A SUMMARY OF CLIMATE CHANGE IMPACT ASSESSMENTS FROM THE U.S. COUNTRY STUDIES PROGRAM

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Abstract. Forty-nine countries participating in the U.S. Country Studies Program (USCSP) assessed climate change impacts in one or more of eight sectors: coastal resources, agriculture, grasslands/livestock, water resources, forests, fisheries, wildlife, and health. The studies were generally limited to analysis of first order biophysical effects, e.g., coastal inundation, crop yield, and runoff changes. There were some limited studies of adaptation. We review and synthesize the results of the impact assessments conducted under the USCSP. The studies found that sea level rise could cause substantial inundation and erosion of valuable lands, but, protecting developed areas would be economically sound. The studies showed mixed results for changes in crop yields, with a tendency toward decreased yields in African and Asian countries, particularly southern Asian countries, and mixed results in European and Latin American countries. Adaptation could significantly affect yields, but it is not clear whether the adaptations are affordable or feasible. The studies tend to show a high sensitivity of runoff to climate change, which could result in increases in droughts or floods. The impacts on grasslands and livestock are mixed, but there appears to be a large capacity for adaptation. Human health problems could increase, particularly for populations in low-latitude countries with inadequate access to health care. The USCSP assessments found that the composition of forests is likely to change, while biomass could be reduced. Some wildlife species were estimated to have reduced populations. The major contribution of the USCSP was in building capacity in developing countries to assess potential climate impacts. However, many of the studies did not analyze the implications of biophysical impacts of climate change on socioeconomic conditions, cross-sectoral integration of impacts, autonomous adaptation, or proactive adaptation. Follow-on work should attempt to develop capacity in developing and transition countries to conduct more integrated studies of climate change impacts.

1. Introduction

The UN Framework Convention on Climate Change requires countries to develop greenhouse gas emission inventories and plans for responding to climate change. The U.S. Country Studies Program (USCSP), an interagency program to assist developing countries and countries with economies in transition in meeting their obligations under the Convention, was the result of a pledge by President George Bush at the 1992 Rio Conference to provide assistance to developing countries to enable them to study climate change. The program is funded and administered primarily by the U.S. Environmental Protection Agency (EPA), U.S. Department of Energy, U.S. Agency for International Development (AID), and the State Department (Dixon, 1997; USCSP, 1999).

Climatic Change **50:** 1–29, 2001.

This paper reviews and synthesizes the results of the impact assessments conducted under the USCSP (see also USCSP, 1999). Forty-nine countries participating in the USCSP focused on assessing the vulnerability of their climate-sensitive resources (i.e., the potential physical and economic impacts of climate change).⋆ As with other country study programs, such as the one sponsored by the UN Environment Programme (Feenstra et al., 1998), the most important characteristic of the USCSP was that in-country researchers carried out all the assessments of potential climate change impacts. They received training on a limited set of methods for assessing impacts from developed country experts, mainly from the United States. The experts also provided guidance and review throughout the process.

The vulnerability assessments cover eight critical sectors that are sensitive to climate change: coastal resources, agriculture, grasslands/livestock, water resources, forests, fisheries, wildlife, and health.

Table I displays the sectors assessed by each USCSP country that conducted impact assessments. About 150 country sector assessments were conducted under the USCSP. An appendix lists the country study reports from which the information in this paper is derived.

2. Methods for Conducting USCSP Impact Assessments

The general approach recommended by the USCSP for conducting a vulnerability assessment is presented in Figure 1. After selecting sectors to be assessed, climate change scenarios and baseline socioeconomic (population, economic conditions) scenarios extending through 2075 are selected. The climate change scenarios provide inputs for the biophysical and socioeconomic models or methods that are used to assess potential impacts of climate change. Most of these methods allow impacts to be assessed under alternative policy scenarios for adapting to climate change. The impacts on each sector are initially analyzed in isolation, and results may then be integrated across sectors to account for interactions among related sectors. For example, an agriculture assessment could incorporate changes in water supply from the water resources assessment. The adaptation assessment is then used to evaluate which, if any, policy options may be implemented in anticipation of climate change to mitigate potential adverse climate change impacts.

The brief summary of the methods used by most of USCSP participants that follows does not contain details on the models or other quantitative methods used in the assessment. More detailed information is provided in Benioff et al. (1996) and Smith et al. (1996b).

⋆ A smaller number of these countries also undertook adaptation assessments. For the most part these adaptation assessments are not discussed here.

Table I

Impact assessments by USCSP countries

Country	Coastal resources	Agriculture	Grass-lands/live-stock	Water resources	Forest	Fisheries	Wild-life	Health
Africa and the Middle East								
Botswana			•	•	•	•		
Côte d'Ivoire	•	•		•	•			
Egypt	•	•		•				•
Ethiopia		•	•	•	•			
The Gambia	•	•	•	•	•	•		
Kenya		•		•	•	•		
Malawi				•	•		•	
Mauritius	•	•		•		•		
Mozambique	•	•	•	•	•			•
South Africa		□	□	□	□	□	□	□
Tanzania	•	•	•	•	•			•
Uganda		•	•	•	•			
Zambia		•	•	•	•		•	•
Zimbabwe		•			•			
Asia and the Pacific								
Bangladesh	•	•		•	•	•		
China	•	•	•	•	•			
Fiji	•							
Indonesia	•	•			•			
Kazakhstan		•	•	•	•			
Kiribati	•							
Marshall Islands	•							
Micronesia	•	•		•	•		•	
Mongolia		•	•	•	•			
Nepal		•		•				
Philippines	•	•		•				
Sri Lanka	•	•			•			•
Thailand	•	•		•	•			□
Eastern Europe and Former Soviet Union								
Bulgaria		•			•			
Czech Republic		•		•	•			
Estonia	•	•		•	•			
Poland	•	•		•				
Romania		•		•	•			
Russian Federation		•		•	•			
Slovak Republic		•		•	•			
Ukraine	•	•		•	•			
Latin American								
Argentina [a]		•						
Bolivia		•	•	•	•			
Central America [b]	•	•		•				
Ecuador		•			•			
Mexico	•	•		•	•			
Peru	•							
Uruguay	•	•	•					
Venezuela	•				•			

• Completed impact assessment.
□ Impact assessment not completed at time survey was conducted.
[a] Argentina did not receive funding from the USCSP on V&A, but participated in USCSP-sponsored workshops.
[b] Includes Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama.

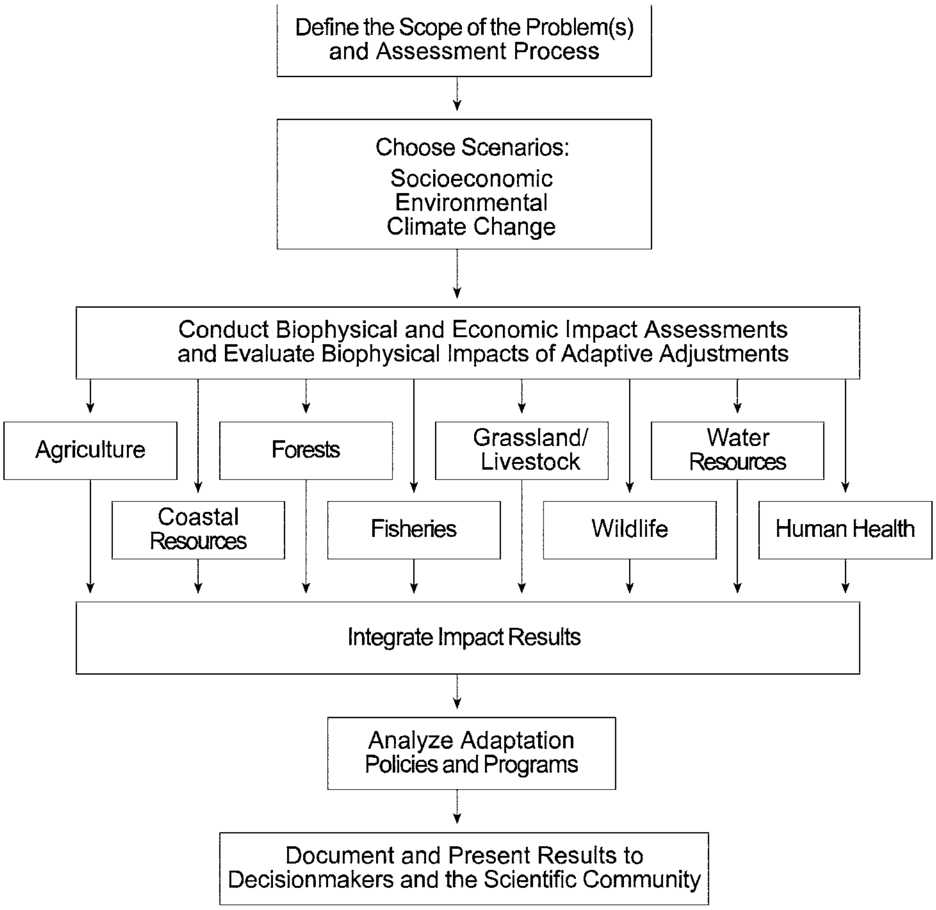

Figure 1. Vulnerability and adaptation assessment process. Source: Benioff et al., 1996.

2.1. METHODS AND DATA SOURCES

The USCSP decided that it would offer training on a specific method (in some cases a set of methods) for each sector. The problem facing the USCSP was that the skills and data quality and availability varied considerably across countries. Some countries such as China and Russia had already been conducting climate change impacts before the USCSP. Some countries were quite poor in financial resources and data availability. For example, Mozambique had only recently emerged from a bloody civil war. During that time, few data, such as meteorological data or river flow data, were collected.

To make it possible for all participants, regardless of technical capability or data availability, to conduct analysis, simple and easy methods were used. So, for example, CLIRUN (Kaczmarek, 1993), which needs only monthly runoff data, was provided to participants to estimate changes in runoff. The Holdridge model

(Holdridge, 1967), which estimates potential vegetation distribution using only average annual temperature and precipitation, was provided as a method for examining forests. Clearly, more sophisticated models were available, but they generally are more data intensive and complicated to apply, and fewer countries would have been able to successfully apply them.

Although most of the countries used models and methods provided, all participants could use whatever method they preferred, and some used other methods. For example, the Czech Republic also ran the BILAN and SACRAMENTO (Burnash et al., 1973) models in addition to CLIRUN.

2.2. CLIMATE CHANGE SCENARIOS

Climate change scenarios for each country were generally created using estimates of regional climate change generated from general circulation models (GCMs) or using incremental (also referred to as arbitrary; see Smith and Hulme, 1998) climate change scenarios (e.g., +2 °C and +/–10% change in precipitation). The National Center for Atmospheric Research supplied output from the following GCM models to countries participating in the USCSP:

- Goddard Institute for Space Studies (GISS; Hansen et al., 1983),
- Geophysical Fluid Dynamics Laboratory (GFDL or GFD3; Wetherald and Manabe, 1988),
- United Kingdom Meteorological Office (UK89; Mitchell et al., 1990),
- United Kingdom Meteorological Office (UKMO; Wilson and Mitchell, 1987),
- Canadian Climate Centre Model (CCCM; Boer et al., 1992),
- Geophysical Fluid Dynamics Laboratory Transient (GF01; Manabe et al., 1991),
- Oregon State University (OSU; Schlesinger and Zhao, 1989).

These GCMs estimate an increase in average global temperatures of 2.5 to 5.2 °C for a doubling of CO_2 levels in the atmosphere. This is consistent with the higher end of the estimated range of 1.4 to 5.8 °C warming by 2100 (IPCC, 2001). The primary models used were the CCCM, GFD3, and GISS.

2.3. BASELINE (SOCIOECONOMIC) SCENARIOS

Socioeconomic scenarios are developed to help understand how vulnerabilities to climate change may be affected by changes in population, income, technology, and other factors. Population estimates provided to the individual countries were generally taken from Bos et al. (1994). Information on regional economic growth rates, agricultural production, and deforestation was from Leggett et al. (1992). These estimates were developed by the IPCC to determine greenhouse gas emissions over the next century and the subsequent rate of climate change and are referred to as the $IS92_{a-f}$ set of scenarios.

While a number of countries developed baseline socioeconomic scenarios, only a few integrated them into their analyses. For example, some of the water resource studies integrated baseline scenarios. Analyses of impacts of sea level rise generally focused on current development of coasts (which for many countries was quite useful because the USCSP helped them develop an inventory of development on their coasts), but did not consider future development.

Note that developing baseline scenarios is quite difficult for developing and transition countries because there are many uncertainties about development paths (see, for example, Yates and Strzepek, 1998). Different development paths could have profoundly different implications for vulnerability of developing and transition countries. This is a matter that needs further attention in successor programs to the USCSP.

2.4. SECTORAL VULNERABILITY ASSESSMENT METHODS

The analyses of biophysical and socioeconomic impacts of climate change in specific sectors used the following methods:

Coastal resources. The coastal zone assessments mainly applied the IPCC Common Methodology, a seven-step procedure for analyzing coastline vulnerability to accelerated sea level rise (IPCC CZMS, 1992). Some countries applied aerial videotape-assisted vulnerability analysis (AVVA), which uses detailed field data to identify land and infrastructures that are at risk and determines protection costs for a range of response options (Leatherman et al., 1995). As noted above, many countries had no inventories of their coastlines before the USCSP. A number of countries examined the benefits and costs of protecting (currently) developed coastal areas from sea level rise.

Agriculture. The Decision Support System for Agrotechnology Transfer (DSSAT 3), an integrated software system that simulates crop production and water requirements in response to weather, soil conditions, and management practices, was the primary tool recommended for countries in assessing impacts to climate change (Rosenzweig and Iglesias, 1994). The crop models included in DSSAT 3 simulate the direct physiological effects of increased atmospheric CO_2 on crop yield and water use. Because the crop models can simulate different management options, they were used to assess responses in both irrigated and dryland agricultural systems, and to estimate adaptation of farm level management practices under climate change conditions. The models most frequently used were CERES-Wheat and CERES-Maize, and they were calibrated for each site. The studies were carried out in a transect of agroecological representative sites within a country, and results were scaled up to determine national changes in crop yields. The agriculture analysis did not examine market effects and adjustments such as changes in the price of cash crops. Other studies (e.g., Rosenzweig and Parry, 1994) have demonstrated the importance of market factors in affecting production and trade patterns. The studies also did not examine soil erosion or nutrient loss.

Grassland/livestock. The SPUR2 suite of models (Hanson et al., 1992) simulates the effects of climate change on grassland ecosystem processes and cattle production (Baker et al., 1993; Hanson et al., 1993). The suite includes models for estimating plant growth, soils/hydrology, domestic animal growth and production, wild animals, and grasshoppers. SPUR2 includes a generalized beef steer model, simulating the life of an animal, and a steer model, simulating the growth of a young animal during a simulated grazing season. These models are data intensive, but technical advisors to the program provided default values for instances where data were unavailable.

Water resources. The water resource assessments mainly used lumped integral models, also known as water balance models. They use monthly mean values of temperature and precipitation and modeled a basin as a single, homogenous unit. The models recommended were CLIRUN (Kaczmarek, 1993), which is a standalone model, and WATBAL (Yates, 1996), which extends the CLIRUN approach. Most countries estimated change in runoff, but did not examine management implications. Since monthly models were used, the studies did not estimate change in flooding.

Forests. Most of the assessments applied the Holdridge Life Zone Classification (Holdridge, 1967), which relates the distribution of major ecosystems (called life zones) to the climatic variables of biotemperature, mean annual precipitation, and the ratio of potential evapotranspiration to precipitation (PET ratio). The Holdridge model has the virtue of being simple and easy to apply, which is an advantage in data-poor environments. However, the relatively simple relations in the model do not account for species diversity, density, or migration. Some studies used gap models, in which each plant is modeled as a unique entity with respect to the processes of establishment, growth, and mortality (Shugart and West, 1980). A major problem in using gap models in developing countries is that adequate species data are often not available to enable such models to be built.

Fisheries. The fishery analyses used a wide variety of approaches, including analysis of changes in thermal structure of lakes and changes in habitat (habitat suitability models). These analyses do not require extensive computer equipment or specialized analytical instrumentation, can be applied to a variety of species and habitats, and can be completed in a timely manner. Fishery management was not modeled.

Wildlife. To assess wildlife impacts, countries used two methods – climatic correlation and habitat suitability. The climatic correlation technique (CLIMCORR; Markham and Malcolm, 1996) uses the strong correlation between geographic distribution of many species, communities, ecosystems, and biomes and climate. The Habitat Suitability Indices (HSI), which were developed by the U.S. Fish and Wildlife Service, allow users to create simple models to quantify the capacity of an area to support a species (U.S. Fish and Wildlife Service, 1981). Both the wildlife and fishery models are relatively simple and results should be interpreted with caution, since the HSI is only a guide to the likely quality of the habitat, not an absolute estimate of quality.

Human health. The relationship between climate change and human health is quite complex and difficult to model. The methods for assessing the vulnerability of human health range from identification and mapping of sensitive populations and pertinent diseases within the country's borders, to extrapolations of the association between hot humid air masses and mortality (e.g., Kalkstein and Greene, 1997), to the integrated modeling of vector-borne diseases in the context of climate, ecosystem, and societal change (e.g., Martens et al., 1994).

2.5. ADAPTATION

There was some limited analysis of adaptation in coastal resources, agriculture, water resources, and forests.* For example, a number of the coastal resource studies examined the benefits and costs of defending developed coastal areas from sea level rise. Some agriculture studies examined the effectiveness of farm level adjustments in mitigating yield reductions. Some of the water studies examined the cost-effectiveness of enhancing supplies or reducing demand for water in response to drought. In general, examining either autonomous (see Carter et al., 1994) or proactive adaptations was not routinely done in the studies. In many cases, potential adaptations were identified, but not analyzed. Adaptation analyses in the USCSP are discussed in more depth in Smith et al. (1996b).

3. Results of the Vulnerability Assessments

We briefly summarize the results by sector of the vulnerability assessments conducted by USCSP countries. This summary does not capture the complexity and depth of individual country assessments, but identifies broad patterns and lessons learned. Results are not presented for all countries and all sectors studied within countries. In many cases, quantitative assessments were not conducted or reported, and so results could not be tabulated and reflected in this analysis.

3.1. COASTAL RESOURCES

In general, coastal vulnerability was analyzed by examining the potential impacts from specified levels of sea level rise, most often 0.5 or 1.0 m. Since coastal assessments consider only one variable – sea level – and because the change in sea level is assumed to occur in only one direction (i.e., increase), we can be more certain about potential impacts in this sector than in other sectors such as agriculture and water resources, where the directional impacts of climate change are more uncertain.

* However, in the follow-up Support for National Action Plans, several countries examined the costs and effectiveness of adaptation options in depth (USCSP, 1999).

Table II presents estimated land loss from inundation and erosion due to sea level rise. This is presented primarily for sea level rises of 0.5 and 1.0 m, but other estimates are presented as noted. As shown below, in addition to inundation and erosion, some countries considered potential impacts from saltwater intrusion and different conditions for storm surges under increased sea level. Amplified storm surges may create greater vulnerability than sea level rise alone.

An analysis of the results from these countries suggests that with 0.5 m sea level rise, about one-half of the land loss is due to erosion and one-half is due to inundation. At 1.0 m sea level rise, the portion of land loss from inundation is greater than the portion from erosion. The total area inundated (erosion plus inundation) increases almost threefold when predicted sea level rise doubles from 0.5 to 1.0 m.

The total impact of sea level rise is underestimated by the results presented here, because countries tended to look at only sections of coast, not their entire coast. In doing so, they generally selected case studies of particularly important or vulnerable coastlines.

A common concern for countries with significant coastal resources is the impact on human populations and on other sectors. For instance, in its study of Chittagong, Bangladesh calculated that 96% of the 11.2 km^2 of land lost to erosion under 1.0 m sea level rise would be agricultural land. Egypt and Côte d'Ivoire also identified sea level rise impacts on coastal cities as having particular economic importance.

To determine appropriate adaptation responses to sea level rise, a number of countries compared the cost of protecting coastlines from sea level rise with the benefits in terms of the value of land and structures that would be inundated or lost to erosion. For instance, using the replacement cost method, Tanzania estimated the value of structures lost under 0.5 and 1.0 m sea level rise as U.S. $70 million and U.S. $121 million, respectively. With 1.0 m sea level rise, protection of the vulnerable portion of the coastline of Dar es Salaam would cost U.S. $380 million and protection of the populated coastline of Tanzania would cost U.S. $12.7 billion.* Table III illustrates other results from comparing benefits and costs of coastal resources adaptation. The benefits exceed the costs in most cases, but the existence of some low ratios points out the importance of carefully evaluating benefits and costs of adaptation.

3.2. AGRICULTURE

Table IV indicates the general direction of changes in crop yields (i.e., increases, decreases, or both) based on scenarios generated from climate change models summarized across different models for most of the countries assessing agriculture. This table does not reflect how yields would change after farmers made adaptations such as changing planting dates or switching varieties. While the table emphasizes

* Estimates were converted from Tanzanian shillings to U.S. dollars. 1 Tanzanian shilling (Tsh.) = 0.001408 U.S. dollar {4/23/99; http://www.oanda.com/converter/classic}.

Table II

Examples of land loss from inundation and erosion due to 0.5 and 1.0 m sea level rise

Country	0.5 m		1.0 m	
	Inundation (km^2)	Erosion (km^2)	Inundation (km^2)	Erosion (km^2)
Bangladesh[a]		5.80[b, c]		11.20[b, d]
China[e, f]	1153[b]		6520	
Côte d'Ivoire	8.9	27.6	17.8	55.1
Egypt[e, f, g]	15.473			
Estonia			593.0	
The Gambia	5.0		92.3	
Indonesia			230.04[h]	
Peru			78.32[i]	
Philippines[j]	20.99[b]		55.6	
Poland	845.1[b]		1727.7	
Sri Lanka	41.0[b]	6.0[a]	91.2	11.5
Tanzania		2.090		2.117
Ukraine	12.8[k]	52.25[k]	190.0[l]	102.4[l]
Uruguay	19.8[e, m]	0.068[n]	39.6[e, m]	0.291[n]
Venezuela	52.6	26.4	77.7	40.5

Note: Many results are only from case study sites and are not for the entire country.

[a] Only for sandy shores of eastern Bangladesh, i.e., Chittagong, which is a hilly area. A 1.0 m sea level rise is estimated to inundate 17% or more than 22,000 km^2 of the entire country, most of which is in western Bangladesh.

[b] 0.3 m sea level rise.

[c] Agricultural land only.

[d] 0.75 m sea level rise.

[e] Lower bound estimates shown.

[f] Does not distinguish between inundation and erosion.

[g] Alexandria and Rosetta areas only.

[h] Low-land part of Semarang City.

[i] Sum of ten study areas.

[j] For Manila Bay Coastal Area – a scenario of 2.0 m sea level rise will result in 891.1 km^2 loss of land by inundation.

[k] 0.46 m sea level rise.

[l] 1.15 m sea level rise.

[m] Coast between Colonia and A Chuy.

[n] Coast of Montevideo.

Table III

Benefit-cost ratios[a] from coastal resources adaptation assessments in selected countries

Location	Level of protection	Sea level rise scenario		
		0.3 m	0.5 m	1.0 m
China (Zhujian Delta)	Full protection	7.7	14.3[b]	12.8
Estonia (Tallin and Pärnu)	Full protection	–	–	0.9 and 2.3[c]
Poland (entire coastline)	Full protection	2.6	–	4.6
	Partial protection	3.3	–	–
Venezuela (all study sites)	Full protection	–	0.02	–
Uruguay (entire coastline)	Full protection (sea walls)	7.6–21.6	7.0–30.8	10.3–42.9
	Full protection (beach nourishment)	3.2–9.0	3.2–13.9	4.9–20.4

[a] Benefit-cost ratios calculated from the benefit-cost analyses in the national reports.
[b] Ratio based on a benefit-cost analysis for a 0.65 m scenario.
[c] These ratios are for a 1.0 m sea level rise and a 1.5 m storm surge respectively.

many of the most important crops worldwide, several countries also considered the vulnerability of additional crops of national importance, such as barley, cotton, and groundnuts. There appears to be a mix of estimated increases and decreases in crops, although of the crops studied, more are estimated to decrease than increase. There also appear to be some differences in the regional sensitivity of crop yields to the climate change scenarios. Results from Africa (mainly Egypt and Côte d'Ivoire) and Asia (particularly Bangladesh and the Philippines) show a tendency toward decreases in crop yields, while results from Europe show a tendency toward increases in crop yields. Results from Latin America are limited to only three countries and have both increased and decreased yields. Because results are limited and scattered, these conclusions should be treated as preliminary.

Overall, the results suggest that while agricultural impacts may not be catastrophic, especially when potential adaptation measures are considered, individual countries and regions within countries could experience significant negative impacts. Thus, some countries could be harmed while others could benefit.

Many countries included CO_2 fertilization effects on crop yields in their analysis. In some cases, CO_2 fertilization was found to have a larger impact on crop yields than temperature or precipitation changes, although drier conditions could offset the positive effects of CO_2 fertilization.

Some countries noted that current interannual climate variability may be of more immediate concern than long-term climate change. For example, in Indonesia the vulnerability of its agriculture sector to variable El Niño/Southern Oscillation effects under current climate conditions is greater than the vulnerability to climate change over the next 20 years, but in 60 years the effects of climate change could be

Table IV

Direction of crop yield changes across general circulation model scenarios

Country	Crop					
	Wheat	Maize	Soybean	Rice	Other	Other
Africa						
Côte d'Ivoire		↓		↓[b]		
Egypt	↓	↓	↓	↓	↑ Cotton	↓ Barley
Ethiopa	↑↓					
The Gambia		↓			↓ Millet	↑ Groundnuts
Kenya		↑↓				
Zambia	↑↓	↑	↑↓	↑	↑ Oils[a]	↑ Cassava
Zimbabwe		↑↓				
Asia and Pacific						
Bangladesh	↓			↓		
China[a]	↑↓	↑↓		↓		
Indonesia				↑↓		
Kazakhstan[a]	↑↓					
Mongolia[a]	↑↓					
Philippines		↓		↑↓		
Sri Lanka					↑↓ Tea	
Eastern Europe and Former Soviet Union						
Bulgaria	↑↓	↓				
Czech Republic	↓	↑			↓ Potato	↑ Early vines
Estonia					↓ Barley	
Romania	↑	↑				
Russian Federation	↑↓					
Slovak Republic	↑					
Ukraine	↑					
Latin America						
Argentina	↑↓	↓	↑			
Bolivia		↑[c]	↑↓		↑ Potato	
Mexico[a]		↓[d]				

Note: Summary based only on GCM scenarios, and includes CO_2 fertilization unless otherwise noted. Countries that conducted only sensitivity analyses (Nepal, Poland, Uruguay) are not included because the range of sensitivity analyses is so broad that crop yields would generally have mixed results.

[a] Does not include CO_2 fertilization.

[b] Results are mixed when adaptation is assumed.

[c] Irrigated maize is estimated to have decreased yields. Irrigated land in Bolivia is a small fraction of total arable land (CIA, 1999).

[d] Indicated as an increase in land area unsuitable for crop.

↓ Yield decreases for all GCM scenarios.

↑ Yield increases for all GCM scenarios.

↑↓ Increases and decreases for all GCM scenarios.

as great as the El Niño effects.* Other issues that may be important in understanding vulnerability of agriculture to climate change include the following:

- Warmer temperatures may lead to increases in pests and diseases harmful to crops.
- Changes in frost-free dates may induce soil nutrient changes.
- Changes in precipitation may induce flooding or drought, causing direct physical impacts on agricultural lands.

3.3. GRASSLANDS AND LIVESTOCK

Although not directly comparable across countries, average biomass generally is estimated to increase for warm-season grasses and decrease for cool-season forbs and legumes as optimal grassland conditions shift toward the poles. There appear to be smaller impacts on livestock yields than on grassland biomass, because livestock can adjust consumption (e.g., they can graze over a larger area should grassland productivity decline). To some extent, this implies that there currently exists excess capacity of grasslands in the livestock sector or that analysts are assuming that the area of production can increase.

Some countries found considerable spatial variance in their results. For instance, Mongolia found that while the impact of climate change on pasture production in the Gobi Desert areas may be negative, in colder regions climate change could have favorable effects on plant production. Even with these regional variations, Mongolia still found that at all sites, plant quality and livestock production decline under climate change scenarios.

Although countries found no significant overall change in grasslands and livestock, several did note that changes in interannual climate variability would have important impacts. For instance, Uruguay found that because seasonal variability is already a major concern for farmers, increased variability would be detrimental to the production of livestock. Similar results regarding the impact of climate variability on grasslands are discussed in Allen-Diaz (1996). Some countries did find positive net impacts of climate change, such as Tanzania, where scenarios with increased precipitation and temperature led to increased rangeland carrying capacity.

3.4. WATER RESOURCES

Table V displays the range of change in runoff for some of the countries assessing water resources. Most countries considered multiple river basins, and the results varied between basins. Generally, scenarios assuming an increase in temperature and no change in precipitation resulted in a drop in runoff. However, changes in precipitation appear to have a greater influence on runoff than do changes in

* Some recent research has found that climate change could result in more frequent El Niños (e.g., Timmerman et al., 1999).

Table V

Change in annual runoff for selected countries based on results from GCM models

Country	Change in annual runoff	
	Minimum	Maximum
Africa		
Botswana	–53%	+17%
Côte d'Ivoire	–22%	–4%
Ethiopia	–33%	+40%
The Gambia	–69%	+63%
Malawi	–40%	+162%
Asia		
Mongolia	–0.3%	+26%
Philippines	–12%	+32%
China	–15%	+17%
Latin America		
Mexico	–42%	+123%
Eastern Europe and Former Soviet Union		
Czech Republic	–10%	+3%
Estonia	+2%	+68%
Kazakhstan	–29%	+25%
Romania	–24%	–3%
Ukraine	–20%	+128%

temperature. In many countries, if precipitation were assumed to increase, runoff was estimated to increase, even with higher temperatures, and if precipitation were assumed to decrease, runoff was estimated to decrease. For example, in The Gambia, for each 1% change in precipitation, there is a 3% change in the same direction of runoff.

Most countries showed mixed results in terms of increases and decreases in runoff. One striking aspect of Table V is the range of estimated changes in runoff and the estimated high sensitivity of runoff to changes in climate. For example, estimated changes in runoff in The Gambia ranged from –69% to +63%.* Such large changes in runoff are likely to substantially increase the risk of drought or flood. Two countries, Estonia and Mongolia, estimated either no change or increases in

* Wolock and McCabe (1999) found similarly high sensitivities of runoff for major river basins in the United States.

runoff under all the scenarios tested. It is interesting that both of these countries are in high latitudes. Since they are likely to receive more precipitation and may not have as large an increase in evapotranspiration as low-latitude countries, high-latitude countries may be more likely to have increased runoff (Rind et al., 1990; Houghton et al., 1996). Indeed, the results for Estonia and Mongolia are consistent with this hypothesis.

Only two countries, Côte d'Ivoire and Romania, found a reduction in runoff under all scenarios.

Those countries that examined the effects of changes in runoff on the adequacy of the water supply to meet demand found that baseline changes in population would have a much greater effect than climate change. They also found that changes in runoff, even if positive, might be overwhelmed by increased demand. For example, Ethiopia estimated changes in runoff varying from –33% to +40%. The 33% reduction in runoff was estimated to result in a 25% reduction in supply. Ethiopia found that population and economic growth by 2075 could result in demand exceeding supply because demand was estimated to increase twentyfold above present levels. This situation would be made worse if runoff declined. Even the 40% increase in runoff would not completely meet the higher demand.

In general, the effect of climate change on runoff is difficult to predict. A few areas might see increased runoff (which can alleviate water shortages but increase flood risks), but for most areas the change is uncertain. Change in precipitation, which is uncertain at the regional level, is the most important factor affecting runoff. Until scientists have a substantially improved understanding of how precipitation will change, it will remain difficult to reliably forecast future water supplies.

3.5. FORESTS

Most countries evaluated the vulnerability of their forest sector in terms of changes in the land area of different forest types or projected changes in biomass. Most countries used the Holdridge Life Zone classification, which allows for a first cut analysis of potential impacts on forest resources under the various climate scenarios. This approach does not consider CO_2 fertilization, which enhances forest growth and reduces water demand (Neilson et al., 1998).

Most countries reported a general shift in forest type to warmer climate types (e.g., subtropical shifting to tropical forests). Countries found that changes from dry to moist forest or vice versa were largely driven by changes in precipitation rather than temperature. Table VI displays estimated changes in biomass from forest sector studies for subcountry regions and countries, using a number of different climate change scenarios. While it is difficult to draw specific conclusions from the country studies because of the different models and approaches used, a general impression is that there could be a decline in biomass. However, it is interesting that some countries such as The Gambia found potential increases in biomass.

Table VI
Examples of forest sector vulnerability results

Country	Region	Scenario	Percent change in biomass
Bolivia	Nationwide	GISS	–92% to –32%
		UK89	–44% to +34%
		+2 C/+10% P	–81% to –13%
		+2 C/–10% P	–83% to –19%
Estonia	Tudu	Four different scenarios	+5.3% to +13.2%
	Võhma		–33.5% to –28.0%
	Virstu		–47.4% to 9.6%
	Kärevere		–75.9% to –23.5%
	Risti		–42.1% to 1.6%
The Gambia	Nationwide	GFD3	+72.0%
		GISS	+0.2%
		UKMO	–46%
		OSU	–75% [a]
Mongolia	Nationwide	UK89	–27.2% larch
			–35.3% Siberian pine
			–5.1% birch
			–4.2% scotch pine
Romania	Bistrita – 2060	GF01	–4.8% red maple
	Predeal – 2060		–16.7% red maple
Slovak Republic	Pilsko	CCCM	+17%
	Dobrocsky		+5%
	Sitno		–38%

For some countries, climate change may exacerbate current conditions. For instance, in Zambia, more than 80% of households use either fuelwood or charcoal for their domestic energy requirements. Zambia is currently losing 250,000–300,000 hectares of its forest cover annually to human activities, and a decrease in forest productivity could make the situation worse. Based on this, the Zambia report concluded that climatic changes that affect the resilience of forest vegetation types could grossly affect income and welfare.

Other interesting results of forest vulnerability assessments under the USCSP include the following:

- Even where the dominant ecosystem type is not expected to change, conditions may change to allow for the introduction of invasive species. For example, Estonia found that while the climate change scenarios would not change the primary ecosystem type, they could increase the spread of invasive species, including silver fir, hornbeam, and sessile oak.

- In some cases, simulations indicate that the estimated climate change would be significant for individual tree species even when the Holdridge model does not estimate shifts in forest type.
- If warming increases potential evapotranspiration, there would be a tendency toward more drought stress.
- Impacts on specific forest reserves or national parks may be important. For example, Sri Lanka found that the most vulnerable forest areas would be the Sinharaja Forest Reserve and the Peak Wilderness Forest Reserve, and Venezuela found that most of the country's natural forest reserves would be affected.
- While the USCSP studies for the most part did not model societal-forest interactions, population pressures were generally recognized. For example, as noted above, Zambia reports that given the country's reliance on forest products, climatic changes could affect the resilience of forest vegetation types and thus could adversely affect society.

The finding that composition of forests could change with a shift to warmer climate species is consistent with the IPCC. However, the IPCC found that, in general, it is not clear whether forest biomass will increase or decrease (e.g., Neilson et al., 1998).

3.6. FISHERIES

Few countries examined the vulnerability of fisheries to climate change as part of the USCSP, and we do not attempt to generalize results. For many areas, a lack of location-specific information on species' responses to potential climate change makes it difficult to assess fishery vulnerability. For instance, in Bangladesh, there is very little or no work on the physiology and ecology of indigenous species of finfish or prawns. As a result, it is difficult to estimate the likely effects of climate change on different fish or prawn populations.

In general, changes in temperature and salinity were estimated to result in changes in species mix and both increases and decreases in different species' productivity. Sea level rise would lead to flooding and loss of productive habitat for many species (e.g., shrimp), generally resulting in decreased productivity. The net result for the fishery sector depends on which effects are stronger. In some developing and transition countries, a significant number of people depend on fish in their diet, especially for protein, so impacts on the fishery sector may also affect the health of the population.

3.7. WILDLIFE

Two countries, Malawi and Zambia, used the Habitat Suitability Indices to examine the vulnerability of key wildlife species to climate change. Although it is difficult to generalize from only two country studies, the vulnerability of wildlife to climate change primarily appears to be a function of changing habitat. Current human activities may be causing habitat fragmentation, which is probably the greatest current stress on wildlife. This could be exacerbated under climate change.

For Malawi, vulnerability studies suggest that there would be declines in nyala and zebra in the Lengwe and Nyika National Parks. Nyala is a vulnerable species that may not adapt easily to climate-induced habitat changes. On the other hand, if increased temperature is accompanied by lower precipitation, as is the case in two of the scenarios, tourism might increase because increased ambient temperature could improve accessibility to drier parks. Whether tourists would be less likely to go to the parks because of the loss of nyala was apparently not assessed.

In Zambia, changes in rainfall could significantly affect wildlife through changes from open grasslands and scattered bushlands to denser bushlands (under increased precipitation) or desert-like conditions (under decreased rainfall). In addition, increased or decreased rainfall would significantly affect the behavior and habitat of migratory wetland species. Given the vulnerability of Zambian wildlife to drought and habitat disturbance, it is likely that climate change, whether it leads to increased or decreased rainfall, could dramatically affect both the size and the diversity of many populations.

3.8. HUMAN HEALTH

Zambia and Sri Lanka completed assessments of the potential health effects of climate change. Although it is difficult to draw generalizations from only two countries, these countries found that climate change could increase risks to human health. Zambia qualitatively considered characteristics of malaria, bilharzia/schistosomiasis, cholera, dysentery, bubonic plague, and malnutrition. Their assessment was limited largely by the lack of available data. Consequently, no models were run to assess impacts of particular diseases, and potential impacts can only be speculated. In Zambia, the health effects of climate change would appear to affect poorer populations for a variety of reasons, including poorly ventilated structures being conducive to mosquitoes and lack of good water and sanitation services. Existing conditions such as environmental degradation, quarrying, poor drainage systems, and inadequate water taps seem likely to exacerbate health impacts from climate change.

Sri Lanka also studied the potential effects of climate change on the incidence of malaria, and found that malaria could become more prevalent in areas where it is not currently a risk.

The effect of changes in population, income, and quality of health care systems in the countries was not assessed.

4. Assessment Conclusions and Challenges

4.1. CONCLUSIONS ON VULNERABILITY ASSESSMENTS

The IPCC distinguishes between sensitivity, how a system is directly affected by climate change (e.g., change in crop yields), adaptability, how a system could respond to climate change (e.g., switch crops), and vulnerability, the net effect after sensitivity and adaptability are considered (Watson et al., 1996). Although dozens of countries assessed climate change impacts under the USCSP, one should be cautious about using these studies to draw sweeping conclusions about the vulnerability of developing and transition countries to climate change. The USCSP studies tended to focus on identifying sensitivities of systems, i.e., first-order biophysical effects. Adaptability was assessed only for coastal resources and in some of the agriculture, forests, and water resources studies. Without thorough consideration of underlying socioeconomic changes, integrated impacts, and adaptability in all sensitive sectors, it is difficult to draw firm conclusions about vulnerability.

Nonetheless, some preliminary conclusions about sensitivity and vulnerability can be drawn, although these conclusions do not necessarily apply to all countries. For the more managed systems, the USCSP studies found the following:

- Sea level rise could cause substantial inundation and erosion of valuable lands, but protecting developed areas would be economically sound. Countries conducted limited assessment of the ecological consequences of sea level rise.
- The studies tend to show mixed results for changes in crop yields. African and Asian countries, particularly southern Asian countries, tended to estimate decreases in yields. Many countries found mixed results and some even estimated increases in yield of some crops, particularly in Europe and Latin America. Adaptation could significantly affect yields, but it is not clear whether these adaptations are affordable or feasible (e.g., whether farmers could afford fertilizers or pesticides). On the whole, some countries may lose while others may win. These conclusions are consistent with those of the IPCC, which found that global agriculture will most likely provide enough food to feed the world, but there are likely to be geographic shifts in production (Watson et al., 1996).
- Impacts on water resources are uncertain mainly because of uncertainty about regional change in precipitation patterns. The studies tend to show a high sensitivity of runoff to climate change, which could result in increases in droughts or floods. The ability of water resource systems to adapt was not thoroughly assessed.
- The impacts on grasslands and livestock are mixed, but for the few countries studied, there appears to be a large capacity for adaptation.
- There could be increased human health problems, particularly for populations in low-latitude countries with inadequate access to health care.

For the relatively more unmanaged systems, the USCSP assessments found the following:

- The composition of forests is likely to change. Many of the assessments found that biomass could be reduced, although this latter finding is not necessarily supported by other assessments (e.g., Houghton et al., 1990).
- There are potential negative impacts on wildlife, with some species possibly having reduced populations.
- The effects on fisheries are indeterminate.

Human health and the relatively unmanaged sectors were studied in only a few countries, so one should be careful about overinterpreting results. Interestingly, a key factor affecting wildlife and human health is baseline socioeconomic changes. Current baseline issues such as continued destruction of wildlife habitat and lack of healthcare infrastructure may exacerbate the potential vulnerability to climate change. One common theme from many of the assessments is that the impacts of baseline changes may be much greater than the impacts of climate change.

On the whole, it appears that there is high sensitivity to climate change in many developing countries. However, vulnerability is harder to determine. It appears that many unmanaged systems could be quite vulnerable to climate change.

4.2. CHALLENGES OF ASSESSING CLIMATE CHANGE VULNERABILITY AND ADAPTATION IN DEVELOPING AND TRANSITION COUNTRIES

Assessments of vulnerability have been conducted for almost two decades in developed countries, but the assessment of vulnerability in developing and transition countries has begun only recently. The main purpose of the USCSP was to transfer capacity on assessment of climate change impacts to developing and transition countries. The program appears to have been a success in meeting that goal: hundreds of scientists in scores of developing and transition countries received training on impacts methods and analyzed the effects of climate change scenarios on their countries. The results are reflected in the many peer-reviewed publications emerging from the program and the high participation of developing and transition country scientists who were involved in the program in such activities as the Intergovernmental Panel on Climate Change.

While this program has substantially expanded knowledge of potential climate change impacts, it had a number of important limitations, including the following:

- General circulation models often do not adequately simulate current regional climates, so their estimates of future climate should be treated as scenarios. All methods for creating regional climate change scenarios should be treated as tools in identifying potential changes in climate and sensitivities of sectors to climate change. This uncertainty about regional climate change may be the greatest impediment to predicting the effects of climate change. It is not necessary, and perhaps not possible, to achieve accurate forecasts about regional climate change, but more certainty about the change in direction of key variables such as precipitation would be of substantial assistance in predicting at least the direction of change of key variables such as runoff.

- Changes in baseline socioeconomic conditions, with a number of notable exceptions, were not integrated into vulnerability assessments. Baseline changes could significantly change vulnerability of developing and transition countries. Of those countries that developed baseline socioeconomic scenarios, only a few integrated the baseline scenarios into their analyses of vulnerability to climate change.
- There was little analysis of integration of impacts across sectors. For example, a reduction in water supplies may limit the availability of water for irrigation. Most of the assessments addressed each sector in isolation, and addressed interactions among sectors only qualitatively, if at all.
- There was only limited analysis of adaptation. The coastal resource, agriculture, and water resource sectors engaged in limited analysis of autonomous or proactive adaptations. In many cases, the studies identified potential adaptations but did not analyze them.

The USCSP was successful in that it engaged hundreds of scientists in climate change impact assessment. Follow-on studies need to build on this by addressing such important analytic functions as developing and integrating baseline scenarios, integrating related cross-sectoral impacts, and more fully analyzing the effects of autonomous adaptation and the costs and effectiveness of proactive adaptation.

Acknowledgements

This work was funded through contract 69-W6-0055 between the U.S. Environmental Protection Agency and Stratus Consulting Inc. The views expressed in this article are the authors do not necessarily represent the views of the U.S. EPA. We appreciate the comments of Richard Klein and an anonymous peer reviewer. We are indebted to Megan Harrod, who helped us assemble the information and create the tables, Christina Thomas who provided thoughtful advice and editing of the manuscript, and Shiela DeMars, who helped us pull this all together. The technical advisors to the USCSP played a critical role in developing and training participants on methods. They include Cynthia Rosenzweig, Ana Iglesias, Kenneth Strzepek, David Yates, Stephen Leatherman, Thomas Smith, Barry Baker, John Balbus, Jay Malcolm, Michael Birdy, and Ihor Hlohowskyj. We wish to acknowledge the continued support and encouragement of Jack Fitzgerald, Sandy Guill, Carole Cook, and Robert Dixon of the USCSP.

Appendix A

Table A.I
Reports from USCSP countries

Country	Report [a]
Bangladesh	‘Bangladesh Climate Change Country Study: Assessment of Vulnerability and Adaptation to Climate Change’, Bangladesh Center for Advanced Studies.
Bolivia	‘Analysis of Ecosystem Vulnerability and Adaptation to Climate Change and Options of Mitigation’, Oscar Paz Rada et al. (translated by Shiela DeMars), Ministerio de Desarrollo Sostenible y Medio Ambiente Secretaria Nacional de Recursos Naturales y Medio Ambiente/Subsecretaria de Medio Ambiente Programa Nacional de Cambios Climaticos.
Botswana	‘Vulnerability and Adaptation under Climate Change: Hydrology and Water Resources Sector’, P. P. Zhou and H. Masundire, Ministry of Mineral Resources and Water Affairs — Department of Mines, Final Report – June, 1998.
Bulgaria	‘National Climate Change Action Plan of Republic of Bulgaria’, Energoproekt (National Institute of Meteorology and Hydrology, Forest Research Institute, Institute for Nuclear Research and Nuclear Energy), Final Report – Sofia, March, 1999.
China	‘China Climate Change Country Study’, Research Team of China, Tsinghua University Press, December 1998, Beijing,
Côte d’Ivoire	‘Vulnerability and Adaptation to Predicted Climate Change – Assessment of the Major Socio-Economic Sectors in Côte d’Ivoire’, Ministère du Logement, du Cadre de Vie et de L’Environnement and Ministère de L’Enseignement Supérieur, de la Recherche et de L’Innovation Technologique. Abidjan, November, 1996.
Egypt	‘Aquaculture in Relation to Effect of Environmental Changes in Egypt’, Prof. Mohamed A. Ibrahim, National Institute of Oceanography & Fisheries, Alexandria, 1997.
	‘Assessment of Strategy and Policy Measures for Adaptation to Climate Change in Egyptian Agriculture’, Helmy M. Eid, Organization for Energy Conservation & Planning, Final Report – Giza, February, 1997.
	‘Vulnerability Assessment of the Coastal Zone of Egypt, to the Impacts of Sea Level Rise’, Prof. M. El-Raey, Prof. O. Frihy, Prof. S. M. Nasr, Saleh El-Kaffas, Samah Ahmed, Eng. Yasser Fouda, G. M. El-Hattab, G. Kh. Dewidar, Cairo University, Final Report – Cairo, April, 1997.
	‘Adaptation Studies for Impact of SLR of Port-Said Governorate, Egypt’, Ezz El-Dean El-Raey, Organization for Energy Conservation & Planning, Draft Report – Cairo, August, 1997.

Table A.I
(Continued)

Country	Report [a]
Estonia	'Vulnerability and Adaptation to Global Climate Change: The Estonian National Report', Are Kont et al., Draft Report – April, 1996.
Ethiopia	'Synthesis Report on the Results of Vulnerability and Adaptation to Climate Change for Ethiopia', Abebe Tadege, Ademe Mekonnen, Kinfe Hailemariam, Ibrahim Mohammed, Wondwessen Asfaw, Abaye Tedla, Negash Mamo, Tamiru Worku, National Meteorological Services Agency (NMSA), Addis Ababa, August, 1996.
Fiji Islands	'Vulnerability and Adaptation Assessment, Coastal Impact of Sea-Level Change, Suva and Vicinity, Viti Levu, Fiji Islands', Steve Solomon and Jens Kruger, South Pacific Applied Geoscience Commission (SOPAC), Draft Report – November, 1995.
The Gambia	'GOTG/USCSP Collaborative Study on the Vulnerability of Major Socio-Economic Sectors of the Gambia to Climate Change and Assessment of Adaptation Measures and Options', State Department of The Presidency, Fisheries and Natural Resources, Government of The Gambia National Climate Committee Department of Water Resources, Draft Report – 1997.
Indonesia	'Vulnerability and Adaptation Assessments of Forest Vegetation in Indonesia', I. Handoko, R. T. M. Sutamihardja, Ng. Gintings, I. Risdiyanto, Y. Sugiarto, Gunardi, and M. Y. Ishadamy, Department of Geophysics and Meteorology Faculty of Mathematics and Natural Sciences, Bogor Agricultural University; Ministry of Environment; Forestry Research Center.
	'A Case Study on Coastal Resources: Vulnerability and Adaptation', Sobai Sutisna and M. F. Raharjo.
	'Effects of Interannual Climate Variability and Climate Change on Rice Yield in Java, Indonesia', I. Amien.
Kazakhstan	'Climate Change Vulnerability and Adaptation Assessment in Kazakhstan', Olga Pilifosova, Irina Eserkepova and Svetlana Mizina, eds. Kazakh Scientific and Research Institute for Environment and Climate Monitoring (Kazniimosk), Almaty, 1996.
Kenya	'Sensitivity of Maize Growing Zones to Climate Change: The Effect of Climate Change on Maize Production Trends in Zones III–IV of Kenya', Bancy M. Mati and Frederick K. Karanja.
	Kenya Country Study on Climate Change, Final Report – September, 1997.
	'Potential Impacts of Climate Change on Forests in Kenya', J. G. Kariuki, T. O. Omenda, P. O. Oballa and D. M. Kamweti, Ministry of Research, Technical Training and Technology, Nairobi, October, 1997.

Table A.I
(Continued)

Country	Report [a]
	'Sensitivity of the Hydrologic Cycle in the Tana River Basin Due to Climate Change', Francis M. Mutua, Department of Meteorology, University of Nairobi, Draft Report – Nairobi, June, 1996.
	'Assessment of the Vulnerability and Adaptations to Climate Change of the Fisheries of Lakes Naivasha and Victoria, Kenya', Micheni J. Ntiba, Department of Zoology, University of Nairobi.
Kiribati	'Assessment of the Vulnerability of Betio (South Tarawa, Kiribati) to Accelerated Sea Level Rise', Steve Soloman, South Pacific Applied Geoscience Commission, September, 1997.
Malawi	'U.S.A. Country Studies Program to Address Climate Change: Support to Malawi for Vulnerability and Adaptation Studies', Ministry of Research and Environmental Affairs, Preliminary Report – October, 1996,
Mauritius	'Coastal Geomorphology and Impacts of Sea-Level Rise on Coastal Zone with Adaptive Measures', NCC Working Group, Meteorological Services, September, 1996.
Mexico	'Mexican Country Study: Area Vulnerability/Subarea: Industry and Energy Systems', Maria Teresa Sanchez Salazar, Maribel Martinez Galicia, Norma Martinez Laguna.
Mongolia	'Vulnerability and Adaptation Assessments for Mongolia', S. Bayasgalan, B. Bolortsetseg, G. Tuvaansuren, D. Dagvadorj, V. Ulziisaikhan, R. Mijiddorj, L. Natsagdorj, P. Batima, D. Erdenetsetseg, Ulaanbaatar, Mongolia, Final Report – March, 1996.
Nepal	'Vulnerability and Adaptation Assessment of Climate Change Scenarios in Agriculture Production Systems in Nepal'. Kirin Shanker Yogacharya and R. B. Pradhan, Center for Agriculture Technology, Katumandu, Nepal, February, 1997.
The Philippines	'Vulnerability and Adaptation of Rice and Corn Production to Climate Change in the Philippines', A. R. Maglinao, P. P. Evangelista, B. G. Pajuelas and E. D. Samar, Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), Final Report – Quezon City, January, 1998.
	'Vulnerability Assessments and Evaluation of Adaptations on Coastal Resources Due to Accelerated Sea Level Rise: Manila Bay Area in Luzon, Philippines', Rosa T. Perez, Renato B. Feir and Efren Carandang, Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), Luzon, December, 1997.

Table A.I
(Continued)

Country	Report [a]
Poland	'Strategies of the GHG Emission Reduction and Adaptation of the Polish Economy to the Changed Climate', Maciej Sadowski, Anna Olecka, Marta Radwan, Anna Romanczak, and Alicia Sienkiewicz (eds.), Institute of Environmental Protection, Draft Report – Warsaw, 1996.
Romania	'Country Study on Climate Change in Romania: Vulnerability Assessment and Adaptation Options', Co-Ordinator: V. Cuculeanu, Draft Report – March, 1996.
Russia	'Climate Change Action Plan Report', Yu. A. Izrael, S. I. Avdjushin, I. M. Nazarov, Yu. A. Anokhin, A. O. Kokorin, A. I. Nakhutin, and A. F. Yakovlev, Russian Federal Service for Hydrometeorology and Environmental Monitoring, Final Report – Moscow, 1999.
	'Vulnerability and Adaptation Assessments for Russian Agriculture, Forestry and Water Resources to Climate Change', Yu. A. Izrael and S. I. Avdjushin, Russian Federal Service for Hydrometeorology and Environmental Monitoring, Final Report – Moscow, 1996.
Slovakia	'Vulnerability and Adaptation Assessment for Slovakia', Milan Lapin, Olga Majercakova, Jozef Mind'as, Frantisek Spanik and Dusan Zavodsky, Slovak Hydrometeorological Institute/Ministry of Environment of the Slovak Republic, Final Report – Bratislava, 1997.
Sri Lanka	'Final Report of the Sri Lanka Climate Change Country Study', J. Ratnasiri (ed.), Ministry of Forestry and Environment – Environment Division, Final Report – Colombo, March, 1998.
Tanzania	'National Action Plan on Climate Change in Tanzania', The Centre for Energy, Environment, Science and Technology (CEEST), Draft Report – November, 1998.
	'Draft Chapters for the Assessment of Vulnerability and Adaptation to Climate Change in Tanzania', The Centre for Energy, Environment, Science and Technology (CEEST), Draft Report – June, 1997.
Thailand	'Thailand's Country Study on Climate Change', Saksit Tridech et al., Thailand Environment Institute, December, 1997.
Ukraine	'Country Study on Climate Change in Ukraine: Assessment of Adaptation Options', Nikolay Raptsoun and Natalya Parasyuk, co-ordinators, Agency for Rational Energy Use and Ecology, Final Report – Kiev, 1997.
	'Country Study on Climate Change in Ukraine: Vulnerability Assessments to Climate Change', Nikolai Raptsoun and Natalya Parasiouk, co-ordinators, Agency for Rational Energy Use and Ecology, Draft Report – Kiev, 1996.

Table A.I
(Continued)

Country	Report [a]
	'Country Study on Climate Change in Ukraine', Nikolai Raptsoun and Natalya Parasyuk, co-ordinators, Agency for Rational Energy Use and Ecology, Kiev, 1997.
Uruguay	'Development of Climate Change Action Plans in Uruguay', Cecilia Ramos Mañé, Silvana Giordano, Carlos D. Víctora, Comisión Nacional Sobre el Cambio Global (CNCG), Uruguay, Final Report – December, 1998.
	'Assessment of Climate Change Impacts in Uruguay', Annie Hareau (ed.), Comision Nacional Sobre el Cambio Global (CNCG), Uruguay, Final Report – December, 1997.
Venezuela	'Assessment of the Vulnerability to Sea Level Rise – Venezuela', Maria de Lourdes Olivo and Martha Perdomo, Ministry of Environment and Renewable Natural Resources/Ministry of Energy and Mines, November, 1996.
Zambia	'Vulnerability and Adaptation Studies: Health Impacts Assessments', J. S. Phiri and D. B. Msiska, Environmental Council of Zambia.
	'A Draft Report on the Wildlife Impact and Adaptation Assessment', Charles Masiye Phiri and Musonda Mumba, Environmental Council of Zambia.
	'Vulnerability and Adaptation Assessment Study of Zambian Forest Ecosystems', K. Mwansa and Chilumba N. Chipepo, Environmental Council of Zambia, January, 1988.
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	'Vulnerability and Adaptation Assessment: Agriculture Sector', B. Chirwa, M. Phiri and P. Mulenga. Environmental Council of Zambia, Draft Report – February, 1998.
Zimbabwe	'An Assessment of Climate Change in Maize Production in Zimbabwe', Johannes M. Makadho.
	Climate Change and Zimbabwe's Forest Sector: Potential Impacts, Adaptation and Mitigation Alternatives', P. T. Mushove. September, 1995.

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(Received 28 December 1999; in revised form 2 January 2001)