major program areas include: "Managing Societal and Natural Resources", "Ecosystem Processes and Biodiversity", and "Health and Environment" (SCOPE, 2003). Only a few CEE countries are members (Table 8).

Agenda 21 and the UN Commission for Sustainable Development

At the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil, in 1992, world nations adopted the Rio Declaration on Environment and Development. Agenda 21 is a plan for environmental improvement and sustainable development that calls for national strategy plans through the organizational mechanism of the UN Commission on Sustainable Development. Only two CEE countries have moved beyond the planning to implementation stage, Poland and Romania (Table 8).

The United Nations Development Programme's Regional Bureau for Europe and the Commonwealth of Independent States includes a regional environment program whose objective is to integrate environmental protection with economic and social development. Meeting national Agenda 21 goals are part of the program activities (UNDP, 2003b).

European Environment Agency (EEA)

All CEE countries, with the exceptions of Bosnia-Herzegovina, Moldova, Ukraine and Serbia and Montenegro, participate in activities of the EEA. Among other responsibilities, EEA has coordinated the preparation of the three state of the environment reports cited previously, the third of which gives specific attention to CEE and the newly independent states of the former Soviet Union. EEA is an organization for dissemination of information to decision makers and the public; it has no regulatory responsibilities. However it has a major role in guiding CEE countries to monitor and report environmental conditions in a uniform system.

European Centre for Nature Conservation

The European Centre for Nature Conservation (ECNC) is an umbrella organization of universities, institutes, environmental agencies and information centers dedicated to supporting nature conservation policy. Many CEE countries have participating organizations in ECNC.

Convention on Biodiversity

Similar to the Agenda 21 plans, national reports or plans under this international agreement again contribute to environmental awareness and protection. COB is governed by a "Conference of the Parties" not unlike the UN FCCC mechanism, with a secretariat based in Montreal, Canada. More than half of CEE nations have so far participated in COB.

Man and the Biosphere Program

Among CEE nations, Bulgaria has the greatest number of biosphere reserves (16) in UNESCO's Man and the Biosphere Program (Table 8). The importance of these reserves for climate change research is their potential as long term ecological monitoring sites for environmental impacts.

Long Term Ecological Research

As part of the International Long Term Ecological Research program, a CEE regional LTER network, based in the Czech Republic, has six CEE representatives. The goals of LTER include prevention of environmental damage, understanding of ecosystem dynamics, maintaining biodiversity, and prediction of future states of ecological systems. Cooperative projects, scientific meetings, and publications are the mechanisms used. In the same way as the MAB reserves, LTER offers the potential for understanding climate change impacts.

DIVERSITAS

DIVERSITAS is the biodiversity component of the four part network of international global change programs which also includes IHDP, IGBP, and the World Climate Research Program (WCRP). CEE participation in this relatively new program is limited to several national contact points; only Russia has a national DIVERSITAS committee.

World Conservation Union (IUCN)

The IUCN is also an umbrella organization of government, ministry and non-governmental organizations for environmental conservation and ecological sustainability. A majority of CEE nations have participating organizations (Table 8).

National Councils for Sustainable Development

Many CEE countries are represented in the National Councils for Sustainable Development network The goals of this umbrella organization include bringing governments and civil society together for sustainable development; integrating economic, social and environmental actions; and bringing Agenda 21 to the local level (NCSD, 2003).

Ecolinks

Ecolinks is an activity funded by the U.S. Agency for International Development to build within-country partnerships between business, government and associations, and between these entities and partner organizations in the US to address environmental problems, choose appropriate technology, and adopt environmental 'best management' practices. Six CEE countries are focal in this program; an additional three also participate (Table 8).

Global Water Partnership

The Global Water Partnership, based in Sweden, is an organization committed to sustainable water development through assistance to regions, nations, and local entities. GWP has independent regional foci, including CEE. Twelve CEE nations are represented in GWP activities, which include newsletters, research, planning documents, water clubs, and advice to river basin organizations. The CEE regional activity maintains its own web site (GWP-CEE, 2003b). Given the importance of water in climate change, GWP activities are of great regional importance.

Helsinki Commission

The Helsinki Commission (HELCOM) seeks intergovernmental co-operation to address issues of marine pollution in the Baltic Sea. It derives from the Convention on the Protection of the Marine Environment of the Baltic Sea Area, more popularly the Helsinki Convention. Poland, Russia and the Baltic nations are signatories. HELCOM is an example of efforts that could prove important under climate change.

Although studies of climate change impacts on water quality in CEE are scarce, global warming could accelerate eutrophication processes with negative coastal and marine impacts, particularly from changes in overland runoff and non-point source pollutants, as well as changes in stream assimilation due to changes in temperature and flow.

International Council for Science (ICSU)

As a major international NGO with national science council members, ICSU is the parent organization for international interdisciplinary scientific organizations, including IGBP and SCOPE, and is a co-sponsor of IHDP. Most CEE national academies of science are ICSU members (Table 8).

Observations

The foregoing survey of CEE international global change, environmental and scientific involvement demonstrates that these nations are well poised for national and international research collaboration on global climate change, impacts, vulnerabilities, and adaptation. What is missing is the synergism within and between countries for bringing existing knowledge into an integrated regional assessment framework (see, for example, Knight, 2001; Rosenzweig, 2001). That step does not need to be far off.

New opportunities

The European Union's 6th EU Environmental Action Programme includes a specific climate change element. Goals are to:
(1) Achieve international agreement on the Kyoto Protocol and put it into practice;
(2) Set objectives for cutting greenhouse gas emissions in the main economic sectors;
(3) Establish a scheme for 'trading' greenhouse gas emissions within the European Union by 2005;

(4) Support renewable energy sources, such as wind and solar power;
(5) Help Member States to prepare for the consequences of climate change (European Commission, 2001).

Within the EU, there is a "burden sharing" agreement that set limits for each EU country in meeting overall GHG mitigation goals; presumably CEE countries entering the EU could bring with them 'over achievement' status that could be recognized within European goals. Five CEE countries–Czech Republic, Estonia, Latvia, Poland and the Slovak Republic—have already met GHG mitigation goals.

The last goal–preparing for climate change–provides important opportunities for aspiring EU members in CEE to collaborate with EU institutions in moving toward integrated assessment of climate change impacts, including adaptation strategies.

Comments specific to CEE countries

In this section we return to the national scale, offering some comments based on climate change research within the CEE nations. In virtually all cases, there are significant local research and institutional capabilities to address climate change. National environmental reports, for example those addressing Agenda 21 (UNDSD, 2003), along with the 'National Communications' demonstrate the depth of professional competence and institutional breadth in the region.

Beginning in the Balkans, *Albania* is late on the scene for climate change research, but its 'National Communication' suggests considerable and growing capacity for meaningful contributions. The former countries of Yugoslavia are less involved with climate change issues. *Bosnia-Herzegovina* has had little involvement thus far, not surprising given the efforts of rebuilding a multi-ethnic nation state: climate change is simply not on the agenda. *Croatia* and *Macedonia* are making considerable strides; *Serbia and Montenegro* has not reported to UN FCCC, yet the reputation of scientists from this country is long standing. *Slovenia*, the wealthiest CEE nation, has a strong tradition of environmental research which is available for impact assessment, as indicated by its 'National Communication.' Slovenia's on-line water atlas provides another example for a potential public outreach strategy about environmental and global change issues (Slovenia, 2003).

Bulgarian scholars have made major contributions to international research in the agricultural and forestry areas (see examples in Staneva et al., 2000). A forthcoming book on drought as an analogy for climate change (Raev et al., 2003; Knight et al., in preparation) explores the issue of what can be learned from the impacts of, and responses to, a seemingly unusual dry period that may represent normal future climate. The National Coordination Center for Global Change, based in the Bulgarian Academy of Sciences, is a focal point.

In central Europe, the *Czech Republic* has a formidable national climate change program with numerous research publications (CHI, 2000). Strengths include climate scenarios, hydrology, agriculture, and forests. The *Slovak Republic* has similar research strengths; a Slovak national is a member of the Scientific Committee of IHDP. This person is the only individual from CEE on a steering body of the four global change programs (IHDP, IGBP, WCRP, DIVERSITAS).

Poland and *Hungary* both have long traditions of contributions to environmental and global change issues. Both nations host a unit of the United Nations Environment Programme's GRID (Global Resource Information Database; UNEP, 2003). In Poland, an on-line environmental atlas and many other products speak to GRID-Warsaw's mapping capabilities. GRID-Budapest, funded by PHARE ("Poland and Hungary Assistance for the Restructuring of the Economy") focuses on environmental information for Hungary. Hungary participated in a UNEP/GEF Project, "Economics of Greenhouse Gas Limitations" (UNEP-CCEE, 2003) with a report on the economics of GHG mitigation in Hungary (Ürge-Vorsatz and Füle, 1999).

In east-central Europe, *Moldova* and *Romania* both have established global change research communities and scholars, with greatest strength in the agricultural and ecological areas. Romania has an International Human Dimensions of Global Environmental Change National Committee. Moldova has a similar activity related to UN FCCC, the National Committee on Climate Change (Carman, 2000).

Ukraine has established a national focal point similar to Bulgaria, the Climate Change Initiative Center (Ukraine, 2002). The initiative focuses strongly on GHG mitigation and energy efficiency, but has an important public awareness component and an intriguing on-line "solar school" to explain global warming issues to children (in Ukrainian). *Belarus* has yet to produce a 'National Communication,' but there exists a national climate program, documented by Loginov (1999), which focuses largely on GHG mitigation. An intergovernmental Working Group on Climate Change is based in the Belarus Ministry of Environmental Protection (Carman et al., 2000).

Finally, in the Baltics, *Estonia* had one of the earlier multiple sector assessments; it was the only CEE country selected to do a detailed impact analysis in the "Country Case Study on Climate Change Impacts and Adaptation Assessments" project sponsored by UNEP and GEF (Kallaste and Kuldna, 1998). In many domains, this project reviewed only existing trends related to climate, but in some categories explicit attention was given to climate change. The most important issues for Estonia were determined to be water resources and primary production from agriculture and forests (Table 9). This study, while comprehensive, was not an integrated regional assessment, since it lacked interconnections and feedbacks among sections, and did not trace impacts through the socio-economic systems. Nevertheless, this analysis and the 'National Communication' demonstrate considerable capability. Estonia also participated in the UNEP/GEF "Economics of Greenhouse Gas Limitations" project (Kallaste, 1999). Major climate change

Table 9. Some potential climate change Impacts in Estonia

Impact Type	Nature of Impact	Possible Significance
Phenological Baltic Sea Temperature ↑	Variable Changes Phytoplankton bloom ↑	Not stated Earlier/longer blooms
Ground Water Levels	Greater recharge	Improved potable water supply (+); Better groundwater self purification (+); Faster movement of pollution plumes (−); Threats to farming & structures (−)
River Runoff	Greater amounts; changing seasonality	Earlier winter/spring runoff; longer summer low flows (−)
Agriculture	Longer seasons	Crop and location dependent; mixed results
Grassland husbandry	Fodder production	Improved productivity (+)
Forestry	Productivity increase	High sensitivity to management & harvest strategies

Source: Summary judgments made on the basis of text in Kallaste and Kuldna (1998).

issues for Estonia are addressed by Kont et al. (2003, this issue).

Latvia and *Lithuania*, along with Estonia, are involved in many Baltic environmental projects (BEF 2001 is an example). Progress is being made on impact analysis, but collaboration with neighbors might be helpful. Zalakevicius (2003, this volume) examines climate change impacts on birds in Lithuania.

Conclusions

Overall, there have been considerable research contributions on climate change and impacts in CEE, much done by local scientists. However, most of this work is not integrated within countries, let alone across regions. Thus, there is a significant opportunity for researchers and teams to bring together existing knowledge and to undertake holistic climate impact studies that will inform policy makers and the general population of forthcoming challenges and opportunities. So far, efforts at public outreach and stakeholder participation in assessment activities are limited. Typically, uncertainties are noted qualitatively, but not investigated in detail.

Among many potential items on a climate change research agenda for CEE could be:
(1) Studies of the impacts of climate change and the drive to EU accession on sustainable development opportunities during the period of socio-economic transition;
(2) Comparative international studies of climate change impacts in specific categories at the national and local level, using common GHG emission scenarios, GCM scenarios, climate downscaling, and impact assessment models;
(3) Understanding institutional dimensions of climate change from the viewpoint of research infrastructure, environmental and industrial technology areas;
(4) Understanding national and regional dimensions of environmental and social security, vulnerability, and opportunities;
(5) Research on maintaining fortuitous gains in environmental pollution (e.g. water and air quality) during the period of restructuring and climate change;
(6) Comparative sharing of educational outreach, public information, and stakeholder involvement;
(7) Participation in international networks of human-environment regional observatories, parallel to LTER, to document long-term trajectories of environmental, land-use, socio-economic, and institutional change, with CEE providing the unique examples of regions in transition; and
(8) Integrated assessment of climate change impacts at regional, national and local scales, particularly in terms of ecological, social, economic, and natural hazard dimensions.

We see the need for integrated regional and national assessments as most urgent. Strategies for completion of 'National Communications' to the UN FCCC from CEE nations, as well as examples of national and regional climate change assessments from other countries and from the scholarly literature can point the way. The EU Sixth Environmental Action Programme's climate change element (including GHG mitigation and planning for climate change; European Commission 2001, 2002) could provide impetus and funding for such efforts, beyond the sources of support already available.

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References

Albania, 2002: *The First National Communication of the Republic of Albania to the United Nations Framework Convention on Climate Change (UN FCCC).* Ministry of Environment, Tirana.

Alcamo J. *et al.*, 2003: Development and testing of the WaterGAP 2 global model of water use and availability. *Hydrological Sciences–Journal–des Sciences Hydrologiques* **48**(3): 317–337.

Arnell N.W. 1999: The effect of climate change on hydrological regimes in Europe: A continental perspective. *Global Environmental Change* **9**: 5–23.

Babiker M.H. *et al.*, The evolution of a climate regime: Kyoto to Marrakech and beyond, *Environmental Science & Policy* **5**(3): 195–206

Balteanu D. *et al.* (eds), 2002: *Who is Doing What in Romania? Inventory of Human Dimensions Research.* Bucharest: Report Prepared for the International Human Dimensions Programme on Global Environmental Change (IHDP), 76 pp.

Baltic Assembly, 2003: http: //www.baltasam.org/cover.htm.

Baltic Environmental Forum, 2001: *2nd Baltic State of the Environment Report.* http://www.bef.lv/baltic/baltic2/content.htm.

Beniston M. and Tol R.S.J. (eds), 1997: Chapter 5: Europe. In: R. Watson *et al.* (eds), *IPCC Special Report on The Regional Impacts of Climate Change, An Assessment of Vulnerability.* http://www.grida.no/climate/ipcc/regional/091.htm.

Boschet A-F., Nixon S.C. and Lack T.J. 2001: *European Topic Centre on Inland Waters.* European Environmental Agency, Copenhagen.

Brouwer F. and Falkenmark M., 1989: Climate-Induced Water Availability Changes in Europe. *Environmental Monitoring and Assessment* **13**(1): 75–98.

Bulgaria, 2002: *Third National Communication on Climate Change.* Sofia.

Bürger G., 2002: Selected precipitation scenarios across Europe, *Journal of Hydrology* **262**: 99–110.

Carman R., 2000: *Regional Exchange Workshop on Climate Change, Europe and Commonwealth of Independent States* (Yerevan, Armenia, 10–12 October 2000). National Communications Support Program, UNDP-GEF, New York.

Carman R., Lim B. and Schipper L., 2000: *Thematic Workshop on Vulnerability and Adaptation Assessment* (Chisinau, Moldova, 26–28 January 2000). New York, National Communications Support Program, UNDP-GEF.

Carmichael J.J., Strzepek K.M. and Minarik B., 1996: Impacts of Climate Change and Seasonal Variability on Economic Treatment Costs: A Case Study of the Nitra River Basin, Slovakia. *International Journal of Water Resources Development* **12**: 209–228.

Carter F.W. and Turnock D. (eds), 1993: *Environmental problems in Eastern Europe.* Routledge, London.

Carter F.W. and Turnock D. (eds), 1996: *Environmental problems in Eastern Europe*, updated edition. Routledge, London.

Carter F.W. and Turnock D. (eds.), 2002. *Environmental problems of East Central Europe*. Routledge, London.

Cherp A., 2001a: Environmental assessment in countries in transition: Evolution in a changing Context. *Journal of Environmental Management* **62**: 357–374.

Cherp A., 2001b.: Environmental assessment legislation and practice in eastern Europe and the former USSR. EIA Review **21**: 335–361. Corobov R. 2003. Estimations of climate change impacts on crop

Cramer W. *et al.* (eds), 2001: Europe. In: McCarthy, J.J. *et al.* (eds), *Climate Change 2001: Impacts, Adaptation and Vulnerability* Cambridge University Press, Cambridge and NY.

Croatia, 2001: *The First National Communication of the Republic of Croatia to the United Nations Framework Convention on Climate Change (UN FCCC).* Ministry of Environmental Protection and Physical Planning. Zagreb.

Czech Hydrometeorological Institute, 2000: *National Climate Program of the Czech Republic.* http://www.chmi.cz/info/nkpe.html.

Czech Republic, 2001: *The Czech Republic's Third National Communication on the UN Framework Convention on Climate Change.* Prague: Ministry of the Environment of the Czech Republic and Czech Hydrometeorological Institute.

Development Assistance Committee, 2002: *Capacity Building and Climate Change*, Greek Ministry for the Environment, Physical Planning Public Works. http://env.meteo.noa.gr/BalkanClimate/.

DIVERSITAS, 2003: *An International Program of Biodiversity Science.* http://www.diversitas-international.org/

Dixon R.K., 1997: Climate change impacts and response options in Eastern Europe and Central Europe. *Climatic Change* (Special Issue) **36**(1–2) 232.

Dvorak V., Hladny J. and Kasparek L., 1997: Climate change hydrology and water resources impact and adaptation for selected river basins in the Czech Republic. *Climatic Change* **36**: 93–106.

Estonia, 2001: *Estonia's Third National Communication Under the UN Framework Convention on Climate Change.* Ministry of the Environment Tallinn.

European Centre for Nature Conservation 2003: http://www.ecnc.nl/

European Commission, 1999: *EC Economic and Development Co-Operation: Responding to the New Challenges of Climate Change.* Luxembourg: Office for Official Publications of the European Communities.

European Commission, 2001a: *Environment 2010: Our Future, Our Choice. 6th EU Environment Action Programme.* Luxembourg: Office for Official Publications of the European Communities.

European Commission, 2001b: *Communication from the Commission to the Council, The European Parliament, The Economic And Social Committee and The Committee Of The Regions, On the Sixth Environment Action Programme of the European Community 'Environment 2010: Our future, Our choice.'* Brussels, 24.1.2001 COM (2001) 31 final 2001/0029 (COD).

European Commission, 2002: *EU focus on climate change.* Luxembourg: Office for Official Publications of the European Communities

European Environment Agency, 1998: *Europe's Environment: The Second Assessment.* Luxembourg: Office for Official Publications of the European Communities; Oxford, UK: Elsevier Science Ltd. http://reports.eea.eu.int/92-828-3351-8/en.

European Environment Agency, 2002: *Greenhouse Gas Emission Trends and Projections in Europe.* Copenhagen: EAA. http://reports.eea.eu.int/report_2002_1205_091750/en.

European Environment Agency, 2003a: *Europe's Environment: The Third Assessment.* Copenhagen: EEA Environmental assessment report No 10.

European Environment Agency, 2003b: *European Environment Agency, Home Page.* http://www.eea.eu.int

Evans M., 2003: Emissions trading in transition economies: the link between international and domestic policy. *Energy Policy* 31,9: 879–886.

Global Environmental Facility, 2003: *Project Map.* http://www.gefonline.org/home.cfm.

Global Water Partnership., 2001: *Our Vision for Water in the 21st Century – Central & Eastern Europe.* Stockholm: GWP. http://www.gwpforum.org/gwp/library/Cent & Eastern Europe.pdf.

Global Water Partnership, 2003a: *Central & Eastern Europe.* http://www.gwpforum. org/servlet/PSP?iNodeID=125#.

Global Water Partnership, 2003b: *GWP-Central and Eastern Europe.* http://www.gwpcee.org.

Guerrie M.D. and Delfino J.J., 2002: *Central and Eastern Europe's Water – Bridging the Gap between the Present and the World Water Council's Vision for Water in 2025.* Department of Environmental Engineering Sciences, University of Florida, Gainesville. www.wfeo-comtech.org/WorldWaterVision/ CEEWaterVision2025WFEO.pdf.

Hartig E.K., Grozev O. and Rosenzweig C, 1997: Climate Change, Agriculture and Wetlands in Eastern Europe: Vulnerability, Adaptation and Policy. *Climatic Change* **36**: 107–121.

Helsinki Commission, 2003: *The Baltic Marine Environment Protection Commission (HELCOM).* http://www.helcom.fi/helcom.html.

Henrichs T. and Alcamo J, 2001: Europe's Water Stress Today and in the Future, Chapter 5 in Lehner *et al.* 2001. Center for Environmental Systems Research, University of Kassel, Germany. www.usf.uni-kassel.de/usf/archiv/dokumente/ kwws/5/ew_5_waterstress_low.pdf.

Hristov T.N., 2000: *Bulgaria: Capacity Building for the Bulgarian Human Dimension Programme*, Sofia: Report to the International Human Dimensions Programme, 138 pp.

Hungary, 2002: Hungary, *3rd National Communication for the UN FCCC.* Budapest: Systemexpert Consulting.

International Council for Local Environmental Initiatives. 2003a. Cities for Climate Protection. .http://www.iclei.org/co2/index.htm.

International Council for Local Environmental Initiatives. 2003b. ICLEI members by Region: Europe.http://www3.iclei.org/iclei/mem_by_region.cfm?region=EU.

International Council for Science (ICSU), 2003: http://www.icsu.org/.

International Geosphere-Biosphere Program, 2003: IGBP National Committees. http://www.igbp.kva.se.

International Human Dimensions Programme, 2003: National Committees & Seed Grants Initiative. http://www.ihdp.uni-bonn.de/html/who/natcom-set.html.

IPCC Data Distribution Center, 2003: http://ipcc-ddc.cru.uea.ac.uk.

IPCC, 1996a: Climate Change 1995: The Science of Climate Change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change In: Houghton J.J., Meiro Filho L.G., Callander B.A., Harris N., Kattenberg A., and Maskell K. (eds). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 572 pp.

IPCC, 1996b: Climate Change 1995: Impacts, Adaptations, and Mitigation of Climate Change: Scientific-Technical Analyses. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change. In: Watson R.T., Zinyowera M.C., and Moss R.H. (eds), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 880 pp.

IPCC, 1996c: Climate Change 1995: Economic and Social Dimensions of Climate Change. Contribution of Working Group III to the Second Assessment Report of the Intergovernmental Panel on Climate Change In: Bruce J.P., Lee H. and Haites E.F. (eds), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 448 pp.

IPCC, 2001a: *Climate Change 2001: The Scientific Basis.* Cambridge University Press. Cambridge and NY: http://www.grida.no/climate/ipcc_tar/

IPCC, 2001b: *Climate Change 2001: Impacts, Adaptation and Vulnerability*. Cambridge University Press. Cambridge and NY: http://www.grida.no/climate/ipcc_tar/wg2/index.htm.

IPCC 2001c: *Climate Change 2001: Mitigation.* Cambridge and NY: Cambridge University Press. http://www.grida.no/climate/ipcc_tar/.

IPCC, 2001d: Technical Summary: Climate Change 2001: Impacts, Adaptation and Vulnerability, in *Climate Change 2001: Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change.*: Cambridge University Press. Cambridge and NY http://www.grida.no/climate/ipcc_tar/vol4/english/index.htm.

IPCC, 2002: *IPCC Workshop on Changes in Extreme Weather and Climate Events.* www.ipcc.ch/pub/extremes.pdf.

ISO (International Organization for Standardization), 2003. *ISO 3166 Code Lists.* http://www.iso.ch/iso/en/prods-services/iso3166ma/02iso-3166-code-lists/index.html.

IUCN, 2003: *The World Conservation Union.* http://www.iucn.org/.

Jansson B-O. and Stålvant C-E., 2001: The Baltic Basin Case Study: Towards a Sustainable Baltic Europe. *Continental Shelf Research* 21: 1999–2019.

Kallaste T. and Kuldna P. (eds), 1998: *Climate Change Studies in Estonia.* Stockholm Tallinn Environment Institute Tallinn Center and Ministry of Environment, Republic of Estonia.

Kallaste T., 1999: *Economics Of Greenhouse Gas Mitigation, Estonia Country Study.* UNEP Collaborating Centre on Energy and Environment, Risø National Laboratory, Denmark.

Kaczmarek Z., 1993: Water balance model for climate impact assessment, *Acta Geophysica Polonica* 41: 423–437.

Kaczmarek Z. *et al.*, 1996: Climate Change Impacts on the Water Supply System in the Warta River Catchment, Poland. *International Journal of Water Resources Development* **12**: 165–180.

Kertész Á. and Mika J., 1999: Aridification – Climate Change in South-Eastern Europe, *Physics and Chemistry of the Earth, Part A: Solid Earth and Geodesy* **24**: 913–920.

Knight C.G., 2001: Regional Assessment In A.S. Goudie (ed.), *Encyclopedia of Global Change*, Vol. 2, pp. 304–308. Oxford University Press, New York.

Knight C.G. *et al.*, 2002: *River Environmental Knowledge and Assessment – REKA, Applied to the Yantra River Basin.* National Coordination Center for Global Change, Sofia.

Knight C.G., Raev I. and Staneva M.P. (eds), 2004: *Drought in Bulgaria, A Contemporary Analog for Climate Change*. Aldershot, UK: Ashgate (in press).

Kont A., Jaagus J. and Aunap R., 2003a: Climate change scenarios and the effect of sea-level rise for Estonia, *Global and Planetary Change* **36**(1-2): 1–15.

Kundzewicz Z.W., 2001: Water problems of central and eastern Europe–a region in transition. *Hydrological Sciences–Journal–des Sciences Hydrologiques* **46**(6): 883–896.

Kundzewicz Z.W. and Somloydi L., 1997: Climatic Change Impact on Water Resources in a Systems Perspective, *Water Resources Management* **11**: 407–435

Latvia, 2001: *The Third National Communication of the Republic Of Latvia Under United Nations Framework Convention On Climate Change.* Ministry of Environmental Protection and Regional Development, Riga.

Leemans R. and Cramer W.P., 1991: *The IIASA Database for Mean Monthly Values of Temperature, Precipitation, and Cloudiness on a Global Terrestrial Grid*, IIASA Research Report RR-91-18. International Institute for Applied Systems Analysis, Laxenburg, Austria.

Lehner B, Henrichs T, Döll P and Alcamo J., (2001): *EuroWasser – Model-based assessment of European water resources and hydrology in the face of global change.* Kassel World Water Series 5, Center for Environmental Systems Research, University of Kassel. http://www.usf.uni-kassel.de/usf/archiv/dokumente/kwws/kwws.5.en.htm.

Lenhart S. *et al.* (eds.), 1996: *Vulnerability and Adaptation to Climate Change–A Synthesis of Results from the U.S. Country Studies Program. Interim Report. January 1996*, U.S. Country Studies Program, Washington, DC, USA, 366 pp.

Liszewska M. and Osuch M., 1997: Assessment of the impact of global climate change simulated by the ECHAM1/LSG general circulation model onto hydrological regime of three Polish catchments, *Acta Geophysica Polonica* **45**: 363–386.

Lithuania, 2003: *Lithuania's Second National Communication under the Framework Convention on Climate Change* Vilnius: Ministry of the Environment.

Loginov V.F. 1999: *The National Climatic Program.* Minsk, Belarus: Institute of Geological Sciences of NASB (in Russian).

Long Term Ecological Research – Central and Eastern Europe, 2001.: *CEE Regional ILTER.* http://www.lter.cz/.

Macedonia, 2003: *Macedonia's First National Communication under the United Nations Framework Convention on Climate Change.* Skopje: Ministry of Environment and Physical Planning.

Martinot E. and McDoom O., 2000: *Promoting Energy Efficiency and Renewable Energy: GEF Projects and Impacts.* Global Environment Facility, Washington.

Maziliauskas A., 2000: Water Resources Management in the Baltic States, paper presented at EXPO2000, Hannover, Germany, 17 August 2000. http://www.zef.de/gdialogue/Program/Papers_Day_3/ws-water-maziliauskas.pdf.

Mnatsakanian R., 1992: *Environmental Legacy of the Former Soviet Republics*. Centre for Human Ecology, University of Edinburgh, Edinburgh.

Mnatsakanian R., 2000: *Environmental Lab Collection,* Central European University, Budapest. http://www.ceu.hu/envsci/geo/geo.htm.

Moldova, 2000: *First National Communication of The Republic of Moldova Under The United Nations Framework Convention on Climate Change.* Chisinau: Ministry Of Environment and Territorial Development.

National Councils for Sustainable Development. 2003: http://www. ncsdnetwork.org/features.htm.

Nikitina E., Poussenkova N., Rubina S. and Zuikova G., 2001: *Who is Doing What in Russia? Bibliography on Human Dimensions of Global Environmental Change Research (1990–2000)*. Moscow: Institute of World Economy and International Relations, 50 pp.

Nixon S.C. *et al.*, 2000: *Sustainable use of Europe's water? State, prospects and issues.* European Environment Agency, Copenhagen.

O'Connor R.E., Bord R.J., Fisher A., Staneva M., Kozhouharova-Zhivkova V. and Dobreva S. 1999: Determinants of support for climate change

policies in Bulgaria and the USA. *Risk Decision and Policy* **4**(3) 255–269.

Olesen J.E. and Bindi M., 2002: Consequences of climate change for European agricultural productivity, land use and policy. *European Journal of Agronomy* **16**: 239–262.

Parry M. *et al.*, 2002: Scenarios for climate impact and adaptation assessment. *Global Environmental Change* **12**: 149–153.

Poland, 2001: Republic Of Poland, *Third National Communication to the Conference of The Parties to the United Nations Framework Convention on Climate Change.* Ministry of Environment and National Fund for Environmental Protection and Water Management, Warsaw.

Prinz D. 2000: Global and European Water Challenges in the 21st Century. Keynote Speech. *3rd Inter-Regional Conference on Environment-Water "Water Resources Management in the 21st Century", 1–3 June 2000, Budapest/Hungary. Proceedings*, pp. 247–254.

Raev I., Knight C.G. and Staneva M.P. (eds), 2003: Zasushavaneto v Bulgariya, cuvremenen analog za klimatichni promeni *(Drought in Bulgaria: Contemporary Analog of Climate Change)*. Sofia: Bulgarian Academy of Sciences Press (in Bulgarian).

REC, 2003: *Capacity for Climate Protection.* Szentendre, HU: Regional Environmental Center for Central and Eastern Europe. http://www.rec.org/REC/Programs/ClimateChange.html.

Romania, 1998: *2nd National Communication to the United Nations Framework Convention On Climate Change.* Ministry Of Waters, Forests and Environmental Protection, Bucharest.

Rosenzweig C., 2001: Climate Impacts, *International Encyclopedia of the Social & Behavioral Sciences*, pp. 2003–2010. Elsevier Science, Amsterdam.

SCOPE, 2003: Scientific Committee on Problems of the Environment. http://www.icsu-scope.org/.

Slovak Republic, 2001: *The Third National Communication on Climate Change* The Slovak Republic. Ministry of Environment, Bratislava.

Slovenia, 2002: *Slovenia's First National Communication Under the UN Framework Convention on Climate Change.* Ljubljana: Ministry of the Environment, Spatial Planning and Energy.

Slovenia, 2003: *EuroWaterNet – Slovenija.* Ljubljana: Ministry of Environment and Physical Planning. http://nfp-si.eionet.eu.int/ewnsi/enwnsi-eng.htm.

Smith J. *et al.* (eds.), 1995: *Vulnerability and Adaptation to Climate Change: Interim Results from the U.S. Country Studies Program.* Kluwer Academic Publishers, Dordrecht.

Smith J.B. *et al.* (eds), 1996: *Adapting to Climate Change: An International Perspective.* Springer-Verlag, New York. 476 p.

Smith J.B. and Lazo J.K., 2001: A summary of climate change impact assessments from the U.S. Country Studies Program. *Climatic Change* **50**: 1–29.

Stanev E.V. and Peneva E.L., 2002: Regional sea level response to global climatic change: Black Sea examples. *Global and Planetary Change* **32**: 33–47.

Staneva M.P. *et al.* (eds), 2000: *Global Change and Bulgaria.* National Coordination Center for Global Change, Sofia.

Stanners D. and Bourdeau P., 1995: *Europe's Environment – The Dobris Assessment.* EEA (European Environment Agency) Copenhagen.

START, 2003: *Global Change Science In Eastern Europe and Newly Independent Countries (SCENIC).* http://www.start.org/project_pages/scenic.html.

Strzepek K., Biswas A.K. (eds), 1996: U.S. Country Studies (nine countries). Special Issue. *International Journal of Water Resources Development.*

Strzepek K.M., Yates D.N., (1997): Climate Change Impacts on the Hydrologic Resources of Europe: A Simplified Continental scale analysis, *Climatic Change* **36**: 79–92.

Turnock D. (ed.), 2001: *East Central Europe and the Former Soviet Union: Environment and Society.* Hodder & Stoughton; London: Co-published by Oxford University Press, New York.

Turnock D., 2003: *The Human Geography of East Central Europe.* Routledge, London/New York.

Ukraine, 1998: *The First National Communication on Climate Change.* Kyiv.

Ukraine, 2002: The Climate Change Initiative. Kyiv: Climate Change Initiative Center. http://www.climate.org.ua/.

UNEP-FCCC., 2002: *Climate Change Information Kit.* Châtelaine, Switzerland: UNEP Information Unit for Conventions, www.unep.ch/conventions/ and www.UN FCCC.int.

UNEP-GRID, 2003: *Biodiversity in Central and Eastern Europe.* http://www.grida.no/enrin/biodiv/index_en.htm.

UNESCO, 2003: *Man and the Biosphere Program.* www.unesco.org/mab.

United Nations Development Programme, Collaborating Center on Energy and Environment, 2003: *Economics of Greenhouse Gas Limitations.* http://www. uccee.org/EconomicsGHG/.

United Nations Development Programme, 2003b: *Regional Bureau for the Europe and the CIS, Environment.* http://www.undp.org/rbec/programmes/.

United States Country Studies Management Team, 1999. *Climate Change: Mitigation, Vulnerability, and Adaptation in Developing and Transition Countries.* U.S. Department of Energy, Country Studies Program, Washington.

United Nations Development Programme, 2003: *National Communications Support Program.* http://www.undp.org/cc/index2.htm.

United Nations Environment Programme, 2003: *DEWA-Europe/GRID-Geneva.* http://www.grid.unep.ch/about.php.

United Nations Framework Convention on Climate Change, 2003: *Table of National Communications.* http://UN FCCC.int/resource/ natcom/nctable.html.

United Nations, Division for Sustainable Development, 2003: *National Sustainable Development Strategies – Global Map.* http://www.un.org/esa/sustdev/natlinfo/nsds/map2002.htm.

United States Agency for International Development, 2003: E*urasian-American Partnership for Environmentally Sustainable Economies (Ecolinks).* http://www.ecolinks.org/.

Ürge-Vorsatz D. and Füle M., 1999: *Economics Of Greenhouse Gas Mitigation, Hungary Country Study.* UNEP Collaborating Centre on Energy and Environment, Risø National Laboratory, Denmark.

Visegrad Group, 2000: http://www.visegradgroup.org/.

Watson R.T. *et al.* (eds), 1997: *IPCC Special Report on The Regional Impacts of Climate Change, An Assessment of Vulnerability.* http://www.grida.no/climate/ipcc/regional/index.htm.

Watson R.T. *et al.* (eds), 2000: *Land Use, Land-Use Change And Forestry.* Cambridge UK: Special Report of the IPCC published by Cambridge University Press.

Zeidler R.B., 1997: Continental shorelines: climate change and integrated coastal management. *Ocean & Coastal Management* **37**: 41–62.