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Submitted by:

Consortium for International Earth Science Information Network
2250 Pierce Road
University Center, Michigan 48710 USA
Phone: (517) 797-2700
Fax: (517) 797-2622

Principal Investigator:
Dr. Robert S. Chen
Program Manager

CIESIN

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Consortium for International Earth Science Information Network
Saginaw, Michigan

SEDAC Data and Applications Development Plan V(1)

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APPROVED BY:

Hendrik K. Meij 9-29-95

Dr. Hendrik K. Meij — Date
SEDAC Scientist

Robert A Bourdeau 9-29-95

Dr. Robert Bourdeau — Date
SEDAC System Engineer (Acting)

Robert S Chen 9/29/95

Dr. Robert S. Chen — Date
SEDAC Manager

October 1995

Preface

This *Data and Applications Development Plan* is submitted as required by Section F (Deliveries or Performance) of Contract NAS5-32632 for the Development and Operation of the Socioeconomic Data and Applications Center (SEDAC) in fulfillment of CDRL-12. This annual update of the Plan incorporates changes recommended by the SEDAC User Working Group (UWG) and reflects comments and suggestions from users, collaborators, and the Contracting Officer Technical Representative (COTR).

The Data and Applications Development Plan is a concise and specific plan which includes the following:

- The nature and priority of public policy and decision making issues to which an understanding of global climate change is relevant and which is based on scientific, governmental, or multilateral policy assessments and needs;
- The needs and practices of the socioeconomic and earth science specialists involved in the applications development effort; and,
- The needs and practices of information users and analysts who will be users of SEDAC products and supporting services.

In accordance with the Statement of Work, each task described within the Plan includes:

a. The specific problem or issue area to be addressed including a discussion of any relevant past experience with attempts to attack it;

b. The target users for the new product(s) and service(s);

c. The new product(s) and service(s), including required timeliness of delivery;

d. Scenarios showing how the target users will make use of the new product(s) and service(s) in the course of their information analysis and decision making;

e. Input data and information required including both socioeconomic and Earth science data and information;

f. Resources required for development and operational production of new product(s) and provision of new service(s);

g. User involvement in the development process including evaluation of tests or prototypes;

h. A plan for measuring the effectiveness of the new product(s) and service(s); and,

i. A schedule for completion of the development effort and the commencement of operations.

This version of the Plan was prepared by the SEDAC Data and Applications Development Team with the guidance of the SEDAC Project Scientist and the SEDAC Manager. It has been reviewed and approved by the SEDAC UWG.

Questions or proposed changes should be addressed to:

SEDAC Manager
CIESIN
2250 Pierce Road
Saginaw, Michigan 48710 USA
Tel. 517-797-2611

Executive Summary

This Data and Applications Development Plan describes how the Socioeconomic Data and Applications Center (SEDAC) at the Consortium for International Earth Science Information Network (CIESIN) is responding to SEDAC's mission to develop new applications and information products that synthesize earth science and socioeconomic data in ways that support decision making. The SEDAC data and applications development effort is a primary means by which the Earth Observing System Data and Information System (EOSDIS) program can help to ensure that the scientific investment embodied in NASA's Mission to Planet Earth (MTPE) program leads to tangible benefits to the American people.

The Plan describes the major issues concerned with global climate change, identifies important decision makers and other users who would benefit from improved data and information, and assesses key opportunities for responding to the needs of these users and the scientists who work with them. It then details specific plans for developing selected integrated data products and services and for making them available to the target users on an operational basis.

Two ongoing data and applications development tasks are described in the Plan: Task 2.2, Population, Land Use, and Emissions; and Task 2.3, Model Visualization and Analysis. Task 2.2 has developed an early set of integrated data products and services of considerable value to a diverse set of users in research, government, and the private sector. Task 2.3 has made significant progress in developing tools and mechanisms to help make integrated assessment models more useful for decision making. Continued work in these two applications development areas is expected to provide substantial payoff in terms of expansion of the SEDAC and EOSDIS user community, demonstration of new applications of integrated socioeconomic and earth science data, and implementation of robust and reliable operational services.

In addition to these two applications development efforts, SEDAC plans to initiate a third activity related to environmental treaties and resource indicators, building upon prior "proof of concept" efforts under SEDAC Task 2.1 (Task Management). This activity will enhance the current Policy Instruments Database to incorporate resource indicators based on remote sensing and other earth and social science datasets.

Finally, SEDAC plans to continue an active effort under Task 2.1 in order to ensure continuing interaction with the user community and to serve as a mechanism for identifying and assessing new opportunities for applications development. In particular, SEDAC will continue "proof of concept" activities related to *1)* stratospheric ozone depletion and human health and *2)* population and land use/ cover change in China.

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1.0 Introduction

SEDAC is one of nine EOSDIS data centers that engage in processing, cataloging, archiving, and distributing data derived from space-based platforms, including Earth Observing System (EOS) and Earth Probe flight missions undertaken as part of NASA's MTPE program. One SEDAC priority mission is to support the MTPE program by contributing to its goal of translating scientific understanding into tangible benefits to the American people by developing new policy-oriented information products that synthesize Earth science and socioeconomic data and by providing the resulting operational data and information services to the public. The second SEDAC priority mission is to serve as a two-way "Information Gateway" between the socioeconomic and Earth science data and information domains.

This Data and Applications Development Plan (DADP) principally addresses the first mission. It describes in detail the steps that SEDAC will take to carry out the applications development effort needed in support of decision making and policy analysis concerned with global climate change. It also identifies key information needs as they relate to SEDAC's second mission, i.e., ways in which the development of the SEDAC Information Gateway can provide access to socioeconomic data and information scattered in many different institutions and data centers around the world. The DADP has therefore been developed in coordination with the Information Gateway Plan (IGP), which documents needs and planned activities in the development of the SEDAC Information Gateway.

The DADP and the IGP together provide key inputs into the SEDAC Science Data Plan (SDP). The SDP details the specific datasets and services that SEDAC will provide, the associated levels of priority and service, and other information pertinent to how data products are archived and managed in ways that support the needs and priorities identified in the DADP and the IGP.

The DADP, along with the other key SEDAC plans, is intended as a "living" document. Both scientific knowledge and concerns about global climate change are evolving rapidly. Needs, priorities, and opportunities will change over time as well. It is therefore critical that SEDAC remain flexible and keep a long-term perspective on data and information needs. By updating and revising the DADP and other plans based on careful interactions with the scientific and user communities and with NASA management and the other EOSDIS Distributed Active Archive Centers (DAACs), SEDAC can maintain and improve the relevance and utility of its products and services while at the same time ensuring coordination and sound management of its resources.

Comments and suggestions about the DADP are welcome at any time. These should be directed to the SEDAC Project Manager or the SEDAC Project Scientist.

1.1 Past Year Accomplishments

During the past year, SEDAC has developed a range of integrated products and services as a result of two major applications development activities: Population, land use, and emissions; and Model visualization and analysis. These include:

1) *Online Access to Integrated Population/Land Cover Data* for the conterminous U.S. that ties together 1-kilometer land cover data from EROS Data Center (EDC) with gridded population and housing data from the U.S. Census. Variables include Total Persons and Total Housing Unit Structures from the 1990 census and the land cover classification (159 classes).

2) *An Archive of Census-Related Products* which contains Boundary Files, Standard Extract Files, Enhanced Migration Files, an Intersection Dataset, and ZIP Equivalency Extract Files derived from selected U.S. Bureau of the Census datasets.

3) *The Ulysses Tabulation/Analysis System* which currently provides online access to the U.S. Census Public Use Microdata Samples (PUMS) for 1980 and 1990. Ulysses allows users to generate cross-tabulations from the one-percent PUMS files and provides online access to the data dictionaries for these datasets.

4) *Selected Georeferenced Population Data Products,* including the Gridded Population of the World dataset (5′ x 5′ resolution), the Mexico Population Data Collection, and the Global Population Database (Center for International Research/International Programs Center).

5) *A Model Visualization and Analysis Service* that allows users to view, explore, and work with the data from precomputed model runs for selected integrated assessment models of climate change.

6) *Model Guides* that provide online information and documentation about two integrated assessment models, IMAGE 2.0 and MiniCAM. The guides include a rich set of online literature and documentation, including data dictionaries for the archived model scenarios.

7) *A Thematic Guide to Integrated Assessment Modeling* which presents a detailed, non-technical discussion of the concept of integrated assessment, the evolution of integrated assessment modeling, and descriptions of many ongoing integrated assessment modeling activities.

In addition to the above, SEDAC has also developed the Policy Instruments Database (PIDB), an Internet-accessible tool that provides online query capabilities against a database of international environmental treaties. At present, the PIDB contains the text of multilateral environmental treaties, treaty summaries and status reports, linkages to online resources maintained by treaty secretariats, and selected national-level time series of socioeconomic and environmental indicators.

In support of these applications development efforts, SEDAC has also designed and made significant progress in implementing the necessary infrastructure to put these applications into active service. This infrastructure includes:

- the basic hardware and software systems for managing SEDAC data and information resources and services;
- facilities for housing SEDAC equipment, personnel, and data;
- institutional agreements with key data sources to ensure ongoing access to the data and information needed for applications support;
- working relationships and linkages with key user communities and groups, including the SEDAC UWG;
- basic design concepts, implementation procedures, and other plans as thoroughly documented in various contract deliverables; and
- highly qualified personnel and other individual and institutional contributors that provide the range of capabilities necessary to develop and implement innovative products and services, properly manage data and information resources, and support user applications.

During the past year, SEDAC has successfully begun to serve an increasing number and variety of users. For example, during its first six months of availability, the Archive of Census-Related products served more than 1,500 unique hosts and delivered more than 30,000 files and 15 GB of data. Georeferenced data products were delivered to both earth scientists and social scientists involved in global change research. The Ulysses tabulation system is being used by a variety of individuals in state and local government, non-profit organizations, universities, and businesses. The prototype Model Visualization and Analysis services were demonstrated to participants in a "dry run" policy exercise organized by UWG member Dr. E. Parson at the International Institute for Applied Systems Analysis (IIASA). The PIDB is being used by project officers in the World Bank and Global Environmental Facility (GEF) to determine the particular environmental treaties that may apply to in-country World Bank or GEF projects.

For further information about recent SEDAC progress and user activity, please see the SEDAC *Annual Progress Report*, the *User Model Report*, and other SEDAC documents.

1.2 Objectives of the Mission to Planet Earth Program

During the past year, NASA and the MTPE program have made significant progress in refining and articulating their goals and strategies. In particular, the *Mission to Planet Earth Strategic Enterprise Plan 1995-2000* (May 1995) states:

> The overall mission of NASA's Mission to Planet Earth Enterprise is to develop understanding of the total Earth system and the effects of

> natural and human-induced changes on the global environment (NASA, 1995a: 5).

The Plan goes on to identify six goals:

1) Increase scientific understanding of the Earth as an integrated environmental system and of its vulnerability to natural variations and human influences;

2) Observe and characterize the entire Earth system and make resultant data widely available;

3) Contribute to wise and timely national and international environmental policy;

4) Foster the development of an informed and environmentally aware public;

5) Expand and improve the scientific return on investment by seeking and using advanced, cost-effective engineering and scientific techniques having potential for multiple uses;

6) Ensure the availability of human and physical resources necessary to achieve the MTPE mission over the long term.

A recent National Research Council (NRC) review of the U.S. Global Change Research Program (USGCRP) and NASA's Mission to Planet Earth/Earth Observing System recommends that:

> The USGCRP as a whole, and NASA's Mission to Planet Earth (MTPE) Program specifically, should maintain a **science-driven** approach to observation and information technology that employs current technology while investing in the development of new technology with clear applications to support the program's specific scientific priorities. (NRC, 1995: 20-21).

The report goes on to point out that MTPE missions "will contribute to practical applications such as natural hazards mitigation, water resources management, and food and fiber production, as well as advances in the Earth sciences" (NRC, 1995: 23). In particular, the NRC recommends:

> The capabilities of MTPE/EOS should be exploited fully via enhanced public access to the information products. (NRC, 1995: 23).

MTPE science priorities for 1995-2000 are expected to focus in four areas:

- Atmospheric ozone;
- Seasonal-to-interannual climate prediction;
- Long-term climate variability; and
- Land cover change and global productivity.

The goals of the MTPE stratospheric ozone research effort include documentation of trends and patterns of UV radiation at the Earth's surface, provision of a monitoring strategy for stratospheric ozone for the 21st century, and formal assessment of the state of scientific understanding of potential impacts of human actions and technologies on stratospheric ozone.

In the area of long-term climate variability, the MTPE program seeks among other things to understand causes of climate change by determining natural and human-related forcing mechanisms and the feedbacks that govern climate variability, to forecast predictable aspects of multi-year climate on a region-by-region basis, to assess formally the state of scientific understanding of climate change on a regular basis, and to develop a strategy for long-term monitoring of selected climate forcing and diagnostic variables.

The MTPE land-cover/land-use change program addresses four areas: *1)* land-cover conversion; *2)* land-use intensification; *3)* verification; and *4)* modeling. Program goals include the identification of the current distribution of land-cover types and their conversion to other types; improved understanding of the consequences of intensified management of agricultural and agroforestry systems in the tropics and sub-tropics; measurement of the long-term *in situ* degradation of forest ecosystems; improved understanding of the consequences of international agreements; and investigation of forestry and agriculture in temperate and boreal climates.

As part of its efforts to restore its research and analysis program, the MTPE program will support basic research to evaluate the potential of Lewis and Clark satellite data in applications to natural hazard risk assessment and mitigation, high precision forestry and agriculture, urban planning, and biodiversity studies. It will also contribute to an interagency effort to improve undertanding and remote sensing methods related to water resource and natural hazard issues in the mid-continental U.S. Finally, it will support studies of critical land processes that affect the vulnerability of ecosystems and agriculture to weather and climate variations, focusing in particular on Mexico, China, and India.[1]

1.3 SEDAC's Role in Mission To Planet Earth

SEDAC has a clear role to play in the MTPE program. For example, under Goal 3 of the Strategic Enterprise Plan cited above, NASA identifies objective 3.1, to "ensure the availability of MTPE data and understanding for policy makers". It points out that "one of the nine DAACs is dedicated to social and economic sciences data, " i.e., SEDAC. It also outlines a strategy for facilitating "the increased understanding of global change issues among policy makers through the provision of sample user application scenarios by 1997" (NASA, 1995a: 23).

Under objective 3.2, NASA indicates that MTPE will "support all formal integrated assessments on the global environment beginning in 1995." The Plan specifically

[1] D. Butler, Office of Mission to Planet Earth, personal communication, September 1995.

notes that "MTPE scientists have a responsibility to participate in national and international global change assessments," including those undertaken by the World Meteorological Organization, United Nations Environment Programme, and the Intergovernmental Panel on Climate Change (NASA, 1995a: 24).

Under objective 3.3, NASA recognizes the need for "integrated models" that:

> ...capture a sufficient level of detail available in individual arena models, and couple them in a manner that does not compound the errors from individual ones, or create new errors. The user must be able to run specified alternate assumption sets and meaningfully compare the resultant states predicted by the model (NASA, 1995a: 24).

As a strategy for meeting this objective, NASA indicates it will undertake to "apply at least one integrated model of the global atmosphere, oceans, and land surface incorporating space-derived data by 1998."

Clear roles for SEDAC are also evident under other goals. For example, as part of Goal 2's aim to make data widely available, SEDAC and the other DAACs not only carry out "responsibilities for processing, archiving, and distributing EOS data and related data and for providing a full range of user support", but also "support global change researchers whose needs cross traditional discipline boundaries" (NASA, 1995a: 22). These efforts to make data more available tie in closely with Goal 4, which includes the objectives of making information and assessments available to the general public and the educational community. The latter goal includes efforts to support curriculum development, put a MTPE "home page" in place on the Internet, and reach out to teachers and students. In addition, SEDAC could potentially have important roles in the areas of pursuing "technology transfer and commercialization opportunities" (Objective 5.4) and in fostering "new cooperative activities and partnerships among the NASA MTPE, university, and industry communities" (Objective 6.4).

More recently, NASA has attempted to improve its understanding of the EOSDIS user community. At the EOSDIS Potential User Group Conference held in Leesburg, Virginia in June 1995, MTPE brought together a wide range of "potential users" to characterize the needs and characteristics of the diverse user community including researchers, commercial and operational users, resource planners and managers, policy and decision makers, the legal community, educators, libraries, the press, and the general public. The preliminary draft conference report has been made available via the World Wide Web (WWW; see http://bbq.ncgia.ucsb.edu:80/eosdis/newversion/title.html) and in hard copy (NASA, 1995b). It is clear from this report that a wide range of users could benefit from EOSDIS data and information resources, but that much remains to be done to make this happen.

In summary, it appears that SEDAC can contribute to MTPE goals and strategies in a number of ways. As detailed in this document, SEDAC can develop and put into operation new products and services utilizing interdisciplinary remote sensing and socioeconomic data that will help potential users take better advantage of EOSDIS

data and information resources. Such products and services can also improve user awareness of other data and information services provided by EOSDIS and broaden and deepen the overall EOSDIS user community, e.g., by reaching out to communities not traditionally served by NASA or other remote sensing data providers. Through its Information Gateway and outreach activities (documented elsewhere), SEDAC can also help EOSDIS develop new channels for reaching the general public, the educational community, and other categories of users. Finally, specific SEDAC products and services such as those related to population, land use, international environmental agreements, integrated assessment modeling, ultraviolet radiation, China, and Mexico may have direct application and utility in meeting specific MTPE research objectives.

2.0 Global Climate Change Issues

Global climate change is one of a set of "global change" issues that have received increasing attention in the U.S. and around the world in recent years. The U.S. Global Change Research Act of 1990 defines global change as "changes in the global environment (including alterations in climate, land productivity, oceans or other water resources, atmospheric chemistry, and ecological systems) that may alter the capacity of the Earth to sustain life." Changes in the earth's climate system are of particular interest because of their potential global and long-term implications, the major role that human activities may play in causing such changes, and their close linkages with other forms of environmental change and variability. From a socioeconomic perspective, however, it is important to recognize that climate change is one of a large number of interlinked environmental and societal issues such as population growth, sustainable development, and resource management that currently face decision makers at all levels of society.

The USGCRP defines global change issues as including:

> ...long-term climate change and greenhouse warming; changes in atmospheric ozone and ultraviolet (UV) radiation; and natural climate fluctuations over seasonal to interannual time periods. Other related global issues include desertification, deforestation, land use management, and preservation of ecosystems and biodiversity. (CENRR, 1994: 2)

Within the Earth Observing System program, there have been additional efforts to refine these global change issues in relationship to measurement needs and the prominent role of space-based systems in improving understanding and monitoring of global change. For example, the *EOS: Science Strategy for the Earth Observing System* prepared by Asrar and Dozier states:

> At present, NASA focuses on five policy issues—identified by the national and international scientific community—to hone EOS measurement objectives:
>
> 1) Ozone depletion in the stratosphere, resulting in a significant increase in the ultraviolet radiation reaching the Earth's surface, which could cause considerable health hazards;
>
> 2) Climate variability caused by natural and human-induced activities that could affect patterns of precipitation and temperature, thus agricultural and industrial production and distribution;

> 3) Global warming and long-term climate change, which could contribute to diminished water supplies of suitable quality for agricultural and industrial use, and can be traced to deforestation, other anthropogenic changes to the Earth's surface, and human-induced introduction of trace gases to the atmosphere;
>
> 4) Decline in the health and diversity of animals and vegetation because of long-term changes in atmospheric chemistry, precipitation, runoff, and groundwater; and
>
> 5) Social and economic consequences of climate changes and their effects on health, standard of living, and quality of life. (Asrar and Dozier, 1994: 95).

This set of issues provides a useful boundary for the major areas to be addressed by SEDAC. Climate change and efforts to deal with it cannot be easily separated from the closely related problems of ecosystem and land use change, depletion of stratospheric ozone, and short-term climatic variability. On the other hand, too broad a menu of issues could well diffuse SEDAC's ability to produce a coherent set of products and services of value to key information users. SEDAC will therefore focus on three key issues:

- global climate change (including seasonal and interannual fluctuations);
- stratospheric ozone depletion; and
- land use and ecosystem change (including effects on biodiversity, desertification, and deforestation).

Although a detailed technical description of these key issues is beyond the scope of this Plan, it is useful to summarize here the broad outlines of each issue and the current decision-making and policy context for each.[2]

2.1 Global Climate Change

According to the Framework Convention on Climate Change, the earth's climate system encompasses the "totality of the atmosphere, hydrosphere, biosphere and geosphere and their interactions." The complexity of the interactions are typically illustrated through the so-called Bretherton diagram (Figure 1), which depicts the major processes, linkages, and feedbacks that are known to operate in the earth's climate system. Notably, this diagram provides only a simplified view of the ways in which human activities may influence or be influenced by particular components of the climate system.

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[2] For an overview of the issues and access to key literature on these subjects, see the CIESIN online Thematic Guides available through the WorldWideWeb at http://www.ciesin.org.

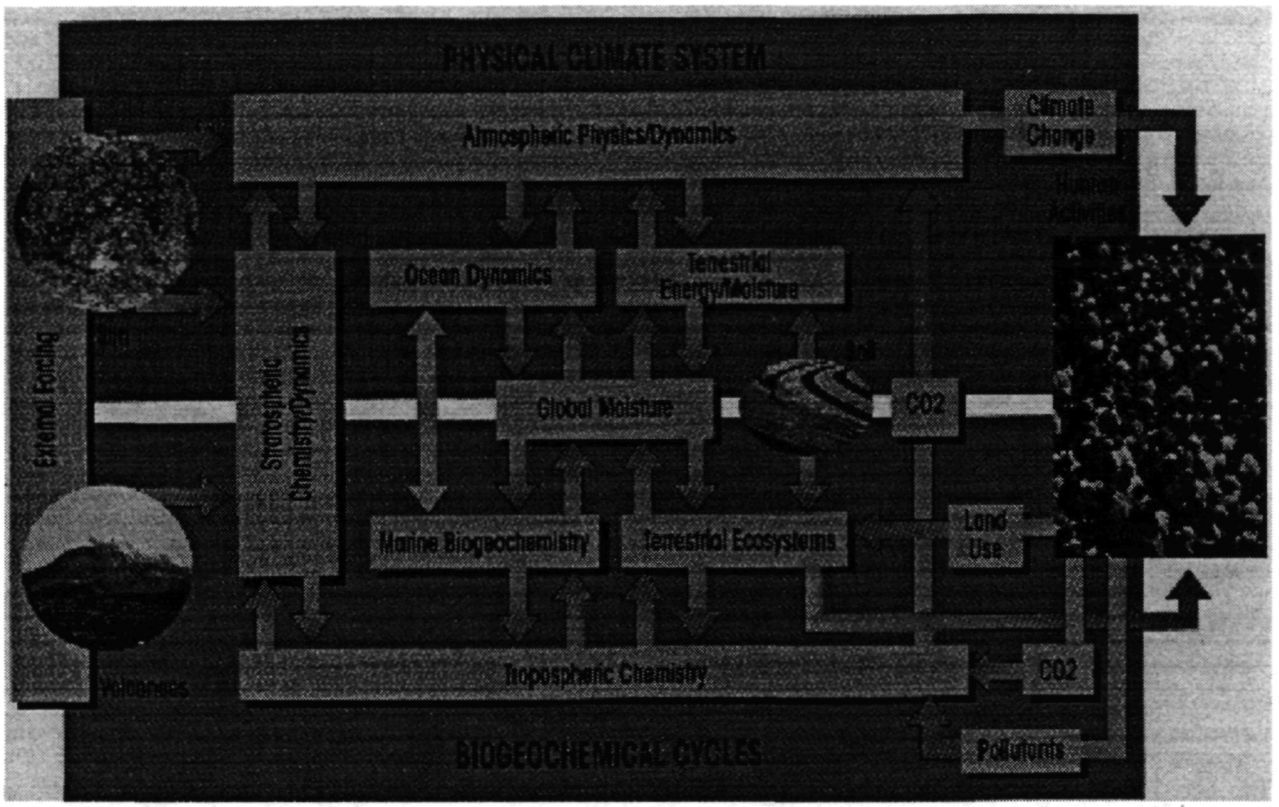

Figure 1. Simplified version of the "Bretherton" diagram. This diagram illustrates linkages between the physical climate system, biogeochemical cycles, and human activities (NSF, 1988).

Most of the concern about global changes in climate has centered on the emission of radiatively active trace gases into the atmosphere as the result of human activities such as burning of fossil fuels and deforestation. Broad international scientific consensus exists that increased atmospheric concentrations of carbon dioxide (CO_2), methane, and other trace gases could lead to significant increases in global mean air temperatures near the earth's surface (commonly referred to as global warming or the "greenhouse" effect). Such global warming would not be distributed evenly across the globe and could well be accompanied by changes in rainfall patterns, humidity, storm frequency and intensity, seasonal and interannual variability, cloudiness, sea level, ocean circulation, and other aspects of climate.

Unfortunately, present methods for analyzing climate changes are unable to predict reliably the distribution and timing of such changes. Similarly, the ability to predict the likely impacts of such changes on human activities and welfare is also poor. What is certainly clear is that future climate changes, if they occur, would have important effects—some beneficial, some adverse—on the ecosystems and other natural resources upon which the world's rapidly growing population depends. Moreover, the ability of different groups around the world to adapt to such changes will vary greatly depending on their economic status, technological capabilities, and other factors.

International concern about global warming led to negotiation of the Framework Convention on Climate Change, which came into force on March 24, 1994. As of August 25, 1995, 141 countries had signed the Convention.[3] Article 2 of the Convention states:

> The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

Signatories of the Convention agree, among other things, to develop national inventories of anthropogenic sources and sinks of greenhouse gases (except those controlled by the Montreal Protocol on Substances That Deplete the Ozone Layer); to formulate national programmes to mitigate climate change and facilitate adaptation to climate change; to cooperate in technology transfer related to reduction of greenhouse gas emissions; to promote sustainable management and conservation of greenhouse gas sinks and reservoirs (including forests, oceans, and other ecosystems); to cooperate in preparing for adaptation (especially with regard to coastal zone management, water resources, agriculture, and the protection and rehabilitation of areas affected by drought, desertification, and floods); to take climate change considerations into account where feasible in their relevant social, economic and environmental policies and actions; to cooperate in research, observation, and data management and exchange concerning the climate system and the economic and social consequences of various response strategies; and to promote education, training, and public awareness related to climate change.

In addition, developed country signatories agree to adopt national policies and take measures that demonstrate leadership in modifying longer-term trends in anthropogenic emissions consistent with the objective of the Convention; to provide financial resources in support of developing country efforts to inventory greenhouse gases, develop implementation plans, and engage in technology transfer; to assist those developing countries that are particularly vulnerable to the adverse effects of climate change in meeting the costs of adaptation; and to assist in the transfer of environmentally sound technologies.

At the national and international level, the global change issue has thus come to focus on the specific sets of actions needed to stabilize greenhouse gas emissions such that any ensuing climate changes do not constitute "dangerous" interference

[3] The text of the Convention and list of countries that have ratified it are available at the United Nations Framework Convention on Climate Change treaty secretariat at http://www.unep.ch/iucc.html. Also see the SEDAC PIDB at http://sedac.ciesin.org/pidb/pidb-home.html.

with the climate system. Clearly, a key question is what constitutes "dangerous" interference. Related to this question are uncertainties about the degree to which natural and human systems can adapt to climate change, which depends among other things on rates of change and adaptation and on needs for sustainable economic development. Concerns about intergenerational and international equity, other pressing problems of sustainable development, and valuation of costs, benefits, and risks complicate these important policy questions.

At the subnational level, interest in global climate change has emerged not only as the result of national and international commitments to address the issue but also because of concerns about local contributions to global change and the potential local impacts of such change. Awareness is growing at local and regional government levels that their decisions and actions could have important effects on energy consumption and sources, land use changes, and other activities that influence not only global climate changes, but also interlinked local and regional environmental conditions. Many private companies, utilities and utility regulators, citizen groups, and other organizations have engaged in discussions and decisions concerning global climate change. As nations move more aggressively to implement stabilization activities, these subnational discussions and decisions are likely to increase in number and importance. For example, in Charleston, South Carolina, local zoning ordinances have been changed to require a larger coastal zone set-back to account for potential sea-level rise. Similarly, Portland, Oregon has enacted an aggressive energy conservation program to reduce its emissions of radiatively active trace gases.

Finally, it is critical to point out that global climate change needs to be viewed in the context of present-day variability in the climate on seasonal and interannual time scales. Decision makers throughout society—including farmers, gardeners, water managers, truckers, pilots, insurers, emergency response professionals, and managers of energy and industrial facilities—adapt to daily, weekly, seasonal, and sometimes interannual weather and climate fluctuations. Global climate changes are likely to be felt most directly in terms of changes in the frequency and intensity of weather and climate extremes such as heat waves, freezes, droughts, floods, storms, and forest fires. Addressing the decision-making context through which different economies and economic sectors deal with these fluctuations and extremes will not only help in improving long-run adaptation to climate change, but also yield more immediate benefits.

2.2 Stratospheric Ozone Depletion

Approximately 90 percent of the earth's ozone is contained in the region of the atmosphere known as the stratosphere, which lies between 15 and 50 km above the earth's surface. Stratospheric ozone plays a critical role in chemical and biological processes by filtering ultraviolet radiation in the 220-320 nm wavelength range. The region of greatest concern for biological effects is the ultraviolet-B (UV-B) range from 280 to 320 nm. Lower amounts of stratospheric ozone result in greater amounts of UV-B reaching the surface, which can lead to damaging effects on

humans, plants, and animals. Increased UV-B in the lower atmosphere may also affect tropospheric chemistry, perhaps influencing atmospheric concentrations of methane and the production of photochemical smog.

Concern about depletion of the stratospheric ozone layer was raised in the early 1970s in the context of proposed development of fleets of commercial supersonic transports (SSTs) that would have emitted large amounts of water vapor and nitrogen oxides into the stratosphere. Subsequent research showed that chlorofluorocarbons (CFCs) used as a propellant in aerosols could also make their way to the stratosphere and lead to loss of ozone. This led the United States and other countries to ban non-essential uses of CFCs as an aerosol propellant and to negotiate the Vienna Convention for the Protection of the Ozone Layer which was ratified by 43 countries in 1985. However, no specific protocol for reducing CFC emissions was agreed to at that time (Morrisette, 1989).

In 1985 a team of British researchers working in Antarctica first reported unusually low ozone levels, which later became known as the "ozone hole." The existence of the Antarctic ozone hole was confirmed after reexamination of satellite data. CFCs were recognized as a likely cause of the ozone hole as well as a potentially important contributors to greenhouse warming. This new evidence contributed to negotiation and ratification of the Montreal Protocol on Substances That Deplete the Ozone Layer. The protocol was originally signed in 1987 and substantially amended in 1990 and 1992. It now provides for the phase out of production and consumption of CFCs, halons, carbon tetrachloride, and methyl chloroform by the year 2000 (2005 for methyl chloroform).[4] Current evidence from both surface and space-based instruments indicate that ozone is decreasing at all latitudes outside the tropics, reaching a record low in 1993 following the eruption of Mt. Pinatubo in June 1992.

In response to these scientific and policy developments, many nations, cities and other subnational authorities, and industrial organizations have taken action to control production and use of CFCs and other ozone-depleting substances and to promote the development and introduction of safe alternatives. CFCs are very stable and non-reactive with other chemical compounds which has made them ideal for many applications such as refrigeration and air conditioning and use as propellants, cleaning solvents, and blowing agents. CFC alternatives must be evaluated based on such criteria as toxicity, chemical stability, ozone depletion potential, global warming potential, and suitability as a replacement. In some cases, no suitable alternatives are presently available on an economically feasible basis, which may make certain "essential" uses of CFCs eligible for exemption from the phase out under the Montreal Protocol.

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[4] The text of the Protocol and descriptions of the amendments are available via http://www.ciesin.org/thematic/PI/POLICY/montpro.html. For current ratification status, see gopher://unep.unep.no:70/00/unep/convent/vienna%22/vie-rat, which is available through the SEDAC PIDB.

With observed decreases in stratospheric ozone over heavily populated regions of the Northern Hemisphere, ozone depletion has become a very real public health concern. Increases in skin cancer and cataracts in human populations are expected in a higher UV-B environment. Cumulative exposure to UV-B is related to cataracts and cataract-related blindness, and acute exposures may cause photokeratitis or "snow blindness." UV-B damage to the skin reduces its immunological defenses, impeding resistance to infectious diseases and skin tumors and diminishing the effectiveness of vaccines. Such immunosuppression effects could have health implications for patients who suffer from Acquired Immune Deficiency Syndrome (AIDS). Other dermatological effects include severe photo-allergies and accelerated aging of the skin. The public health and medical communities in many countries have begun to take action to warn and educate the public about these health risks.

Public awareness and education on the dangers of UV-B radiation are critical in mitigating the health effects of excessive exposure. Recently the U.S. National Oceanic and Atmospheric Administration (NOAA) has developed a "UV forecast" similar to a program implemented in Canada several years ago.[5] This forecast, delivered through local newscasts, estimates the level of UV-B exposure for the next day and recommends courses of action such as limiting outdoor activity or wearing sunscreen with a high sun protection factor (SPF) if UV-B levels are expected to be high. Since the incidence of skin cancer is believed to be controlled to a significant degree by behavioral factors, education and awareness programs such as the UV forecast can play an important role in preventing future cases of skin cancer and other UV-B-induced human health effects.

Other concerns relate to the environmental effects of stratospheric ozone depletion. For example, higher UV-B may inhibit phytoplankton growth in the upper ocean layer, which could impact the entire marine ecosystem. Increased UV-B may also affect certain forest species, crops, and other plants, affecting crop yields and plant competitiveness. Increased UV-B may also enhance photochemical smog, which can in turn worsen impacts on forests and crops as well as human health. Ozone depletion thus adds to the list of inter-related environmental threats that farmers, foresters, pollution regulators, and other resource and ecosystem managers must face now and in the future.

2.3 Land Use and Ecosystem Change

Changes in land use and ecosystems are closely interlinked with global climate change and other environmental changes. Both terrestrial and aquatic ecosystems play vital roles in the biogeochemical and hydrological cycles that moderate regional and global climate. Human use of the land affects the rates of emission and absorption of key greenhouse gases and the overall level of carbon storage in biomass. For example, deforestation in the tropics is potentially a major source of carbon dioxide emissions, and reforestation is often cited as an important option for stabilizing atmospheric carbon dioxide levels. Overgrazing and certain other

[5] See ftp://hurricane.ncdc.noaa.gov/pub/data/uvi/.

agricultural practices contribute to land degradation and desertification, which are associated with changes in albedo, roughness, evapotranspiration, moisture retention, runoff, dust burdens, and other land surface, hydrological, and microclimatic properties. Nitrogen fertilizers, irrigated agriculture, and livestock production are also significant contributors to greenhouse gas emissions.

If changes in global climate and stratospheric ozone do occur, the adaptive ability of ecosystems—and the humans who depend on them—may depend in large part on biodiversity and the ways in which humans manage land and water resources. Biological resources in the tropics are a key source of the genetic materials needed for breeding new crop varieties that are resistant to certain pests or diseases or that can thrive under different climatic and management conditions. They are also an important source of materials for new medicines. Other sensitive ecological areas include wetlands, river deltas, mountain environments, and forests. In many cases, these areas serve as breeding grounds for many different types of wildlife, as filters for environmental pollutants, and as buffers that prevent or ameliorate damage from natural hazards, soil erosion, and land degradation.

Adaptation options for managed ecosystems are generally improving because of technological advances in agriculture, forestry, biotechnology, and other fields. However, access to these technologies is not evenly distributed around the globe. In many instances, societies are facing major difficulties in coping with ecosystem degradation as populations increase in river basins, coastal plains, hill slopes, and ecologically marginal lands. Measures to assist adaptation in ecosystems that are not directly managed are not as well developed. Once degraded, ecological systems can take decades to centuries to recover.

Much recent attention to land use and ecosystem change stems from the United Nations Conference on Environment and Development (UNCED), held in June, 1992 in Rio de Janeiro, Brazil. The conference produced five major agreements on global environmental issues, including two formal treaties, the Framework Convention on Climate Change and the Convention on Biological Diversity. The other three UNCED agreements were non-binding statements on the relationship between sustainable environmental practices and the pursuit of social and socioeconomic development. Agenda 21 is a wide-ranging assessment of social and economic sectors with goals for improving the environmental and developmental sustainability of each. Chapters 10-15 of Agenda 21 deal with land resources, deforestation, desertification and drought, mountain development, agriculture, and biodiversity.[6] The Rio Declaration summarizes consensus principles of sustainable development, and the Statement on Forest Principles pledges parties to more sustainable use of forest resources.

The Convention on Biological Diversity, commonly referred to as the Biodiversity Treaty, defines biodiversity as "the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and

[6] For discussion and text, please see http://www.ciesin.org/thematic/PI/TREATY/unced.html.

the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems." Parties to the Treaty affirm their sovereignty over biological resources within their borders and take responsibility for conserving biological diversity and for utilizing biological resources in a sustainable manner. The Biodiversity Treaty entered into force on December 29, 1993 with signatures from one hundred sixty-seven nations.[7]

Many other treaties and conventions exist to protect biodiversity and related land and marine resources. For example, in the field of nature conservation two international conventions and one international program provide for designation and at least some protection of internationally important sites around the world. These are the Convention of Wetlands of International Importance ("Ramsar Sites"); the Convention Concerning the Protection of the World Cultural and Natural Heritage ("World Heritage Sites"); and the UNESCO Man and the Biosphere Programme ("Biosphere Reserves"). The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), signed by 113 countries as of 1992, seeks to eliminate trade in endangered species and to control trade in species that could become endangered. Both global climate change and stratospheric ozone depletion as well as other environmental changes suggest long-term difficulties in maintaining the viability of particular ecosystems and species.

The Centre for International Forestry Research recently hosted a dialogue on forestry and sustainable development issues. The dialogue brought together 50 scientists, key persons from the post-Rio forest initiatives, and representatives from nongovernmental organizations (NGOs), industry, government, and development agencies. The group identified a series of urgent program development priorities that include: criteria and indicators for the assessment and prediction of impacts of forest management, conservation, and sustainable development of forests; linkages between trees and forest ecosystems and the general health of the environment; reliable methodologies and mechanisms for assessing the contribution of forests to sustainable national development; role of local communities in maintaining healthy forests; and the impact of forest management on biological diversity.

At the national and subnational level, many governments have adopted programs and implemented legislation concerned with land use and ecosystem protection. However, traditions of land use management vary greatly, from approaches that rely on government regulation to those that focus on market forces and other incentives. Policies that affect land use and ecosystem management include zoning and housing laws, industrial and energy development planning and regulation, coastal zone management programs, transportation planning, urban and rural development strategies, tourism and recreation promotion, emergency response planning and disaster relief activities, trade and economic development policies, and tax regulations. Such policies must balance pressures due to population and economic needs with both short and long term environmental concerns.

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[7] For discussion and text, please see http://www.ciesin.org/TG/PI/TREATY/bio.html. For current ratification information, see gopher://unep.unep.no:70/00/unep/convent/biodiv/bio-rat.

On the research side, the Land-Use and Land-Cover Change (LUCC) Project of the Human Dimensions of Global Environmental Change Programme (HDP) and the International Geosphere-Biosphere Program (IGBP) has recently issued a draft Science Plan.[8] The plan calls for a set of integrative research foci and activities to improve understanding of: *1)* the driving forces of land use as they operate through the land manager; *2)* the land-cover implications of land use; *3)* the spatial and temporal variability in land-use/cover dynamics; and *4)* regional and global models and projections of land-use/cover change. The plan identifies three research foci—land-use dynamics, land-cover dynamics, and regional and global models—and two integrating activities—data and classification and scalar dynamics.

In the discussion of data and classification activities, the report points out:

> The human dimensions datasets have not been well defined by the social science global change research community. At the earliest possible opportunity, it will be necessary to define the research requirements for data. This process should involve a collaboration between the Human Dimensions Data and Information Systems Office (HDP-DIS) and the IGBP-DIS Office. A workshop following the open science meeting should be the venue to engage the research community to define specific datasets; the role of the open meeting would be to define the science questions and specify topical areas which will need supporting data. These will certainly include economic, political/institutional, demographic, and policy data. Some of the obvious data are population density, patterns and level of consumption, land tenure, functioning of the market, and the like.

The report goes on to note:

> One additional point must be made: satellite observations alone cannot explain the socioeconomic and political factors that are the cause of land-cover change, nor can they identify the factors that influence regional trends or local dynamics. It is only possible to address these issues by also using demographic census data and other sources of relevant social science data. The social science variables should be merged spatially and temporally with the physical science data on land-cover change, along with other variables such as soil type, hydrography, kilometers of road constructed, and distance to markets.

These observations support the need for integrative data approaches in both the scientific and applied user communities.

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[8] CIESIN provided partial support for this effort through its NASA Grant.

3.0 Global Climate Change Information Users

Characterizing the global climate change user community is difficult in part because of the diverse nature of the issues as described in the previous section. In addition to highly focused international negotiations and national legislative and regulatory decision processes, important decisions are also made at regional, state, and local scales by both public and private decision makers. Regional water authorities plan the construction of dams and reservoirs. States regulate energy and related utilities, transportation, land use, and construction. Cities and towns guide coastal-zone development and invest in infrastructure. Industrial firms make decisions about product design, production processes, and plant sites. Insurance companies provide farmers with crop insurance and home-owners with hazard insurance. Health and safety officials plan for natural disasters and design public education and awareness campaigns. Individuals and households make decisions about which goods and services to purchase, how to heat and cool their homes, and where to take vacations. All of these decision makers are potential users of data and information related to climate change and variability and efforts to mitigate or adapt to it.

The individuals and groups who make these decisions have both implicit and explicit assumptions about environmental and societal boundary conditions and about how their actions will affect and be affected by changes in these conditions over time. Implementation of their decisions is also modified and constrained by the interplay of environmental and socioeconomic systems including the related decisions made by others. For example, in market economies, decisions to change energy sources based on their associated carbon emissions will be affected by—and in turn may affect—prices of energy in both the short and long term. A decision to construct hydroelectric facilities must take into account projected future demand for water and energy, prices of generated electricity relative to other energy prices, projected future water supply, and related environmental and socioeconomic impacts. All of these factors are influenced directly or indirectly by assumptions about future climate, population growth, economic development, and environmental sustainability, among other things.

In light of the diversity and complexity of the global climate change community, it is important for SEDAC to focus carefully on key users and their major needs. In particular, SEDAC should match its resources and capabilities closely with specific types of users who do need integrated earth and social science data, including especially remote sensing data. In some cases, this may involve providing information directly to *decision makers;* in others, it will entail providing data and analysis services to *information analysts* and other intermediaries who support the decision making process. In both instances, it is critical to work closely with *social and earth scientists* who possess key knowledge and skills needed in making

decisions. A brief review of these three categories of user is warranted along with an assessment of their major data and information needs and practices.

3.1 Information Users and Their Needs

The broad community of users concerned with global climate and other environmental change can be broken into four main groups:[9]

- Large-scale governmental decision makers, such as those involved in the negotiation of international treaties and the formulation of national legislation. Key users include national governments and international governmental organizations.
- Small-scale governmental decision makers, such as those involved in implementation of policies and resource management. Key users include regional governmental organizations, state and local governments, and sometimes autonomous utility regulators and regional resource managers (e.g., air pollution control authorities, watershed managers, and regional transportation planners).
- Nongovernmental decision makers, such as those involved in decisions about economic and research investments and management of private resources. Key users include corporations and other businesses, trade and industry groups, insurers, the media, private foundations, universities and other research and educational institutions, and citizens and advocacy groups.
- Grassroots investigators, such as students, educators, interest groups and involved citizens. Many such individuals have a basic understanding of global change issues and can have important direct or indirect influence on decision making.

With such a diverse community of decision makers, information needs are equally diverse. The information needs of diplomats negotiating an international environmental agreement are very different from the needs of city planners in California or Italy. The city planners want to know what climate change might mean for the 100-year flood plain on the stream that runs through the middle of their urbanized area. The diplomats, on the other hand, are interested in understanding how a 20% reduction in carbon emissions might affect the overall economic development of their nations. Such decision makers are likely to make decisions within different frameworks based on their time horizons, constituencies, responsibilities, training, and access to information. Moreover, the degree to which decisions stem from individual versus group authority varies greatly with political and economic systems, which impacts the probability of successful implementation of any particular decision or set of decisions.

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[9] Based on discussions of the Harvard-CIESIN Commission on Global Environmental Change Information Policy.

Table 1. The user community, their roles, and outputs.

Information Users	Roles	Example Activities/Products
Large-scale government: National government - Executive Branch - Legislative Branch	Formulate, implement, enforce, and evaluate national policy Participate in international activities Establish policy and economic framework for other decision makers	National legislation (e.g., Clean Air Act) Regulatory, administrative, and research activities of agencies (e.g., EPA, USDA, NASA) National reports and assessments (e.g., EPA, GAO) Research funding Institutional capacity building Consensus building and coordination Infrastructure investments Tax policies and incentives
International organizations: - United Nations - World Bank	Manage and resolve multi-national issues and problems	Development assistance Capacity building Monitoring Assessment
Small-scale government: - Regional organizations - State governments - Local governments	Formulate, implement, enforce, and evaluate programs Establish policy and economic framework for business, households, etc.	Legislation (State Environmental Policy) Regulations and laws Environmental and policy assessments Consensus building and coordination Infrastructure investments Tax policies and incentives
Nongovernmental Groups: - Advocacy, lobbying groups - Universities, Research Institutes - Corporations, consultants - Foundations - Interest groups	Watchdog Options development Public mobilization Knowledge building Information brokers Implementation	Reports, press releases, etc. Education and public awareness Lobbying Assessments (objective and stakeholder) New products and services New knowledge and interpretation Compliance with regulations and laws
Talented amateurs: - Educators - Students - Informed citizens	Watchdog Information dissemination Public awareness Grassroots mobilization Self-enrichment	Letters to editor of local paper Public lectures and talks Public testimony at hearings Local assessments

Table 1 provides an initial assessment of the roles of the different decision-making groups, the type of activities in which they are engaged, and the products that they produce. Roles vary from formulation of policies to providing input on their modification and implementation. Activities include research, assessment, monitoring, education, and outreach.

The data and information needs associated with these roles and activities are equally varied. They include:

- highly technical data necessary for research, monitoring, and development of new products and services;

- generalized, aggregated information needed for overall decision making, education, and public awareness;
- longitudinal and retrospective data for analysis of changes over time and establishment of baselines;
- real-time data for monitoring and "watchdog" purposes;
- short- and long-term projections for assessment of potential impacts;
- comparable data and information for broad geographic regions and administrative units;
- detailed data and information for specific regions, administrative units, and socioeconomic sectors;
- environmental data and models for understanding and assessing the nature, distribution, and timing of environmental changes;
- socioeconomic data and models for understanding and assessing the nature, distribution, and timing of socioeconomic changes; and
- integrated data and models for understanding and assessing the interactions of environmental and socioeconomic systems and the resulting distribution and timing of changes and impacts.

Meeting these differing information needs within the information user community will require a carefully coordinated strategy and approach. This may be especially difficult because of the diversity of natural and social science information that is available about global change. In this regard, the NRC Committee on the Human Dimensions of Global Change (1994: 15) has identified the need to bridge "the gap between decision makers, who need answers about how global change might affect their decisions and how their decisions might affect global change, and scientists, who create knowledge about global change that ideally provides the answers that decision makers seek." Similarly, Chapter 35 of Agenda 21 calls for actions to:

> Support the development of new user-friendly technologies and systems that facilitate the integration of multidisciplinary, physical, biological, and social/human processes which, in turn, provide information and knowledge for decision makers and the general public (Agenda 21, 35.12).[10]

3.2 Data and Information Analysts and Their Needs

Important intermediaries in closing the gap between decision makers and the scientific community are information analysts, i.e., individuals who assess the

[10] Full text is available at gopher://infoserver.ciesin.org/00/human/domains/political-policy/intl/confs/UNCED/unced-finals/35---science

policy, economic, social, and sometimes the technical aspects of a problem in support of decision making. Such analysts work within virtually all governments, corporations, NGOs, and other organizations of any size. Many also work as independent professional consultants and advisors to such groups. By targeting these analysts, SEDAC can direct its efforts to a more well defined user community and provide more sophisticated data, information, and associated analysis tools to those who can utilize them.

Information analysts can be found in a variety of settings, including:

- Government agencies, e.g., international, national, state, and local agencies charged with specific management, regulatory, and policy analysis tasks;
- Consulting firms, universities, and other research institutions that advise government and other groups;
- Corporations involved in activities such as resource management, manufacturing, transportation, and financial and insurance services;
- Advocacy and lobbying groups that seek to influence legislation, regulation, and taxation at international, national, state, and local levels; and
- Media and educational organizations.

During the past year SEDAC has handled a significant number of requests for data originating from university level educators, research librarians, private consultants and the media. Their intended uses varied widely from supporting newspaper articles analyzing population movements and career development to providing data for Congressional committees.

One of the most effective ways to find and reach relevant information analysts may be to work through professional societies and other networks that include large numbers of policy analysts, especially those oriented towards data management or environmental issues. For example, the Association of Public Data Users (APDU) includes representatives from many key data sources and users. Professional societies typically focus on particular issues or sectors, e.g., the Air Pollution Control Association, the American Water Resources Association, the American Public Health Association, the International Geographical Union, the Society for Risk Analysis, the American Planning Association, the Association for Public Policy Analysis and Management, and the Association of Energy Engineers. Many of these have specialty groups, special meeting sessions, and, increasingly, electronic discussion lists and other fora that deal with global environmental change issues.

Earlier work by CIESIN has helped to identify and characterize specific organizations that are actively involved in the analysis of global change issues. These include more than five hundred interdisciplinary groups based in research institutes, universities, foundations, and NGOs. Continued work by SEDAC to refine its user model (Task 3.3) has provided more detailed information on the specific

characteristics, practices, and needs of information analysts in organizations such as these.[11]

In general, the data and information needs of information analysts overlap substantially with the needs of decision makers identified above. More specifically, it is expected that information analysts:

- already have access to certain data sources and networks, information, and models specific to their areas of expertise;
- interpret data and generate information products within their areas of expertise; and
- draw upon the expertise and judgment of technical experts as needed.

Specific needs therefore relate to:

- Improving access to data and information sources and supporting analysis and visualization tools, e.g., through online and/or real-time networking;
- Providing access to data and information products outside of a particular analyst's area of expertise;
- Developing data and information products that combine more than one area of expertise; and
- Improving access to technical expertise, especially in terms of timeliness, balance, and depth and breadth of knowledge across both natural and social science disciplines.[12]

As detailed later in this Plan and in the IGP, SEDAC seeks to address all four of these needs in specific ways.

3.3 Social and Earth Scientists and Their Needs

Social and earth scientists have played prominent roles in identifying global climate change as an important national and international issue and in helping to frame discussion and responses. More recently, the scientific community has come to the realization that more specific guidance and research is necessary to support decision makers, information analysts, and the decision making process in general. For example, the FY1995 USGCRP document states:

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[11] See the *SEDAC User Model Report*. NASA has also undertaken some efforts to identify potential users in a number of areas. See http://bbq.ncgia.ucsb.edu:80/eosdis/newversion/title.html for a draft version of the report from the 1995 EOSDIS Potential User Group Conference (NASA, 1995b).

[12] These needs are consistent with those identified in by the Harvard-CIESIN Commission on Global Environmental Change Information Policy and an analysis by C. Linville (1995) of the use of global environmental change research and data by Congressional support agencies (Office of Technology Assessment, Congressional Research Service, General Accounting Office, and Congressional Budget Office).

> To strengthen the science/policy linkage, the USGCRP is intensifying efforts to improve communication with decision makers and to identify those information needs that have the most significant implications for near-term policy development. The USGCRP is increasing support for research in the areas of: social, economic, health, and policy sciences; understanding the interactions of terrestrial ecosystems with global change; understanding and predicting the environmental impacts of global change; and developing tools for conducting assessments of global change. In addition to focused USGCRP research activities, contributing research is directed toward developing more efficient and cost-effective technologies for energy, transportation, manufacturing, environmental controls, and information transfer (CENRR, 1994: 6).

A recent NRC report acknowledges the increased focus on end-to-end or "integrated" assessment in support of policy decisions and points out the need for more emphasis on research in three areas not previously emphasized in the USGCRP:

- ecological and socioeconomic impacts and effects of global environmental change;
- research on policy options for mitigation and adaptation and on their costs and benefits; and
- research on methods for the integration of knowledge.

The report then suggests five priority research areas for USGCRP development:

- Understanding land use change;
- Improving policy analysis: research on the decision-making process;
- Designing policy instruments and institutions to address energy-related environmental problems;
- Assessing impacts, vulnerability, and adaptation to global changes; and
- Understanding population dynamics and global change.

In all five areas, the report emphasizes the need for interdisciplinary teams of scientists from both the natural and social sciences. It highlights key data needs and opportunities related to use of geographic information systems (GIS), georeferenced social data, remote sensing data, large social science datasets, and methods for integrated assessment (NRC, 1994).

This proposed research agenda, designed to support the focus and objectives of the USGCRP, provides a useful indication of the specific social and earth scientists who are most likely to work directly with decision makers and information analysts or to

collaborate together on developing applications. Though the report did not explicitly list specific types of experts, it is clear from the text that the recommended priority research areas should involve:

- land use researchers, including those who monitor, analyze, and model land use and land cover change;
- experts on biodiversity, agricultural practices related to greenhouse gas emissions, and urban and rural development;
- researchers on coastal resource use and water resource transfers, including economic, political, and institutional issues;
- analysts concerned with decision making processes including risk perception, communication of scientific knowledge and uncertainty, value of information, and decision theory;
- economists and other social scientists concerned with various possible policy instruments for mitigation and adaptation, e.g., emissions permits, tax policies, technology transfer, insurance, and legal approaches;
- researchers interested in innovation in energy technology and in the management and diffusion of such technology;
- climate impact assessors who examine vulnerability of social and environmental systems to climate change and adaptive behavior;
- climatologists involved in generating scenarios of climate change for use in climate impact studies;
- demographers and other population specialists concerned with migration, fertility, and mortality as they may interact with global change;
- interdisciplinary experts involved in developing methods of integrated assessment, including construction of integrated assessment models; and
- experts on remote sensing data, GIS, and manipulation of large social science datasets.

This group of social and earth scientists and other professional analysts engaged in interdisciplinary global change research is only a small proportion of all social and earth scientists. However, it is still much larger than the limited cadre of space scientists that NASA has traditionally targeted for research and data support. The much greater diversity of scientists engaged in global change research oriented towards decision making suggests the need for coordinated efforts to:

- promote interdisciplinary communication and interaction, especially between research and policy communities;

- share data and information resources across disciplinary boundaries, including remote sensing data, georeferenced social data, and climate model scenarios;
- encourage development of standards for data quality, continuity, access, exchange, archiving, and documentation;
- develop integrated natural/science datasets and models; and
- make new tools and resources such as GIS, online access to large datasets, longitudinal and baseline datasets, and integrated assessment models more widely available.

As described in the next section and in the IGP, SEDAC has begun to pursue a number of promising opportunities that specifically address the needs of social and earth scientists involved in working with decision makers and analysts in the context of the applications development and Information Gateway efforts.

4.0 Data and Applications Development Approach and Planning

One of SEDAC's primary missions is to develop new application products that synthesize earth science and socioeconomic data and to make such products and associated services available to information users and decision makers. Numerous opportunities exist for developing such products, more than can be pursued effectively given limited time and resources. SEDAC must therefore take into account its own capabilities and potential contributions, especially in the context of ongoing national and international research and assessment activities and plans. In particular, it should be cognizant of the interests and expected activities of other global change data centers and research institutions, especially those sponsored by NASA. It must stay abreast of ongoing technological developments in the area of computer- and network-based applications, an area of rapid change and high national and international interest. Because of the global nature of climate change and the international character of interest in the issue, it is also important that SEDAC take a broad international approach when appropriate.

Above all, SEDAC must implement a user-driven approach in its efforts to develop specific applications and services in support of its mission. Only by working closely with specific information users will SEDAC be able to ensure that its activities and services do help users in constructive and timely ways. SEDAC has therefore taken the approach of identifying target users early on in the process of developing applications products. It works with selected users to develop specific products and services that meet their needs in the near term. Such near-term success with a small set of users is critical not only to ensure that benefits start to flow from SEDAC activities as quickly as possible, but also to lay the groundwork for continued interaction and learning with the user community and for expansion of SEDAC services to a wider range of users. The value of this approach is already evident in the response to SEDAC's first-year activities.

Careful planning and management of the applications development tasks are therefore warranted. On the one hand, SEDAC should be flexible over time, as priorities and needs change and as relevant programs, activities, and technologies evolve. In particular, SEDAC needs to be aware of key points in time where its products and services may be especially valuable, e.g., in preparations for particular discussions or decisions at national or international levels or when key user communities start to utilize electronic networking services. On the other hand, a long-term perspective is needed in order to ensure continuity, productivity, and substantive contributions. Such a perspective is particularly important given the long life cycles of space-based sensors and the importance of longitudinal social science data in studies of the global change and its human interactions.

In this regard, it is important to recognize that data efforts in the social sciences often have lead times for planning, initiation, implementation, and subsequent processing that are as long if not longer than those needed to plan, launch, and assimilate data from satellites. For example, planning for the decadal U.S. census occurs on a 5-10 year cycle and it may take 5-10 years for some data and initial results to become available. Similarly, the development of integrated assessment models is likely to be a long and continuing process that will require incremental improvements over the course of many years. In many instances, the gradual development of institutional linkages and working relationships with key data and research institutions can lay the groundwork for subsequent higher profile collaborative activities when the need and resources emerge.

A continuing SEDAC objective is therefore to identify important gaps in available information products and services and to pursue near-term opportunities for filling in these gaps. Some of the key gaps and opportunities identified in various reports and assessments and in CIESIN's past activities are described briefly in Section 4.2. Since there are clearly more opportunities listed here than can be effectively pursued, SEDAC needs to set priorities carefully based on a clear set of criteria. These criteria and the resulting selection of tasks are detailed in Section 4.3.

In the long run, SEDAC needs to monitor opportunities for new applications development and to adjust its priorities on an ongoing basis. This can be done through the annual updating of the DADP, IGP, and work plan, through ongoing interactions with the UWG, by keeping in close contact with the relevant user, scientific, and data communities, and by building on key institutional linkages including SEDAC's links with other DAACs. Such planning activities are discussed in Sections 4.4 and 4.5.

4.1 User-Driven Approach to Applications Development

The key measure of SEDAC's success is its ability to provide useful services to decision makers, information analysts, and the social and earth scientists who work with them. It is therefore vital that SEDAC collaborate with selected target users at an early stage of development of its services and activities. This can help ensure that SEDAC meets key information needs in effective and efficient ways and that immediate benefits begin to flow from SEDAC activities. This user-driven approach serves as a foundation for continued development of applications products, both in terms of demonstrating SEDAC capabilities to other potential user communities and in building SEDAC's internal base of skills, tools, and other resources.

It is important, however, to recognize the challenge of working with decision makers and analysts. Decision making processes are often driven by a range of competing pressures and needs. Global climate change is only one of many pressing issues faced by most decision makers and their institutions. In the U.S., many different stakeholders can affect decision making, and virtually all decisions must undergo scrutiny and revision in many different fora. Attention spans are limited and often punctuated by intervening crises and distractions. Other groups vie for the

time and attention of decision makers and analysts, seeking to provide alternative services or to promote specific viewpoints or analyses.

Decision makers and analysts are also very sensitive to the origin, credentials, and capabilities of the people and institutions who approach them. In some cases, they may understand the necessity of balancing differing viewpoints and analytic approaches; in others, they may desire unbiased inputs and analyses from neutral parties. Some analysts may wish to obtain the required data, tools, and skills in order to perform assessments of their own; others may want to access the full range of available analyses in order to assess prospects for disagreement or consensus. In all cases, it is clear that success in reaching decision makers and analysts depends greatly on the uniqueness and value of the services or assistance that can be rendered.

SEDAC, as a NASA-supported data center, has both a clear mandate to assist decision makers and analysts in ways that enhance the public interest and a clear "comparative advantage" in terms of its broad access to NASA and related data. CIESIN's status as a neutral, non-profit, university-based institution and its solid track record in accessing and integrating social and earth science data strongly support SEDAC's position. It is important that SEDAC build on this solid foundation by consistently interacting with the user community on a knowledgeable, responsive, and highly professional basis. This includes having:

- a good understanding of the basic issues and the decision making process;
- the ability to communicate well with decision makers and analysts in their own terms and to respond flexibly to their short- and long-term needs; and
- the capacity to bring the state-of-the-art in data, analytic tools, and information technology to bear on the identified needs of user communities.

The first two items above highlight the importance for SEDAC to engage personnel who are very experienced in working with the relevant user communities and who have solid background or training concerning key global climate change issues. It is vital that SEDAC demonstrate understanding of the problems and constraints faced by decision makers and work constructively to help users overcome these. SEDAC must try to build long-term working relationships with decision makers based on trust and a sense of SEDAC's reliability, integrity, and long-term commitment in working on global climate change problems.

The third item above suggests the importance of SEDAC's ability to:

- monitor and access the state of the art in the development of new information technologies, data integration approaches, and analysis tools;
- access a wide range of relevant data from both the socioeconomic and earth sciences and pull together key datasets using appropriate integration methods;
- prototype and develop possible new applications and services with ongoing advice from and collaboration with selected target users; and

- put real services into operation in ways that support information needs effectively on a continuing basis.

Users need to know that the time they spend working with SEDAC will provide them with access to the best available data and information resources and technologies.

With these capabilities in mind, SEDAC has formed a Data and Applications Development Team (DADT) which includes personnel with strong background and experience in global climate change issues, data integration and data development, technology prototyping and development, and support for users. This team provides a key integration and coordination function across SEDAC to make sure that applications are developed in close collaboration with target users and in ways that meet both near-term and long-term needs. The major goals of the DADT are to ensure consistent and professional interaction with the user community, prompt and efficient follow-up on these interactions across SEDAC tasks, and sensible planning of activities and allocation of resources in response to user needs.

Working with the SEDAC Project Scientist, other relevant SEDAC personnel, and the SEDAC UWG, the DADT has undertaken to:

- identify key needs for applications development in areas of SEDAC expertise by interacting with the relevant scientific and user communities;
- identify key target user groups that appear most in need of assistance and most receptive to collaborating with SEDAC in the development of specific applications development products;
- identify and evaluate promising opportunities for providing new, value-added applications and services that involve integrated earth and social science data, including in particular space-based data;
- establish working relationships with selected target user groups and with related individuals and institutions that can assist directly in the development and delivery of required services;
- determine requirements for prototype products and services based on user needs and interactions; and
- coordinate development, internal and external testing, and evaluation of integrated datasets, prototype tools and services, supporting documentation, and operational capabilities.

More details on how the DADT are carrying out these activities in the context of specific applications development tasks are provided in Section 5.

4.2 Opportunities for Applications Development

During the first contract year, SEDAC has identified four new major opportunities for applications development. An "opportunity" is defined here as a need on the part of one or more specific target user groups for integrated earth and social science data (especially remote sensing data). Of particular interest are opportunities where SEDAC has some unique, value-added capabilities that could serve as the basis for working with selected target users to meet their specific needs. The two ongoing applications tasks are not evaluated here as they are "opportunities" to which SEDAC has already committed significant resources for at least two years (current plans for these tasks are given in section 5).

The four new opportunities are:

- Environmental Treaties and Resource Indicators;
- Stratospheric Ozone Depletion and Human Health;
- Population and Land Use/Cover Change in China; and
- Vulnerability to Climate Extremes in the U.S.

Brief descriptions of these opportunities are given below. These opportunities have been identified in the course of SEDAC's first-year activities and through contacts with the user community. Only general descriptions of target users are given here; more detailed assessments of selected target users and planned services are given in Section 5 for selected tasks.

4.2.1 Environmental Treaties and Resource Indicators

The 1994 NRC report recommends USGCRP efforts to improve policy analysis through research on the decision-making process and to design policy instruments and institutions to address energy-related environmental problems. Both efforts would require understanding of the key policy instruments available to decision makers and assessments of the actual or potential effectiveness of these policy instruments as applied to particular problems.

To assess the effectiveness of different global climate change policy instruments such as environmental treaties and other environmental agreements, it is necessary to have access to relevant policy material at all levels of government. However, finding and accessing this policy material can be a very difficult and time consuming process. Relevant material includes legislation submitted and passed by local, state, regional, national, and international governmental bodies; statements, country reports, negotiation drafts, and other supporting materials produced in intergovernmental conferences, preparatory meetings, and legislative and administrative hearings; judicial decisions and supporting case materials; regulations and directives from executive and administrative bodies; and in some cases informal strategy documents, discussion papers, technical assessments, and

other policy-relevant items. Notably, some policy instruments may be relevant even though they have not yet been applied in the context of global change.

Many of these policy instruments have specific requirements regarding monitoring of environmental conditions. Indeed, evaluation of compliance and progress through monitoring is an essential element in developing and implementing effective policy instruments. Space-based data are expected to be an important asset in the monitoring process. For example, NASA data on stratospheric ozone concentrations have clearly played a key role in the development and implementation of protocols to control CFC emissions. Remote sensing data on deforestation rates and land cover change may well be used as benchmarks in the development of protocols related to biodiversity and greenhouse gas emissions.

Information on environmental treaties and other policy instruments should be of interest and utility to a variety of users. For example, NASA and other earth scientists may be interested in finding out about pollution control regulations and deforestation and desertification control efforts that apply to areas where they are conducting ground truth or other observational activities. Those interested in estimating future greenhouse gas emissions and land use changes at the national or subnational level may want to know when specific countries have agreed to participate in relevant treaties and which countries have not yet done so. More generally, the broad community interested in long-term sustainable development at subnational, national, and global scales are likely to be interested in the effectiveness of policy instruments in promoting or hindering progress in sustainable development and resource management as they relate to agriculture and land use, industrial and economic development, and human health and welfare.

Opportunity for Applications Development

The opportunity exists to address the needs of a diverse set of users for interlinked data on policy instruments and associated environment and resource data in several ways. First, it is clear that users at present do not have good access to the wide variety of existing international treaties related to the environment and resource management and associated information on their ratification. Making the full text of such treaties available in electronic form along with companion data on national-level ratification would improve access to this information by decision makers, information analysts, and social and earth scientists interested in decision making at national and international levels, and aid them in identifying key linkages between relevant treaties and associated monitoring and verification needs.

Second, linkage of international-scale treaty information with data on national and subnational policy instruments would permit users to assess whether policies have been implemented by signatory and nonsignatory countries at national and subnational levels and the degree to which such policies may be in compliance with international treaties. Conversely, there are many cases where national and subnational policies have been implemented prior to international agreement; it

would be useful to examine how such policies may have influenced international negotiations.

Third, linkage of environmental treaty information with resource indicators would permit users to investigate interrelationships between specific policy instruments and observed conditions. For example, the policy instruments collection on deforestation could tie in directly with a database composed of remotely sensed and ground-based data on deforestation. Early experimentation with such links suggests that considerable methodological development may be necessary to produce credible results.[13] However, successful integration in this area would provide a unique framework and tool for evaluating alternative approaches for dealing with human contributions to global climate change.

SEDAC would build on its "proof of concept" policy instruments database which has pulled together the full text of more than 120 international environmental treaties and associated ratification information. This effort has initially focused on nine global environmental issues: climate change, stratospheric ozone depletion, transboundary air pollution, oceans, deforestation, biological diversity, desertification and drought, population, and trade and environment. The project has been developed with direct input and advice from the user community, including representatives from the Climate Change Convention Secretariat, major policy research groups, and NGOs. It would be important to add other users from NGOs (e.g., the World Resources Institute and the Electric Power Research Institute) and treaty secretariats (e.g., Biodiversity Treaty Secretariat) that would be interested in and have expertise regarding data on sustainable development monitoring and conditions.

4.2.2 Stratospheric Ozone Depletion and Human Health

As noted in Section 2.2, depletion of the stratospheric ozone layer is expected to pose an increased health risk to many heavily populated regions of the world. Aggressive CFC reduction efforts at national and international levels have resulted in a reduction in growth rates of CFC concentrations in the atmosphere. Although concentrations continue to rise, concentrations in the lower atmosphere are expected to peak in the next 3-5 years and begin a slow decline over the following 50-75 years to pre-1980 levels. Thus, even though CFC levels seem to be stabilizing as a result of international protocols, it is critical to recognize that ozone depletion and associated increases in UV-B radiation will remain a significant concern well into the middle of the 21st century. The scientific and decision making communities therefore need to move beyond their current primary focus on CFC reduction to consider ways to control and mitigate potential health effects resulting from the increased UV-B levels.

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[13] A prototype database has been developed at CIESIN that linked information on ratification and compliance concerning the CITES treaty with data on fauna and flora in specific countries.

A key challenge in assessing the public health implications of ozone depletion is that the biological processes leading to UV-induced health effects are not fully understood. Quantifiable dose-response relationships between exposure and effect have not been defined for skin cancer, immune suppression, or cataracts. Skin cancer has received most of the attention in the contemporary literature, but ocular and immune-system damage have also begun to receive greater recognition. Vulnerability to UV varies with age, sex, race, skin type, outdoor behavior, location, altitude, timing, health status, and other risk factors. Some of the consequences of UV exposure only become evident well after the exposure occurs, and they are highly dependent on the duration and frequency of exposure as well as the magnitude of the dose. Migration is another variable that can influence the amount of UV exposure that an individual receives over the course of a lifetime. These confounding factors in addition to uncertain changes in surface UV radiation as a result of ozone loss make quantitative risk assessment difficult at best.

The most effective way to address the risk of UV exposure is generally through education, awareness, and outreach. One task for the public health and medical communities is to convince the public that the risks of "sunbathing" outweigh its perceived benefits. Changing public attitudes regarding the attractiveness of a tanned body will not be easy. Warning messages about unsafe exposure levels are routinely broadcast in Australia and Canada and have recently been introduced in the U.S. by the National Weather Service working with NASA and other agencies. These public service announcements recommend against severe sunburns and suggest protective clothing, sunglasses, and sunscreen applications. Barriers to dealing with this problem are compounded in developing countries where access to information resources and preventive measures is much more limited than in developed countries and where health status is generally lower and living and working conditions lead to greater outdoor exposures.

Opportunity for Applications Development

The opportunity exists to meet the needs of public health researchers, assessment organizations, and planners for better information on vulnerability and exposure to UV radiation. Information is needed not only on overall populations at risk, but also on the specific ethnic backgrounds and socioeconomic behavior of these populations and their past exposure to UV. One of the challenges facing researchers in the diverse fields addressing UV effects is finding and accessing the large amount of published literature and supporting datasets that may be relevant. For example, public health researchers often have difficulties in accessing data on surface doses of biologically effective UV radiation for the specific times and places that match their study populations. Extrapolation of data from specific epidemiological studies is often difficult because of the lack of good data on population distributions and characteristics and corresponding exposure data.

Due to the relatively small number of UV monitoring stations worldwide and the even smaller number with long term time series of UV measurements, historical estimates are generally based on models that simulate the transmission of UV

radiation through the atmosphere. Unfortunately, access to such model estimates is presently limited. Based on prior work supported by CIESIN through its NASA Grant, SEDAC has the opportunity to make a model of surface UV-B doses for selected locations in the U.S. available online. In addition, discussions have been initiated with Dr. Betsy Weatherhead of the NOAA Surface Radiation Research Branch in Boulder, Colorado to cooperate in a proposal to collect, filter, and archive measurements from UV monitoring stations around the country. Such a centralized clearinghouse for UV measurements and historical model estimates would be a valuable resource for the public health user community and for assessment groups such as the United Nations Environment Programme (UNEP) Panel on the Environmental Effects of Ozone Depletion. The latter has just initiated a new review which will be carried out over the next four years.[14]

Other SEDAC and CIESIN activities are also expected to be relevant to this activity. For example, under the NASA Grant CIESIN has already developed online thematic guides on stratospheric ozone depletion and climate change and human health, which include access to a range of relevant literature and data. SEDAC Task 2.2 has made accessible a range of relevant georeferenced data products for the world including demographic, climatic, and topographic data for the U.S. on a 1-kilometer grid. Additional ethnic data for the U.S. could be made available. Many relevant datasets have been identified and cataloged in SEDAC's Gateway or are available through links to other DAACs or the Global Change Master Directory (GCMD).

In summary, the opportunity exists for SEDAC to develop an integrated online information service on stratospheric ozone depletion and human health. This service could provide bibliographic information on published research in the area of UV radiation and human health, access to data used in widely-referenced reports and publications, and access to key health and epidemiological datasets and supplementary resources that would be useful to the research community. Such an information resource would encourage interdisciplinary sharing and application of natural, social, and health data. This service could be especially valuable for public health and medical practitioners to determine specific regional health risks due to stratospheric ozone depletion and to respond appropriately. For example, such personnel may be able to target particular ethnic groups that may be more vulnerable and promote preventive measures that are medically and culturally appropriate.

4.2.3 Population and Land Use/Cover Change in China

Economic policies of the last decade have opened China's market and unleashed an entrepreneurial spirit that has given rise to an improved standard of living for many Chinese, and the vision of opportunity for all. The international business community has responded to the expanded market with aggressive investment in China. This economic growth in turn has increased pressures on environmental

[14] CIESIN staff member Dr. Robert Worrest and SEDAC UWG member Dr. Janice Longstreth are both members of this panel.

resources and added to concerns about China's future contributions to global emissions of radiatively active trace gases and other pollutants. The 1992 NRC report on "China and Global Change" states:

> Because of its tremendous population, economic development strategies, and natural resource base, China is causing significant environmental change, with impacts that extend regionally and, in some cases, globally (NRC, 1992).

UNCED confronted the issue of balancing the need for nations to grow economically with the need to protect the natural environment from irreversible changes that could impact habitability on Earth. UNCED's Agenda 21 challenged nations to establish a policy of "sustainable development." China was the first nation to respond to this challenge through its development of "China's Agenda 21: A White Paper on China's Population, Environment, and Development in the 21st Century." The White Paper was adopted by the 16th executive meeting of the State Council of the People's Republic of China on 25 March 1994. China has gone on to establish a priority program for China's Agenda 21. The program establishes nine priorities, including sustainable agriculture and environmental pollution control, and defines 62 priority projects. China is looking in large part to unaligned multinational agencies, first world philanthropic organizations and government agencies, and foreign industry to invest in its program.

A clear need exists for accurate information about China and its rapid development, including in particular data on past, present, and future changes in economic strategies, population trends, land use/cover, and environmental conditions. Demand for these data will come from scientists, business interests, and decision makers both within China and around the world.

From the point of view of access to information, China presents a paradox. As a nation that invented bureaucracy, China can brag of the best kept historical and modern-day record of environmental and socioeconomic statistics. At the same time, totalitarian policy rooted in centuries of imperialistic culture have made access to China's records difficult for the outside world as well as for bureaucratic entities within China itself.

Opportunity for Applications Development

CIESIN has in the past two years worked actively to improve the accessibility of data and information regarding China. First, CIESIN has collaborated with a group of China experts to develop a scholarly database about China. The project, called China in Time and Space (CITAS), has assembled a database using GIS technology that incorporates a variety of socioeconomic statistics and land use data from 1982 to 1990. The database is resolved to the county boundary (xian) administrative unit and is coupled with a detailed vector county boundary map. In addition, data representing a variety of environmental variables have been extracted from the Digital Chart of the World at the scale of 1:1,000,000. Recently CIESIN has worked

with EROS Data Center and its Consortium member the Environmental Research Institute of Michigan (ERIM) to acquire remotely sensed data that can be incorporated into the CITAS GIS.[15]

Second, CIESIN has invited a number of Chinese institutions to participate in the CIESIN Information Cooperative. A number of key institutions are now participating in the program. In particular, CIESIN has formal agreements in place with the Chinese Academy of Sciences (CAS), Peking University, the Administrative Center for China's Agenda 21, the China Population Information and Research Center, the Chinese Academy for Surveying and Mapping, and the China Economic Monitoring Center (CEMC). This initiative should lead to improved access to Chinese public records. For example, CIESIN currently has rights to provide public access to a 1% sample of the 1982 Chinese census, using the Ulysses tabulation system developed under SEDAC Task 2.2. The CEMC is permitting CIESIN to provide access to a national-level macroeconomic database that includes monthly statistics for hundreds of key variables and economic indicators. CIESIN has also established close ties with the Peking University Remote Sensing Laboratory and with the CAS Institute for Remote Sensing Applications.

Third, as noted previously, the HDP/IGBP LUCC Project has recently issued a draft Science Plan that highlights the need for direct observation and spatial analysis of land-cover dynamics, comparative case studies of land-use dynamics, and development of regional and global models for integrative assessment of the socioeconomic and biophysical driving forces of land-use and land-cover change. It also emphasizes the need for integrating efforts related to land-use and land-cover data and classification and to treatment of "scalar dynamics". As this project moves from its planning stages into implementation, development of a unique national-level database for China will most certainly provide important opportunities for exploratory investigation and testing.

These basic data and associated institutional relationships provide an unprecedented opportunity to develop unique interdisciplinary data resources that address the key issue of population and land use/cover change in China. In particular, SEDAC is investigating the potential for developing both national-level and regionally-focused integrated databases that link remote sensing data at various resolutions with key sources of data on land use and land cover. Such integrated databases would take advantage of access technologies developed in other SEDAC projects to permit users to query data spatially and temporally online.

4.2.4 Vulnerability to Climate Extremes in the U.S.

The 1994 NRC Human Dimensions Committee report emphasizes the need for better assessment of impacts, vulnerability, and adaptation to global change, including interannual climate variability. It argues for "improved and more regionally detailed assessments of the impact of climate change on socioeconomic

[15] A CITAS World Wide Web site is available at http://www.weber.u.washington.edu/~citas.

and ecological systems," for "vulnerability assessments of the ability of resource and human systems such as forestry, agriculture, cities, and industry to anticipate and respond to global changes", and for "improved information for valuing the consequences of global change" (NRC, 1994:26).

One key to understanding impacts and adaptation with respect to global change is better data on the populations vulnerable to environmental processes and variation. As evidenced by the unexpected deaths of hundreds of elderly in Chicago and other cities in the 1995 heat wave in the midwest and northeast U.S., even current climate variability can have significant and unpredictable effects on human life and welfare. This unpredictability stems in part from complex interactions between environmental and societal stresses; it is clear, for example, that the fear of crime, cutbacks in social services, lack of access to even basic adaptation measures, and other socioeconomic factors may have contributed to the high death rates.

A related problem is the shortage of information about the economic resources at risk. One measure of such resources is the value of real estate, structures, and other private and public property. Property values reflect not only the present income-producing capacity of land and associated resources but also their perceived future value as an income source. Environmental hazards such as floods, fires, earthquakes, and toxic contamination clearly have impacts on property values, as do the perceived threat of such hazards. Long-term global environmental change adds a new dimension to such threats, through possible changes in the frequency or magnitude of environmental hazards and increased uncertainty and potential for surprise. Most estimates of economic losses reported in the news media come from local and state officials who make cursory estimates of damages, typically as part of a process for applying for federal disaster assistance. Biases and limitations in this process include the tendency to overestimate damage estimates to ensure qualification for aid and the quick turnaround required for such estimates, before more objective surveys can be conducted. Other estimates have been developed by the insurance industry, but these only cover insured properties and are not widely available.

Opportunity for Applications Development

The opportunity exists to address the needs of emergency response planners, public health and community officials, coastal zone managers, insurance adjusters, and others concerned with vulnerability to hazards by developing a georeferenced database on the potential vulnerable populations and economic resources that might be affected by changes in the frequency, magnitude, or spatial distribution of different hazards. Such data would also be of potential immediate application to current problems of interannual climate variability, e.g., emergency planning for coastal storms and assessment of insurance needs.

Development of such a database would build on SEDAC's ongoing efforts to pull together key geographic, demographic, and economic data from the U.S. Census Bureau and other sources. These data include the number of people, housing units,

and the mean value of owner-occupied housing at the Census block level (about 35 people in metropolitan areas, 80 people in rural areas). The block-level data can be linked with other socioeconomic data such as income (available from STF3A at the block-group level) and property tax records (available from the U.S. Census of Governments and from state and local sources). In addition, the Census PUMS data could be used to identify types of individuals and households with combinations of characteristics that might make them more or less vulnerable to particular natural hazards. Because of the nature of the PUMS sampling frame, careful linkage is needed between the PUMS data and other available data when making geographic inferences at local scales.

Of special interest would be integration of this database with earth science data including especially remote sensing imagery and digital elevation model data. Such linkages would provide users and analysts with a more direct qualitative and quantitative assessment of the land, people, and resources at risk. Remote sensing data could also help refine the level of spatial detail, e.g., through GIS techniques to distribute aggregate data for administrative units within such units. In addition, it should be possible to link the socioeconomic database more directly with data on environmental hazards (e.g., hurricanes, storm tracks, lightning strikes, flood-prone regions, and tornadoes) and with other environmental data (e.g., watershed boundaries, topography, and ecological zones). Some users may well desire access to real-time remote sensing data linked with the underlying population and socioeconomic data. The resulting service would be a powerful tool for assessing present and future economic impacts of environmental hazards, with or without environmental change. A framework for this type of service can be seen in an experimental project being developed by the U.S. Broadcast Emergency Alert System. EAS-L, "Emergency Alert System on the Internet", provides online access to emergency information and data for Houston, Texas (http://www.eas.net/) and attempts to provide a communication channel for coordination of emergency services in the event of a disaster.

Potential uses of the database extend beyond emergency response and disaster relief. For example, decision makers are likely to want to utilize vulnerability data in making present-day decisions about infrastructural development, e.g., investments in dams, flood protection, roads, and buildings. For example, Yohe has developed a decision-support model designed to help decision makers assess the costs and benefits of different responses to the threat of sea level rise resulting from global warming, e.g., coastal protection versus abandonment. The model incorporates local property value data as well as other localized data provided by the user. Wider access to this model and the data needed to apply it could be of value to selected users.

4.3 Selection of Applications Development Tasks

All of the opportunities for applications development identified in the previous section present novel approaches to integrating earth science and socioeconomic data and information resources in ways that could assist specific user communities and support decision making in a variety of ways. It is clear, however, that SEDAC

cannot hope to pursue all of these opportunities simultaneously, especially given its prior commitment to two major applications development activities. Moreover, some opportunities are more ready for active development than others, and some have dependencies on other organizations and programs that are beyond SEDAC's control. Therefore, it is important that SEDAC clearly prioritize its efforts in ways that seek the highest return on investment, i.e., by selecting activities that are the most timely, appropriate, cost effective, and complementary to its mission and capabilities.

Selection criteria that are of particular importance as guides in choosing additional applications development tasks include:

1) Each task addresses the needs of an important set of global change information users;

2) Each task integrates socioeconomic and earth science data or information, including remote sensing data directly or indirectly and as appropriate drawing on other NASA DAACs;

3) Each task leads to concrete, near-term operational products or services for information users, preferably utilizing advanced technologies such as GIS, remote sensing, network access, analysis and visualization tools, or hypertext and search tools;

4) Each task builds on CIESIN's and SEDAC's capabilities and applications development activities, especially in the areas of data management, tool development, integration of data and information across disciplines, and interaction with the user, science, and data communities;

5) Each task can identify well-defined near-term goals and milestones with a high level of return for a reasonable level of initial resource investment;

6) Each task defines a clear role for SEDAC in related ongoing activities in the user, science, and data communities, especially with regard to the timing of outputs relative to key decisions and user needs;

7) Each task has a well defined user community that can be involved in the design and implementation of products and services;

8) Each task can identify complementary resources from other programs, institutions, funding agencies, or other appropriate sources; and

9) Each task leads to longer-term opportunities for product development and operational support through development of unique capabilities, experience, and infrastructure.

In addition, the set of selected tasks should meet several group criteria:

Table 2. Assessment of applications development opportunities versus selection criteria. H=high, M=medium, L=low, D=direct, I=indirect.

Applications Devt. Opportunity	Individual Criterion								
	1	2	3	4	5	6	7	8	9
Environmental Treaties and Resource Indicators	H	H/D	H	H	H	H	H	H	H
Stratospheric Ozone Depletion and Human Health	H	H/D	H	H	H	H	H	M	H
Population and Land Use/Cover Change in China	H	H/D	H	H	H	M	H	M	H
Vulnerability to Climate Extremes in the U.S.	H	M/D	H	H	H	M	H	M	M

10) The selected tasks complement each other in terms of value-added products, interactions with the community, and resource and personnel needs;

11) The selected tasks provide some diversity yet overall balance in terms of national/international focus, subject area, user communities, and data versus information orientation; and

12) The selected tasks fit within the available budget and personnel constraints and take advantage of particular staff talents and interests.

Table 2 provides a qualitative assessment of each of the four opportunities according to the nine individual criteria. Since this type of assessment necessarily involves somewhat subjective judgments based on past experience to date, only a simple "high," "medium," and "low" ranking is used and each criterion is given comparable weight.

This qualitative assessment suggests that the first opportunity is probably the most ready for active applications development as defined by the above criteria. The remaining opportunities still appear to need work in refining the specific user communities and their needs, as well as specific tasks and complementary resources.

Applying the three group criteria to the two existing applications development tasks (Population, land use and emissions and Model visualization and analysis) and the highest rated applications development opportunity (Environmental treaties and resource indicators), it appears that:

- The environmental treaty activity would complement the model visualization and analysis task by providing national-level resource indicators that could be used as benchmarks for comparisons with model scenarios and by providing treaty text and status information that could be used as guides in setting policy variables available in different integrated assessment models;
- The environmental treaty activity would complement the population, land use, and emissions task by providing national indicators for relevant parameters.
- The database and Internet access technologies required by the environmental treaty activity and model visualization and analysis tasks are similar.
- Only a modest level of systems development effort would be needed to enhance the existing PIDB. Thus, it appears that available personnel and budget would be sufficient to provide appropriate staffing and resources to these three projects to accomplish their goals in a timely manner.

In summary, this review of key opportunities for applications development suggests that SEDAC should continue to pursue the existing applications development tasks (Population, land use, and emissions and Model visualization and analysis); initiate one new applications development task (Environmental treaties and resource indicators); and continue limited exploration of other prototype activities (e.g., stratospheric ozone depletion and human health and population and land use/cover change in China).

Detailed plans for the three main tasks are outlined in Section 5. Preliminary plans for continuing the exploration of additional opportunities are also provided. It is expected that this prioritization will be reviewed at least annually both by SEDAC staff and by the UWG.

4.4 Ongoing Identification and Assessment of Opportunities

As noted above, it is important for SEDAC to keep track of opportunities for applications development and to reassess the relative priority of these opportunities on a regular basis. In addition, new opportunities will undoubtedly emerge based on developments in scientific knowledge and program priorities, new and evolving institutional contacts and collaborative arrangements, and new technical and analytic capabilities. Primary responsibility for identification and assessment of such opportunities lies with the DADT working with the SEDAC Project Scientist. It is expected that the UWG will not only review and approve changes in plans as the result of this ongoing process, but will also contribute to it both as a group and on an individual basis.

At key points in time, SEDAC may choose to phase out its emphasis on one or more applications development tasks and phase in a high level of activity on a new task or set of tasks. This does not necessarily mean a halt to the *operational* services and products generated by the original task(s), but it could reduce or halt improvements

or enhancements to such products and services at least temporarily. Such actions need to be taken with great care, as SEDAC's success will certainly be measured to some degree by the continuity and long-term reliability of its services. On the other hand, continued innovation and responsiveness to external priorities are vital in order to maintain SEDAC's utility to a wide range of users.

SEDAC therefore needs to remain flexible in approaching new applications development tasks. In particular, it should recognize that some tasks may need considerable preparatory time at low levels of activity before they warrant more substantial investment of resources. For example, a sensible strategy for addressing the stratospheric ozone depletion and health project is to cultivate key institutional relationships with major public health research, data, and policy institutions concerned with UV-B radiation and its effects. Such contacts typically take time to initiate and to develop into productive relationships. It may also make sense to begin early on to acquire data expected to be needed as inputs, to avoid last-minute problems in assembling data and acquiring redissemination rights. At some future time, a useful cooperative agenda and strategy (and pool of resources) may emerge such that a formal applications development effort makes sense. This strategy is analogous to the preparatory time needed prior to a satellite launch.

For such a flexible approach to be successful, it is important for the DADT and other SEDAC staff to interact and communicate on a regular basis with the broad user community. The objective should be to stay current on evolving user needs, priorities, time schedules, and modes of operation. This can occur through a number of different channels of communication and interaction, including:

- direct contact with the UWG both at meetings and through telephone and electronic contacts;
- participation in selected meetings attended by policy users, including invited meetings and workshops that are part of policy-oriented activities such as the Intergovernmental Panel on Climate Change (IPCC);
- visits by selected representatives from the policy user community to SEDAC (e.g., to present a seminar and discuss SEDAC capabilities);
- papers and publications in newsletters, journals, and other print and electronic media (including, for example, the CIESIN Kiosk); and
- communication with information analysts and other users by telephone, electronic mail, Internet discussion fora, and other means.

Similarly, SEDAC staff must stay in close contact with scientific, data, and technology personnel at other key research and data institutions, particularly the EOSDIS DAACs. SEDAC objectives should be to:

- maintain currency with new research findings relevant to global climate change and its implications for human health and welfare;

- monitor development of new Pathfinder datasets and other potential resources that could be integrated with SEDAC data and information resources;
- track plans for new data collection efforts including future satellite missions and other data initiatives in both the natural and social sciences;
- build working relationships with research and data staff at other key institutions and keep them apprised of user needs, services, and opportunities that may exist; and
- assess ways to develop institutional linkages and other collaborative endeavors to promote applications development.

Finally, the DADT needs to work closely with the SEDAC archives staff. CIESIN's past data development experience suggests the importance of early action to obtain needed input datasets including permission to redisseminate these as part of integrated data products. Such data acquisition activities can also lay the groundwork for future applications development tasks by building positive, cooperative relationships with key members of the research, data, and user communities. In some cases, it may make sense to make key data inputs obtained by SEDAC available to the user community, in part to gain the trust and cooperation of selected representatives.

4.5 Key Institutional Linkages

Building productive working relationships with other research, data, and user institutions is not an easy task. Elements needed for development of integrated products and services are often scattered among diverse sources, many of them difficult to find and access. The broad international and interdisciplinary nature of global climate change issues suggest that few scientists, users, or even data centers are knowledgeable about more than a limited range of the potentially available data and information resources (NRC, 1992). Moreover, traditions and standards for sharing data vary greatly between countries, disciplines, and sectors (e.g., private versus public), as do capabilities for electronic data exchange and networking.

The SEDAC Information Gateway is a key mechanism for improving access to a wide range of data and information resources and to build working links with other institutions concerned with global environmental change and its human dimensions. SEDAC/CIESIN experience to date suggests that participation in an international data sharing activity is an excellent way to build institutional relationships that may then extend to other areas of cooperation and collaboration. This has been the case with the Dutch National Institute on Public Health and Environmental Protection (RIVM), which is interested not only in sharing its data through the SEDAC Information Gateway, but also in collaborating on activities related to population, land use, emissions, and integrated assessment modeling. It is therefore important for the DADT, in conjunction with the SEDAC Project Scientist

and other relevant SEDAC staff, to maintain close coordination with SEDAC Information Gateway activities and plans. Such coordination will benefit both efforts.

It is essential for SEDAC to develop and maintain linkages with EOSDIS and the other DAACs. For example, SEDAC has initiated contacts with Dr. William B. Grant at NASA's Langley Research Center (LaRC). Dr. Grant has compiled an annotated bibliography containing more than 1,000 journal and report references on the UV and ozone issue over the past several years that date back to the early 1900s. Discussions have been initiated to obtain this dataset. Other datasets likely to be needed for a stratospheric ozone depletion and human health project include LaRC's C1&C2 cloud analysis data products of the International Satellite Cloud Climatology Program and the Total Ozone Mapping Spectrometer (TOMS) version 7 data available from Goddard Space Flight Center (GSFC).

Because of its need for long-term relationships with data providers, SEDAC should continue to take advantage of CIESIN's Information Cooperative partners in its applications development activities. For example, SEDAC will maintain contacts with Information Cooperative partners such as the World Conservation Union (IUCN) and UNEP for acquiring updates on treaty status and ratification information as part of the Environmental Treaties and Resource Indicators activity. SEDAC will also work with present partners such as the World Resources Institute (WRI) and with potential new partners that may be important in assembling appropriate resource indicators.

SEDAC's continued working relationship with scientists and data producers keeps the DADT abreast of current data resources required for applications development activities. For example, Professor John Gamble of Pennsylvania State University at Erie has recently completed a Ford Foundation planning grant and will submit a major proposal to Ford Foundation for an Electronic Information System for International Law/Informatique de droit international (EISIL/IDI) which would contain the text of all general multilateral international treaties and all the decisions of the World Court since 1922. If this proposal is funded, it would benefit SEDAC by facilitating access to treaty texts in both English and French. Professor Gamble has indicated that SEDAC and the PIDB would be designated as the environmental law center in the EISIL/IDI project.

Other institutions where linkages may be valuable include:

- Battelle Pacific Northwest Laboratories
- Carnegie-Mellon University
- Consultative Group for International Agricultural Research (CGIAR)
- European Social Science Archives
- INEGI
- International Agency for Research on Cancer (IARC)
- International Institute for Applied Systems Analysis (IIASA)

- The United Nations Development Programme (UNDP) Sustainable Development Network (SDN);
- The Inter-American Institute for Global Change Research (IAI);
- The Intergovernmental Panel on Climate Change (IPCC);
- The World Bank
- National Cancer Institute (NCI)
- National Climatic Data Center (NCDC)
- National Center for Health Statistics (NCHS)
- University Corporation for Atmospheric Research (UCAR)
- University of Missouri-Urban Land Information Center
- U.S. Bureau of Census
- World Resources Institute

More detailed assessment of the need for linkages with these institutions will be provided in the update to the SEDAC *Science Data Plan.*

The broad international nature of responses to global climate change suggests the importance of improving data sharing and interchange with developing nations and nations with transitional economies. Nations in Central and Eastern Europe are of particular interest at present because of their evolving economic and political systems and high levels of interest in establishing systems and networks to support pressing needs for socioeconomic and environmental data and information. High levels of interest in data and information systems are also evident in the rapidly developing economies of Asia. Ongoing Information Cooperative initiatives in China, Estonia, Hungary, Japan, Latvia, Lithuania, Mexico, Poland, Thailand, Ukraine, and many other countries have led to linkages with data sources and institutions in each. Further development of institutional linkages has been undertaken in South and Central America (via IAI) and in Africa, as detailed in the IGP. Careful monitoring of IGP activities by the DADT will help to ensure effective coordination and cooperation between these efforts.

5.0 Data and Applications Development Tasks

As detailed in Section 4, several opportunities for data and applications development show high levels of promise in producing valuable, integrated products and services in support of SEDAC's mission.

The discussion of opportunities in Section 4 identified a wide range of possible users of the proposed integrated products and services. This section focuses more tightly on key subsets of the user community, i.e., those that are among the most likely to utilize and benefit from specific products and services. By examining the needs and modes of use of these specific user groups, and by involving selected user representatives in product design, testing, and implementation, SEDAC can ensure that there will be a core target audience of users who will derive concrete benefits from SEDAC applications. Careful selection of the initial target user groups combined with robust design and implementation strategies will help ensure that other types of users will also benefit from SEDAC applications.

This section provides detailed plans for each of the three new opportunities and the two existing applications development. It indicates specifically:

a. The specific problem or problem area to be addressed including a discussion of any relevant past experience with attempts to attack it;

b. The target users for the new product(s) and service(s);

c. The new product(s) and service(s), including required timeliness of delivery;

d. Scenarios showing how the target users will make use of the new product(s) and service(s) in the course of their analysis;

e. Input data and information required including both socioeconomic and Earth science data and information;

f. Resources required for development and operational production of new product(s) and provision of new service(s);

g. User involvement in the development process including evaluation of tests or prototypes;

h. A plan for measuring the effectiveness of the new product(s) and service(s); and,

i. A schedule for completion of the development effort and the commencement of operations.

The section concludes with a discussion of Task Management.

5.1 Population, Land Use, and Emissions

This applications development task (SEDAC Task 2.2) addresses data and information needs related to population, land use, and emissions. In particular, SEDAC will continue to work directly with selected users concerned with local and regional climate change and variability to identify how key data resources and system tools can be linked and improved to help them assess their decision making problems and alternative solutions. The major goal is to provide ongoing, operational services useful to these analysts for planning, decision making, and supporting analysis and research at local and regional levels.

5.1.1 Specific Problem

During the past year, SEDAC has identified many different possible applications of integrated population, land use, and emissions data, including management of natural resources, assessment of the potential impacts of climate change and variability, emergency response to hazards, urban and regional planning, and estimation of greenhouse gas and other emissions. Many of these applications reflect growing interest in the local and regional impacts of both environmental change and proposed mitigative and adaptive strategies. Local and regional officials, planners, investors, managers, and other interested parties are becoming increasingly concerned about how various forms of climate and other environmental change and variability may affect their natural resources, economies, and constituencies. Many are even more concerned about proposals to stabilize greenhouse gas concentrations through actions to reduce sources and enhance sinks, since these might very well lead to regulations, tax incentives, or other actions that could have significant impacts on local industry, land use, and other aspects of their socioeconomic development.

To address local and regional issues, analysts and decision makers need detailed data about population, land cover, and emissions within their geographic area of concern. Such data can help them assess present and future patterns of change in population distribution, land cover and land use, and associated emissions from industry, transportation, agriculture, and other activities. These data would facilitate local and regional assessment of greenhouse gas sources and sinks and the impacts of proposed mitigation and adaptation policies. In combination with other data available at local and regional levels, it should also be possible to assess key vulnerabilities to climate change and variability, e.g., coastal resources at risk of sea level rise, mountainous areas stressed by development and erosion, ecological areas constrained by natural and human barriers, and water resources subject to diverse environmental, economic, and demographic pressures.

It is important to note that global climate change concerns need to be seen in the context of ongoing decision making related to land use, pollution control, and urban and rural development. Most planners, analysts, and local and regional decision makers must balance short- and near-term needs against proposed near-term actions to control greenhouse gas emissions and potential long-term implications of global

climate change. SEDAC cannot expect to address only global climate change problems without understanding the broader decision making context facing its target users.

5.1.2 Target Users

The initial target users are the key decision makers in the U.S. concerned with socioeconomic and environmental change and variability located in local and regional governmental and nongovernmental institutions. This group includes urban and regional planners, regional environmental analysts in both the public and private sectors, academics and consultants concerned with local and regional problems, and local and regional data and research centers that provide data, information, and advice on applied problems. Examples of the last group are state data centers, state climatologists, and state hydrologists who help state governments, businesses, and other decision makers with accessing and interpreting both natural and social science data. Professional planners and environmental analysts work at all levels of government, including towns, cities, counties, metropolitan areas, states, and groups of states. Many consultants and advisors originate with local colleges and universities that provide technical expertise and guidance for the areas in which they are located. An example of this is the growing number of geography and planning departments that provide local or regional digital mapping and GIS services and train students who often end up working in state and local agencies.

During the past year, SEDAC has initiated contacts with users via four professional groups: State Data Centers (SDCs), the Association of Public Data Users (APDU), the Association of Population Centers, and the Association of State Climatologists. Efforts to reach these groups are expected to continue and expand during the upcoming year. In addition, SEDAC will continue to identify target users through other contacts and channels, including requests that come to SEDAC through User Services or other means.

Some specific examples of other target users are detailed in the user scenarios given below. It is anticipated that the set of target users may be expanded to Mexico and Canada in subsequent project years as new population and land use data become available for applications development activities.

5.1.3 Planned Products and Services

At present, there is no way that widely scattered local and regional analysts can easily access relevant data on population distribution, land cover and land use, and emissions at a sufficient level of spatial detail to be useful. Moreover, linking such data with other relevant data sources is generally difficult. For example, a key data resource in the U.S. is the Census TIGER (Topologically Integrated Geographic Encoding and Referencing) files which provide spatial referencing for Census Bureau data products. However, these files are often difficult and expensive for local and regional users to access. Similarly, access to other large Census Bureau datasets, such as the Summary Tape Files (STFs), can be an obstacle because of their size and

complexity, the expertise needed, and the delays and expense of ordering data through the Census Bureau.

This task will continue its first-year activities to develop four types of products and services:

Expansion of the Archive of Census-Related Products

To provide a base framework of boundary and demographic data, SEDAC has created an Archive of Census Related Products with more than 17,000 data files derived from various U.S. Census sources. These files are available in a form that can be easily imported into a desktop GIS system. Generation of these files was a necessary step in SEDAC's integration of remotely sensed and socioeconomic data. As recommended by the UWG, SEDAC will continue to expand the Archive with additional demographic data, integrated remote sensing/socioeconomic data, and relevant boundary layers. Generation of data layers for 1980 boundaries and demographics to permit analysis of trends will be investigated. Other additions may include the aggregation of STF data to Public Use Microdata Area (PUMA) geographies to permit linkages between summary and sampled data.

Creation of a Master Area Block Level Equivalency File

The creation of a Master Area Block Level Equivalency (MABLE) file and its application in a Geographic Correspondence (GEOCOR) engine will greatly facilitate the generation of future products and services. The MABLE file will essentially link all census geographies at the atomic unit of the 1990 decennial census: the census block. Each record will identify its relationship to other geographies such as block groups, zipcodes, census tracts, and so forth. SEDAC also plans to include the relationships that result from intersecting a 0.25 km^2 grid for the U.S. with census blocks.

Once completed, the MABLE file can then be used with GEOCOR to resolve allocation issues. For example, grid-based data (e.g., primary/secondary land cover classes or measures of emissions) could be allocated to other polygon levels. MABLE and GEOCOR would thus allow raster data to be summarized according to vector-based census geographies. Conversely, aggregate administrative data could be "rasterized" using the 0.25 km^2 relationships with census blocks. MABLE and GEOCOR could also be used to translate data between any combination of supported layers, e.g., zipcodes within congressional districts or vice versa and with various grid sizes (e.g., 1 x 5 km or 2.25 x 2.25 km). They may also be useful in linking survey respondents to specific locations to permit contextual analyses without jeopardizing confidentiality restrictions.

Continued Integration of Socioeconomic and Remote Sensing Data

As recommended by the UWG, SEDAC will continue the task of integrating remotely sensed and socioeconomic data by adding selected socioeconomic and

remote sensing variables to the existing gridded integrated dataset. This will include the elevation and selected climatological variables from the EDC land characterization database, as well as 10-15 additional socioeconomic variables from the Census. These new variables will be added using the same general methods as applied previously. In addition, work will also continue on the creation of an interactive utility for displaying these data. The Interactive System for Analysis Services (ISAS) is expected to provide users with the ability to retrieve data, zoom in on areas of interest, obtain simple summary statistics, and allow for extractions of viewed data upon request.

An effort will be undertaken to identify other remotely sensed data for inclusion in the ISAS prototype. For example, contact has been made with a research group at GSFC that has been working with Operational Linescan data from the U.S. Department of Defense to assess urban land use. In addition, alternative methods for gridding will be investigated, such as techniques for deriving gridded data values from point data.

Improvement of the Ulysses Tabulation System

As recommended by the UWG, work on the Ulysses tabulation system will continue primarily by adding new microdata datasets to the system. It is expected that the U.S. Census 1% PUMS files for 1970, 1980, and 1990 will be made available via Ulysses in the near future. Inclusion of earlier PUMS files from the University of Minnesota (the Integrated Public Use Microdata Sample, IPUMS, 1850-1990, created by the Social History Research Laboratory) is under discussion. At present, a 1% sample of the 1982 Chinese census has been made available on a limited experimental basis; discussions are under way with the responsible Chinese organizations concerning making a sample from the 1990 Chinese census available. Discussions with the Mexican statistical organization INEGI and with Statistics Canada have been initiated which may lead to access to relevant sample data from those countries in the future.

Planned enhancements to the Ulysses Tabulation System include development of a WWW interface to improve user access and ease of use, which should in turn help expand the user base. Based on user feedback, SEDAC may also provide online access to the Ulysses Extraction engine, especially if a tighter coupling between the tabulation and extraction engines can be achieved.

5.1.4 User Scenarios

Initial user access will largely be from the U.S. As data for additional countries become available (e.g., Mexico and Canada), it is expected that the international base of users will expand. Because users are so widely scattered, the primary access channel is expected to be the Internet.

The example scenarios presented below describe how users may make use of products related to population and land use. Four scenarios are presented based on

SEDAC's actual experience in interacting with users during the past year. Additional user scenarios can be found in the SEDAC *User Model Report.*

Small-Scale Government

The West Michigan Environmental Action Council has been charged by the Grand Valley Metropolitan Council with identifying "open-space corridors" for the purpose of growth management in two Michigan counties. Several activities are planned, including the development of county-wide information databases for local government units and an evaluation of desirable growth patterns for the two counties. The Council's immediate need is to educate personnel in the use of a desktop GIS system to support pending decisions. Information is often needed down to the parcel level, e.g., the identification of taxable lots. Demographic data useful at the census tract level include income parameters, household characteristics, and behavioral patterns such as shopping areas, commuting roads, and recreational areas visited. To identify forested lots as potential corridors, remote sensing data are needed in the form of ortho-photo quads, soil data, and land use data. General climatic data such as precipitation and runoff patterns are also useful. Because of past water quality problems, county-wide monitoring of ground and surface waters is already in place. A long-term goal is to integrate the different types of water, land use, and demographic data into a single GIS.

Media

Several large newspaper organizations have expressed interest in the ability to rapidly receive and digest information for very small geographic areas (e.g., inner city tracts) as well as for comparative national-scale studies. One specific need is immediate access to TIGER boundaries and associated data for analysis of ongoing trends and patterns. Another need is the ability to perform rapid analysis on large census datasets with easy connections to display capabilities. Because of widespread concern about environmental issues, a third need is for rapid access to environmental data that can be digested easily into desktop GIS packages. Several users noted their organization's inability to support in-house expertise on remote sensing data and applications, but their interest in using these types of products if they were available in a "friendlier" format.

Social Scientist

A social scientist working on the issue of ghetto poverty has tract-level data for 1970 and 1980 and has requested 1990 tract boundaries from TIGER 92. These are available directly from the Archive of Census-Related Products.

The researcher has also been working with 1980 tract boundaries for 5 metropolitan statistical areas purchased some years ago from a commercial vendor. To produce a common set of boundaries to track the expansion and contraction of the ghetto over time, the researcher has had to review the changes listed in the front of various Census publications, perform laborious manual adjustments, and aggregate data for

1990 tracts according to 1980 boundaries. This is an impractical approach for a large number of cities. Using the proposed MABLE and GEOCOR engines, the researcher would be able to accomplish this task easily.

Natural Scientist

A research team at the Center for the Biology of Natural Systems at Queens College, New York is conducting a nationwide analysis of environmental measures. During the first year, the team identified sources of pollutants for the Great Lakes Region. In its second year, the team is focusing on dioxins and tetrachlorides and how these pollutants reach the human food chain, especially through meat products. They are planning to construct a transport model to trace the flow of pollutants. Their data needs include land use for the Great Lakes region and identification of cattle pasture areas. The EDC land characterization data in combination with socioeconomic data on land use and associated economic activities could be of considerable value to them.

5.1.5 Required Data and Information Inputs

Key data and information inputs are demographic, socioeconomic, and boundary data from the U.S. Bureau of the Census and other sources and land cover characterization data and associated topographic and climate data from EDC and other data centers. Initially these data are needed for the U.S., followed by data for Mexico and Canada and other parts of the world as feasible. Also of direct utility are related socioeconomic datasets that may be important in computing biomass change and emissions now and in the future, e.g., data on population growth and movement, industry, transportation, agriculture, land use change, and occupation.

5.1.6 Other Required Resources

Initial establishment of requirements, conditioning and processing of input datasets, development of integrated datasets, and continued interaction with EDC, Oak Ridge National Laboratory (ORNL), and target users will be carried out under SEDAC Task 2.2. This requires personnel with expertise in processing of large social and natural science datasets, GIS, and software development. Such personnel should also have experience in working with applied data users, e.g., planners, state climatologists, and state data centers.

SEDAC Task 5.4, the Data Archive, has primary responsibility for acquiring and archiving input datasets and for ensuring appropriate handling of output datasets. SEDAC Task 5.2, Catalog Development, ensures that input and output datasets are properly cataloged and that appropriate online guide materials are developed. It is important to note that interest in the data services provided by SEDAC is likely to generate increased interest in related datasets, including the input datasets used in Task 2.2. As recommended by the UWG, SEDAC will continue to make selected datasets of interest to a broad range of users available in a public archive.

Systems analysis, design, programming, and prototyping of the various new services developed in this task are being carried out under the appropriate SEDAC Task 4.0 subtasks. This includes estimation of computing and software development resources necessary to develop the services and put them into operation.

Actual operational support for the online services are provided under the appropriate SEDAC Task 5.0 tasks, especially data distribution and product generation. SEDAC Task 6.0 provides user support and training. Training and user support services are of special interest because of the complexity of the integrated data, the increasingly sophisticated access and analysis services to be provided, and the varied backgrounds of target users. Such services require preparation of training materials, tutorials, and other reference materials to permit users to make the best possible use of SEDAC services. To minimize cost and maximize flexibility and access, such materials are primarily being developed in electronic form for online browsing and distribution.

5.1.7 User Involvement and Testing

User involvement and testing are needed in the preparation of integrated data products and in developing and implementing the proposed online access and analysis capabilities. In both cases, it is critical to obtain inputs from an informed set of users who understand the nature of the data and their utility and limitations in environmental applications. It therefore makes sense initially to work with analysts who have strong experience with population and environmental data. Some of these may be very familiar and comfortable with online access and analysis services, others will not. Such a mix is desirable since the ultimate target community will include both types of users.

One key group is the SEDAC UWG. The UWG has been given early access to prototypes for testing and will continue to receive early access as new products are developed. They will also be asked to review the inputs and feedback received from other users during the prototyping and testing process. In soliciting feedback, SEDAC will be careful to distinguish between feedback on the value and utility of the prototype integrated datasets for specific applications and the effectiveness and usability of the prototype access and analysis services relative to specific user needs.

As noted above, the DADT will work closely with selected target users drawn from such organizations as APDU and the SDCs. It will also take advantage of opportunities to interact with key users, analysts, and providers. Such efforts are being integrated with other SEDAC outreach activities as part of a coordinated strategy (see the SEDAC User Outreach Strategy, in preparation).

Another relevant group is an informal network of advisors and users who have worked with CIESIN in the past or who are currently interested in products and services of the type made available by SEDAC. This group presently maintains contact primarily through electronic mail, including three Listservers maintained by SEDAC: GPOP, SEDAC-GRID, and AGIS-L. GPOP includes representatives from

EDC, the National Center for Geographic Information and Analysis (NCGIA), ORNL, RIVM, and several CIESIN Consortium members. These individuals have direct interest in issues of global climate change and its interactions with land use and emissions. SEDAC-GRID represents individuals whose primary interest are the integrated data products. This list allows SEDAC to make data available to an advanced set of users for alpha/beta testing. AGIS-L represents an informal collaboration with the commercial firm, Strategic Mapping, Inc., which markets the popular desktop GIS program, Atlas Graphics. AGIS-L users represent a large community of actual and potential users who may be able to benefit significantly from SEDAC 2.2 products and services. After UWG approval of this effort in April 1995, AGIS-L membership has grown to 425 as of September 1995, and the list has been quite active in terms of participation and discussion.

SEDAC is also beginning to draw on CIESIN's Consortium member institutions and other collaborating academic and research centers that have analysts in relevant departments and centers. For example, a half-day workshop was recently held in conjunction with one of CIESIN's Board of Trustees meeting that involved faculty members from both Michigan State University and the University of Michigan who are working on population/environment research topics.

When online services reach the external testing stage, SEDAC has begun to broaden the range of users drawing on wider Internet access. One low-cost but effective mechanism for soliciting such inputs has been to utilize various Internet discussion lists and other fora, e.g., the SAS Public Access Consortium list (SASPAC-L), the Social Science Data list (SOSDATA-L), CLIMLIST (an e-mail network of researchers and analysts interested in climate and its human interactions), and DISASTER RESEARCH (an electronic newsletter and mailing list focused on natural and anthropogenic hazards). Many current Census Exploration users, who come from a wide range of institutions, have begun to test the new service.

Training is also an important mechanism for user involvement and testing. Training provides a controlled situation in which user interactions with data and software can be directly observed and assessed. Training also provides users with the opportunity to see how specific services fit into the larger context of network services, e.g., access to data at other DAACs. Because of budget limitations, SEDAC attempts to take advantage of low-cost opportunities to provide training as they become available. For example, SEDAC organized a "hands-on" session at the concurrent annual meetings of APDU and the SDCs in Washington DC in October 1994. Other professional meetings of this kind provide cost effective means of reaching analysts and users likely to benefit from SEDAC services. Such efforts are coordinated through the SEDAC User Outreach Strategy.

5.1.8 Assessment of Effectiveness

It is important to assess the overall effectiveness of the service on a continuing basis. This will be accomplished through:

- collection and regular analysis of user statistics;
- requests for user feedback on both the data content and the online service via electronic mail, online response forms (e.g., using the WWW hypertext protocol), and direct contact with task personnel and SEDAC User Services;
- demonstrations and other direct contacts with users; and
- regular efforts to follow up with users and interview them regarding their use of data, satisfaction with SEDAC products and services, and additional needs and preferences.

The online service is being developed to generate appropriate and accurate user statistics on a timely basis. Such statistics are expected to include data on frequency and timing of access, types of queries, use of different features, system response time, and other indicators of system usage.

In the case of the SEDAC 2.2 datasets and services, it may also be possible to utilize the Science Citation Index to try to track actual citations of SEDAC data and generated products in the published research literature. To facilitate this effort, clear and prominent suggestions need to be given to users on how to cite the referenced data and information properly.

Continuing feedback on the integrated data provided through the online service is also vital. Of particular interest are the ways in which users utilize such data—including especially data and information derived using the service—to address actual policy questions. No automated system can provide this type of information. Therefore, it is important that the system design include accessible and user friendly mechanisms for asking users to provide information about how they are using the data. Similarly, SEDAC will proactively follow up with selected users to ascertain their satisfaction with the data and services obtained and to learn more about the actual use of the derived data and information in relevant applications. SEDAC has discovered that such follow-up is important because users do not necessarily know how well they can use data when they first order it. Such follow-up efforts have generated a range of interesting information about user needs and preferences (see the SEDAC *User Model Report*).

5.1.9 Anticipated Schedule

Key milestones specific to this task are:

• Expanding the Archive of Census-Related Products	
- Addition of STF3A Data (Full version)	October 1995
- Addition of STF1B Data (Full version, Great Lakes Region)	December 1995
- Addition of Census and land cover integrated data	March 1996
• Access to ISAS prototype	October 1995
• Creating a MABLE file	
- Basic MABLE database	November 1995

- Development and testing of GEOCOR Engine — February 1996

- Updating Ulysses
  - WWW interface to Ulysses — November 1995
  - Adding extraction functions to Ulysses — March 1996

It is expected that continued updating and expansion of the integrated dataset and online service will occur as appropriate, as provided for in updates to the DADP and other relevant documents. The milestones are subject to review and revision by the UWG. Additional milestones will be added in future option years based on development and operating experience and user feedback.

5.2 Model Visualization and Analysis Services for Integrated Assessment Models of Climate Change

The second applications development task (SEDAC Task 2.3) supports and enhances the use of integrated assessment models of climate change in analysis, climate change research, and science education. In particular, SEDAC is making a key set of IAMs, input scenarios, output datasets, and documentation available to analysts, researchers, decision makers, and educators involved the following types of institutions and activities:

- the international assessment and negotiating activities of the IPCC and the Intergovernmental Negotiating Committee (INC) and Conference of the Parties (COP) of the Framework Convention on Climate Change;
- U.S. Congressional support agencies and their supporting contractors and staff;
- U.S. Executive branch policy offices and agencies and their supporting contractors;
- nongovernmental stakeholder and interest groups; and
- research teams in universities, laboratories, and industry.

Promoting effective use of IAMs by analysts and decision makers is a key way to improve the use of EOS data in decision making. Several of the IAMs currently available or under development make direct use of the types of data that will be available in improved form as a result of NASA's MTPE program. The IAMs in effect integrate data of this kind with socioeconomic variables such as population density, economics and trade, and estimates of technological improvements. For example, IMAGE 2.0, developed by RIVM in The Netherlands, makes direct use of climate observations, TOMS data, GCM output, and land use and land cover datasets (Alcamo, 1994). The IAM effort at the Massachusetts Institute of Technology (MIT) actually embeds a "one dimensional" GCM as a component of its overall system.[16]

[16] "One dimensional" actually refers to a model that estimates climate parameters by latitude, altitude, and time. This is in contrast to "two dimensional" models that estimate climate parameters by latitude, longitude, altitude, and time.

IAM efforts at the NASA Goddard Institute for Space Studies (GISS) directly incorporate the results of the GISS GCM into the integrated assessment.

The FY1995 priorities of the USGCRP and recent NRC recommendations suggest that new models will continue to appear and that existing models will be incrementally improved (CENRR, 1994; NRC, 1994). A potentially serious problem is that users and others not familiar with IAM methods will find the proliferation of models—and the likely proliferation of disparate results—confusing and even intimidating. IAMs attempt to model very complex systems and, as a result, are themselves very complex. Few outside the IAM community have access to the models, or their associated scenarios, output datasets, or documentation. The overall value of IAMs in the decision making process is at risk unless this problem is addressed through a focused effort to enhance the transparency of IAM efforts to analysts, decision makers, and their constituents. Decision makers are not likely to make controversial decisions on the basis of models unless they are convinced that the models have survived the scrutiny of all concerned stakeholders.

This logic is borne out by the experience of the IPCC in using the results of GCM-based scenarios of climate change. Users of such scenarios have often had difficulty in accessing different GCM model runs and assessing which runs were appropriate for their particular application. Documentation and version control of different models and their variants have been poor. Different conventions have been used to determine the model baselines and to generate scenarios, and few studies have attempted to characterize variability or uncertainty in the scenario inputs. Recent efforts by the Model Evaluation Consortium for Climate Assessment (MECCA) have sought to remedy some of these problems, including production of a prototype CD-ROM containing data from six GCM experiments (A. Henderson-Sellers and C. Hakkarinen, personal communication, 1994). CIESIN has also contributed to an effort to distribute GCM scenarios to participants in the recent IPCC assessment. However, such efforts have come rather late in the development of GCMs and their use in decision making.

This SEDAC Task aims to avert potential problems caused by the proliferation of IAMs by working aggressively with the relevant user and modeling communities while the IAMs are still at a reasonably early stage of development. SEDAC has begun to provide specific services to policy, education, and research users to help them use IAMs more effectively and appropriately. SEDAC will continue to work with the IAM community to improve model access, transparency, and review.

5.2.1 Specific Problem

As noted earlier, Article 2 of the Framework Convention on Climate Change establishes the objective of "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." The parties to the Convention periodically review the state of scientific knowledge about climate change and its impacts, national policies designed to reduce or stabilize emissions of radiatively active trace gases to 1990

levels, and relevant technical, social and economic information. The purpose of these reviews is to determine if a more stringent protocol is required to meet the objective of the Convention. The first such COP was held 28 March through 7 April 1995, in Berlin. A second COP is to be held no later than 31 December 1998.

In preparation for the COPs, analysts and decision makers in each country develop negotiating positions and strategies about the types of protocols they are willing, or unwilling, to accept. These analyses necessarily include evaluations of:

- whether the terms of proposed protocols are necessary and sufficient to address the objective of the Convention;
- whether the terms of the proposed protocols are equitable;
- whether it is feasible to implement the terms of the proposed protocols in their particular national and subnational contexts; and
- whether the benefits of agreeing to the proposed protocols outweigh the costs of implementation.

These analyses exemplify the types of questions that IAMs are being designed to inform. No single IAM will be able to adequately address all of these concerns. This is why multiple IAMs are under development. Each IAM will have strengths and weaknesses that make it more or less applicable to these different categories of questions. However, there is evidence that for models to be effective in the context of contentious international negotiations:

- they must be equally accessible to all parties and related stakeholders in the negotiation;
- their implicit and explicit assumptions must be transparent and understood by all parties and related stakeholders to the negotiation; and
- each party and related stakeholder should be able to construct, submit, and receive (in a confidential manner) the results of alternative model scenarios with which they can evaluate different negotiating positions and strategies.

5.2.2 Targeted Users

A number of different groups are now performing, or are likely to perform, analyses using IAMs. These include:

- Analysts supporting the IPCC Working Groups and the INC and COP of the Framework Convention on Climate Change;
- U.S. Congressional support agencies such as the Congressional Research Service (CRS), the General Accounting Office (GAO), and the Congressional Budget Office (CBO);

- U.S. Executive branch policy analysis offices and their supporting contractors in agencies such as the Environmental Protection Agency (EPA), the Department of Energy (DOE), and the Office of Management and Budget (OMB);
- Nongovernmental stakeholder and public interest groups including various industry and environmental lobbying groups;
- Regional, state and local government agencies;
- Climate change researchers and integrated modelers based in academic, research, and consulting institutions; and
- Undergraduate, graduate and professional degree students interested in environmental issues and decision making.

Clearly, this is a very broad group of users with a variety of different needs and interests. It would be a mistake to speculate about the general requirements of this broad user community and then build a system designed to meet these speculated requirements. Rather, SEDAC has begun to identify a relatively small number of users with real needs that can be addressed through the products and services developed by this task. SEDAC is involving these users throughout the design, implementation, and evaluation process. This SEDAC task is more likely to meet the needs of the broader user community if it can successfully meet the concrete near-term needs of these targeted users.

Following this methodology, SEDAC is targeting its initial model visualization and analysis efforts to the following users:

Convenors and participants of climate change policy analysis exercises

SEDAC staff have been working closely with several groups that have been developing climate change policy analysis exercises. For example, SEDAC has demonstrated its prototype model visualization and analysis service at a "dry run" policy exercise organized by Prof. Edward Parson of Harvard University at IIASA in July, 1995. SEDAC plans to support the actual policy exercise at IIASA in 1996. The requirements of this policy analysis exercise for access to models and their data match the capabilities and time frame planned for SEDAC's model visualization and analysis services.

Discussions have also continued with Prof. Mihajlo Mesarovic of Systems Application International (SAI, Inc.) and Case Western Reserve University and with Dr. Joseph Alcamo of RIVM concerning several recent meetings oriented towards conveying information about IAMs and their results to the policy user community. Parson, Mesarovic, and Alcamo have all been invited to participate in a NATO Advanced Research Workshop being supported by SEDAC in October 1995.

The Congressional Budget Office

This Congressional support agency last published quantitative policy analyses of climate change in 1990 (CBO, 1990). In September, 1994, Working Group I of the IPCC released its policymakers' summary. This summary states that reductions beyond the 1990 baseline established in the Framework Convention on Climate Change are required to significantly delay the onset of warming associated with a doubling of CO_2 concentrations in the atmosphere. This summary and subsequent reports from the other IPCC working groups will likely lead Congress to ask the CBO for new analyses. Analysts from this agency have indicated that they are interested in tracking the progress of, locating, and making use of IAMs in anticipation of these requests.[17]

The Environmental Protection Agency Office of Policy Planning and Evaluation

The EPA Office of Policy Planning and Evaluation has a critical role in the decision making process within the U.S. Executive Branch concerning climate change. The last major EPA assessments of climate change were published in 1989. These assessments were based upon an early IAM constructed under contract by ICF, Inc. More recently, the EPA has been working to integrate the GREEN economic model of the Organization for Economic Cooperation and Development (OECD) with RIVM's IMAGE 2.0. The Office of Policy Planning and Evaluation has also commissioned a climate change decision support system that will utilize IAMs and other information. These efforts could benefit greatly from the availability of a configuration-controlled archive of IAMs, scenarios, outputs, and documentation as a starting point for further analysis.

The Natural Resources Defense Council and the Climate Change Coalition

NGOs have played important roles in climate change decision making. These two NGOs are prominent representatives of their respective environmental and industry sides of the debate. Each has attended the INC sessions of the Framework Convention on Climate Change. They also lobby members of Congress and senior appointees in the U.S. Executive Branch. Each group will want to examine the details of IAMs and their associated input scenarios to ensure that their concerns are properly addressed. However, they do not have the computing and staff resources to host the larger models such as IMAGE 2.0 themselves. These groups would also be likely to submit alternative scenarios to the models as a means to illustrate their concerns to the broader decision making community.

In order to address the needs of these target communities, SEDAC has begun, and will continue, to recruit a small but representative sample of users from the groups mentioned above to become actively involved in the design, development, testing, and "tire kicking" of the products and services listed below. During the first year of

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[17] Analysts indicated these interests during interviews conducted by C. Linville, who at the time was a CIESIN summer fellow and who has now joined CIESIN as an Information Scientist assigned to SEDAC.

this project, SEDAC staff have walked these users through paper designs of the user interface and system design. As working versions of subsystems have become available, SEDAC staff have made them available to selected users on a test basis to elicit comments about the performance and functionality of the emerging system. The system has recently been made available to a larger sample of the user community on a beta-test basis. This version of the system should enable the targeted users to use the system to perform exploratory analysis of IAMs. A full-scale production version of the system will be available by the end of the second project year. After the second year, project activities will focus mainly on model acquisition, ingest, and operational maintenance.

5.2.3 Planned Products and Services

This task will continue its first year activities to develop and provide four classes of major products and services:

- An operational archive of publication quality IAMs, input scenarios, corresponding output datasets, and related documentation;
- Online guides documenting available IAMs, input scenarios, and their corresponding outputs;
- An interactive model visualization and analysis system that enables users to perform exploratory analysis and visualization of archived IAM data; and
- Periodic fora for interaction between users and IAM developers.

The goals of these products and services are to:

- Provide improved access to IAMs, their inputs, and their outputs in an organized framework;
- Support the analysis and understanding of these IAMs, inputs, and outputs by analysts and decision makers; and
- Provide a mechanism for analysts and decision makers to nominate additional model runs.

Operational Archive

SEDAC will continue to work with the IAM community to acquire input scenarios, output scenarios, and related documentation. The focus will primarily be for those models and model runs that are used as the basis for peer-reviewed publications. Where possible and appropriate, SEDAC will also seek to archive, host, and/or distribute the corresponding versions of the models themselves.

During the project's first year, SEDAC has worked to gain access to RIVM's IMAGE models and their corresponding inputs and outputs. The IMAGE models are appropriate for several reasons. First, IMAGE 2.0 is the first of a new generation of

IAMs that link multiple natural and social process models with relatively high spatial resolution. Second, the Dutch government requested that several IMAGE 2.0 scenarios be developed in time for presentation to the first COP to the Framework Convention on Climate Change. This emphasis has created significant interest about the inner workings of the model and its embedded assumptions. Third, IMAGE 2.0 is a successor to IMAGE 1.0, a reduced form model that was used during the negotiations leading up the Framework Convention on Climate Change.

Version 2.0 of IMAGE and data for four key scenarios were transferred to CIESIN in the first year as part of a Memrandum of Understanding (MoU) between RIVM and CIESIN. Full display of these archived datasets is currently available. RIVM has been working on an enhanced version (IMAGE 2.1), and, under the terms of the MoU, will be provided with use of SEDAC computing resources for some of their development and testing of the new version. Lessons used in this experience will be used as a guide in acquiring additional models and scenarios.

MiniCAM, developed by Battelle Pacific Northwest Laboratories, is a reduced form version of Global Climate Assessment Model (GCAM), also developed at Battelle. SEDAC has acquired and partially ingested MiniCAM and a large number of its scenarios into the operational archive.

In order to be considered for acquisition and archiving, an IAM must be reasonably well documented in the scientific literature and tested sufficiently to permit stringent configuration management. A list of models currently being considered for acquisition are given in Table 3.

Online Guides

Archiving is a necessary first step toward promoting more widespread use of IAMs. An equally important—and often overlooked—step is the provision of documentation oriented towards users about the models, each input scenario, and their corresponding outputs. Many users will be primarily interested in documentation that describes, compares, and contrasts the basic structure of the available models and how particular model scenarios have been used to address policy relevant issues. In the case of a Congressional staffer planning a hearing, this information could be used to identify models and the corresponding modelers relevant to the issue being addressed in the hearing. An analyst from a NGO would use this information to get a basic understanding of a model before applying it to a specific analysis. A negotiating team to the Framework Convention on Climate Change would ask one of their supporting analysts to review these guides to ensure the models and scenarios account for their concerns and interests.

Table 3. Integrated assessment models currently targeted for acquisition.

Model/Name	Contact Person(s)	Institution
AIM (Asian-Pacific Integrated Model)	Tsuneyuki Morita (NIES, Japan), Yuzuri Matsuoka (Kyoto University), Mikiko Kainuma (NIES, Japan)	Research Centers National Institute for Environmental Studies , Japan
CETA (Carbon Emissions Trajectory Assessment); low priority due to restrictions	Stephen Peck (EPRI), Thomas Teisberg (Teisberg Assoc.)	Electric Power Research Institute
CSERGE (Center for Social and Economic Research into the Global Environment)	David Maddison (University London), Sam Famkhauser (University London)	University College London
DICE (Dynamic Integrated Climate Economy); top priority for acquisitions	William Nordhaus (Yale University)	Yale University Cowles Foundation for Research in Economics
Edmonds-Reilly-Barnes Model Second Generation Model (SGM)	Battelle	Battelle Pacific Northwest Laboratories
ESCAPE	Michael Hulme (Climate Research Unit, Univ. of East Anglia); Cambridge Univ.	Climatic Research Unit, University of East Anglia
GCAM (Global Change Assessment Model)	Jae Edmonds (Pacific Northwest Lab), Hugh Pitcher (PNL), Norm Rosenberg (PNL), Tom Wigley (UCAR)	Battelle Pacific Northwest Laboratories
GREEN Model	Kathleen Clay (OECD)	OECD
ICAM-1	Hadi Dowlatabadi (Carnegie Mellon), Granger Morgan (Carnegie Mellon)	Carnegie-Mellon University, Engineering and Public Policy
ICAM-2(Integrated Climate Assessment Model)	Hadi Dowlatabadi (Carnegie Mellon), Granger Morgan (Carnegie Mellon)	Carnegie-Mellon University, Engineering and Public Policy
IMAGE 1	Jan Rotmans (RIVM)	RIVM, The Netherlands
IMAGE 2.0 (Integrated Model to Assess the Greenhouse Effect)	Joseph Alcamo (RIVM), Eric Kreileman (RIVM), Maarten Krol (RIVM), Rik Leemans (RIVM), Ge Zuidema (RIVM)	National Institute of Public Health and Environmental Protection (RIVM), The Netherlands
IMAGE 2.1	Joseph Alcamo (RIVM), Eric Kreileman (RIVM), Maarten Krol (RIVM), Rik Leemans (RIVM), Ge Zuidema (RIVM)	National Institute of Public Health and Environmental Protection (RIVM), The Netherlands
ISM (Integrated Science Model for assessment of climate change)	Atul Jain (Lawrence Livermore Lab.) Haroon S. Kheshgi (Exxon), Don Wuebbles (Lawrence Livermore)	Lawrence Livermore Laboratory
MAGICC (Model for the Assessment of Greenhouse gas Induced Climate Change)	Tom Wigley (UCAR), Mike Hulme (Univ. East Anglia), Sarah Raper (Univ. East Anglia)	UCAR Office for Interdisciplinary Earth Studies

Table 3. (continued)

Model/Name	Contact Person(s)	Institution
MERGE (Model for Evaluating Regional and Global Effects of GHG Reductions Policies)	Alan Manne (Stanford), Robert Mendelsohn (Yale), Richard Richels (EPRI)	Electric Power Research Institute
MiniCAM (Mini Climate Assessment Model)	Jae Edmonds (Pacific Northwest Lab), Hugh Pitcher (PNL),Richard Richels (EPRI), Tom Wigley (UCAR)	Battelle Pacific Northwest Laboratories
MIT	Henry Jacoby (MIT), Ron Prinn (MIT), John Reilly (USDA/MIT)	Massachusetts Institute of Technology
NEW EARTH 21	Yasumasa Fujii (Yokahama Univ.), Yoichi Kaya (University Tokyo), Kenji Yamaji (CRIEPI)	TBD
PAGE (Policy Analysis of the Greenhouse Effect)	Chris Hope Head (Environmental Policy Research Group, Judge Institute of Management Studies, University of Cambridge); John Anderson (Env. Res. Management), Paul Wenman (Env. Res. Management)	TBD
PEF (Policy Evaluation Framework)	Dave Cohan (Decision Focus Incorporated); Joel Scheraga (EPA), Susan Herrod (EPA), Rob Stafford (DFI)	U.S. Environmental Protection Agency
TARGETS (Tool to Assess Regional and Global Environmental and Health Targets for Sustainability)	J. Rotmans (RIVM), M.B.A. van Asselt (RIVM), A.J. de Bruin (RIVM), M.G.J. den Elzen (RIVM)	National Institute of Public Health and Environmental Protection (RIVM), The Netherlands

SEDAC will continue to work with the modeling community to create online guides oriented towards researchers, educators, and analysts for each archived model, input scenario, and output dataset. These guides will be accessible via the Internet as WWW hypertext documents. The model and dataset guides will include electronic versions of relevant peer-reviewed publications if SEDAC can obtain the necessary copyright permissions (e.g., Alcamo *et al*, 1994). In cases where sufficient documentation does not exist or is not available for online distribution, SEDAC commissions the necessary documentation from the model developers when possible, and from third-party consultants. The former is likely to be more cost effective and yield higher quality results than the latter. These materials have been, and will continue to be, professionally edited to ensure that they are understood by the target audiences. SEDAC staff prepare appropriate introductory and contextual material to give users an overview of integrated assessment, the range of IAMs, science issues underlying each IAM, and the use of integrated assessment to address decision making. These materials are reviewed by selected members of the IAM community as well as by the UWG.

Interactive Model Visualization and Analysis System

A major impediment to the use of IAMs by almost any interested user is the large amount of time and computer resources required to locate, acquire, and make sense of the datasets before even the simplest exploratory analyses can be performed. When coupled with the risk that a model is not appropriate for the task at hand, potential users often decide to invest their scarce time pursuing other leads. In order to address this problem, SEDAC has developed and released an interactive visualization and analysis system to enable users to perform exploratory analysis of model input and output datasets. This system manages a large database of precomputed model scenarios for each archived model and provides services that allow a user to navigate and visualize model data using a variety of sophisticated tools. Users are able to plot model parameters and outputs in a variety of two-dimensional, three-dimensional, and geographically referenced formats, and to compare scenarios. These services are accessible over the Internet using widely available WWW browsers.

Development efforts during the past year have established the software and database infrastructure required to implement these services. SEDAC then prototyped a limited set of products and services using this infrastructure. During its second year, SEDAC will focus primarily on developing new visualization and analysis functionality including:

1) Handling of discrete data. Currently, the system can only handle data whose values range over a continuous domain (e.g., precipitation and Gross National Product). Data whose values range over a discrete domain (e.g., land characterization classes) cannot be addressed. New features will be added to the database structures and to the analytic and visualization tools to allow for discrete data.

2) Vector Mapping. Raster data can be displayed in a spatial format without additional geographic data. That is, raster data can be mapped onto a raster display without the need for additional spatial information to be provided to ensure the proper relative positioning of points. Vector data, such as polygon attribute data, can only be displayed spatially if corresponding polygon boundaries are provided. Much of the output data from IAMs are referenced to the names of spatial units (e.g., countries or regions), and the display of such data in a map format requires a vector mapping capability. Implementation of such a capability must be careful to avoid or minimize performance problems associated with processing large boundary coverages, e.g., for countries or watersheds. An additional function would be to permit vector-on-raster overlays to permit visualization of superimposed vector and raster data.

3) Aggregation and Raster Plotting. Whereas vector data can be plotted with line graphs and other similar non-spatial visual representations, raster data cannot be easily plotted for time series analysis. It is critical that raster data be

aggregated to an appropriate summary level in a meaningful and defensible way. For example, by aggregating gridded precipitation data to the level of continents, precipitation could be displayed in line plots to show trends in precipitation on a per-continent basis. However, much care is needed to ensure that aggregation is performed in ways that are physically and mathematically appropriate. As above, implementation of aggregation algorithms must be careful to avoid or minimize performance problems.

4) Aggregation and Groupings. A group is a vector summary level and can be used to aggregate vector data. For example, the continent North America presently contains the countries of Canada, Mexico, and the U.S. Eastern Europe is a region which in recent years has seen rapid changes in its constituent countries; aggregation of data is therefore time dependent. Support for time-dependent aggregation of data to the group level has been identified as an important function.

5) Support for Uncertainty and Uncertainty Analysis. Uncertainty pervades the issue of global climate change. The model visualization and analysis task provides an opportunity to inform analysts and decision makers about the existence and nature of uncertainties and will facilitate the analysis of these uncertainties. Uncertainty analysis allows users to take into account their heterogeneous valuation of outcomes and perspectives about risks as they examine the outputs of IAMs (Lave and Dowlatabadi, 1993). Users will be able to examine the consequences of different beliefs about the inputs of IAMs. IAMs such as Carnegie Mellon University's ICAM that explicitly address uncertainty are logical first candidates for this effort. ICAM is a Monte Carlo simulation model. Monte Carlo replications of key ICAM input and output variables will be ingested into the operational archive. Support for uncertainty analysis requires additional information about model runs to be adopted. Changes to both the data model and the information services will be required to provide satisfactory support for the analysis and presentation of uncertainty.

6) Nomination of Model Runs. A possible extension of the system is to allow new model runs to be initiated and processed using SEDAC computing resources. It may be possible to provide this service on an interactive basis for some of the simpler IAMs (e.g., DICE). However, for a large model such as IMAGE 2.0, this type of open access would place an undue burden on a finite supply of computing resources. Instead, SEDAC is investigating the possibility of a procedure for "nominating" specific model runs. Nominations would be vetted with the modelers and an appropriate peer group. This process will help ensure that model scenarios are consistent with the model's original design and capabilities. It will also reduce unnecessary duplication, ensure better documentation and dissemination of scenarios (as appropriate), and keep use of computing resources within a pre-established budget.

Periodic Fora for Interaction between Users and IAM Developers

Model development is a labor- and time-intensive activity that requires a high degree of technical sophistication and concentration. As a result, model development tends to become separate from the more event-driven world of analysis and decision making. This leads to a situation in which modeling efforts are either ignored or used inappropriately in the decision making process. SEDAC is working to develop and convene periodic fora to promote interactions between users and IAM developers. These fora will make use of the interactive model visualization and analysis system and other related services. They will be constructed to bring analysts and decision makers from the target user community together with selected model developers in a structured process. The goal of these efforts will be to:

- inform key analysts and decision makers about progress in integrated assessment and IAM development;
- improve the responsiveness of IAM efforts to user needs through direct interaction; and
- refine and test tools to help analysts better use and interpret IAM results.

These fora are being organized in cooperation with other relevant groups such as RIVM, IIASA, and the Energy Modeling Forum Study Group 14 (EMF14).[18] As SEDAC's initial effort in this area, the SEDAC Manager, Dr. Robert S. Chen, has obtained support from the NATO Environmental Affairs Division to conduct a NATO Advanced Research Workshop on "Integrated Assessment of Global Environmental Change: Science and Policy" in October 1995 at Duke University.

5.2.4 User Scenarios

This section describes how different targeted user communities are likely to interact with the products and services described above.

Convenors and Participants of Policy Analysis Exercises

Policy exercises are often constructed as simulations in which participants play out a series of decisions over time. One or more IAMs are used to take the decisions made at a given time step and play them out for a period of time. The participants are then asked to reevaluate their decisions based on the new situation postulated by the IAMs.

Convenors of these policy analysis exercises could take advantage of SEDAC's online guides and interactive model visualization and analysis system. Participants could use the guides to learn about the structure of the models, their underlying assumptions, and their implementation, including, for example, the definitions and

[18] The EMF-14 effort is led by UWG member John Weyant of Stanford University.

units of model variables. They could then use the model visualization and analysis system to analyze and visualize the results of model runs. They would formulate decisions at each time step based, in part, upon the analysis they were able to perform with these visualization and analysis services. After an exercise is over, participants might still wish to utilize the system over the Internet to help them apply the insights gained during the exercise to their real-world analyses. In addition, the convenors of the exercise may desire to analyze what information the participants accessed and generated using the system.

Congressional Support Agencies and Staff

Staff at Congressional support agencies could make use of the products and services in a number of ways. First, they could use the online guides to track progress in the field of integrated assessment and to identify key individuals involved in the field. Second, they could use the system to explore a number of models to determine those best suited to the questions or issues they would like to see addressed. They could then either contract with the modelers directly for additional model runs, acquire a version of the model for in-house runs from SEDAC's operational archive, or run the model using SEDAC computing resources. Finally, such staff might participate in policy exercises or in SEDAC's periodic fora.

EPA Office of Policy Planning and Evaluation

This office could use the selection, order, and delivery capabilities of the archive to acquire models and corresponding datasets for in-house or contracted modeling activities. Office staff could use the model visualization and analysis service to compare their own scenario experiments with those of others.

Nongovernmental Organizations

NGOs are likely to make extensive use of the online guides and model visualization and analysis services. They will use this information to ensure that the models account for issues of particular use to their constituents. They will also utilize access to model information and scenarios to understand better the information provided by other parties during the negotiation process and perhaps to prepare appropriate support or rebuttal information.

5.2.5 Required Data and Information Inputs

SEDAC Task 2.3 will require the following input data and information:

- Input scenarios for IAMs. These vary from model to model, but generally include both spatially disaggregated and time series data for a variety of socioeconomic and environmental variables;
- Output datasets corresponding to each input scenario;

- Documentation for each model, input scenario, and output datasets, along with permission to use any copyrighted material; and
- Other supporting datasets, e.g., digital boundary files for consistently mapping model outputs.

The effort will also build on recent activities to assess user needs and IAM progress, including the Harvard-CIESIN Commission on Global Environmental Change Policy, the 1994 Global Change Institute on Integrated Assessment of Climate Change, and the Stanford EMF14 Working Group. Two important sources of information are the UNESCO/IAI Workshop on Integrated Assessment on September 1994 in Santiago, Chile and the IPCC's First Special Workshop on Article 2 of the UN Framework Convention on Climate Change, which was held October 1994 in Fortaleza, Brazil. A SEDAC staff member participated in the latter workshop.

It is also important to build linkages with other institutions that have developed IAMs or that can provide access to key IAMs and associated input and output data. RIVM, for example, has been developing a number of data resources that are key inputs into IMAGE 2.0 that may be of wide interest to both users and developers of other IAMs. Other institutions such as IIASA and EPA may wish to make scenarios and model versions available to users through SEDAC's Gateway service. The SEDAC Project Scientist is working closely with the DADT and Information Gateway Team to ensure appropriate coordination of key institutional linkages.

5.2.6 Other Required Resources

Identification of relevant IAMs and scenarios, initial contacts with modelers, and ongoing assessment of user needs are undertaken as part of SEDAC Task 2.3. These efforts require personnel with background in global climate change issues, familiarity with integrated assessment and IAMs, and contacts with the IAM community. Because of the complexity of the IAMs and associated datasets, it is critical for Task 2.3 personnel to work closely with SEDAC Task 5.4, the Data Archive, in the acquisition and archiving process. Similarly, close coordination with SEDAC Task 5.2, Catalog Development, is needed for proper cataloging of the model versions and datasets and quality control of model guides. Planning of the periodic fora is the responsibility of Task 2.3 in conjunction with the SEDAC Project Scientist and SEDAC Manager. The planning of meetings requires collaboration with other institutions and funding sources in order to carry out the full series of fora.

Selected external authors have been used to prepare model guides under contract. In addition, SEDAC will continue to contract with an external editor to edit the guides. The Data Archive task is responsible for the copyright permissions process. Systems analysis, design, programming, and prototyping of the model visualization and analysis system are carried out under the appropriate SEDAC Task 4.0 subtasks. Such work includes the estimation of the computing and software development resources necessary to develop the system and put it into operation.

Actual operational support for the model visualization and analysis system and for the development of online guides is provided under the appropriate SEDAC Task 5.0 tasks, especially data distribution and product generation. SEDAC Task 6.0 is providing user support and training. Training and user support services are of special interest because of the complexity and interdisciplinary nature of the IAMs, the need for careful interpretation of inputs and outputs, and the likelihood that very few users (and not many others) will have in-depth knowledge in all of the substantive areas covered by the IAMs. It will be necessary to develop training materials, tutorials, and other reference materials to permit users to make the best possible use of the IAMs and associated SEDAC services. Such materials will be important inputs for the fora. In order to minimize cost and maximize flexibility and access, such materials have been (and will continue to be) primarily developed in electronic form for online browsing and distribution. However, since many key users may not have good Internet access, it is important to produce hard copy versions of selected materials. Because of the nature and complexity of model output, such hard copies need to include color plates to display key maps, diagrams, and other figures.

5.2.7 User Involvement and Testing

Representative users from each of the major user categories will be involved in all phases of second-year development, testing, and implementation of the model visualization and analysis system. In addition, SEDAC will continue to seek advice from the UWG and those UWG members with particular interest in this area.

SEDAC will continue to make use of user networks of collaborating modeling groups. Some of these groups are directly involved in the IPCC process or in advising particular agencies or national governments. It is expected that EMF14 working group would also be a good source of users and testers. The UWG will be given early access to prototypes for testing all new products and services. They will also be asked to review the inputs and feedback received from other users during the prototyping and testing process. In soliciting feedback, SEDAC will be careful to distinguish between feedback on the value and utility of the IAMs themselves and the effectiveness and usability of the model visualization and analysis system relative to specific user needs.

Training will probably become an important for user involvement and testing. Training provides a controlled situation in which user interactions with IAMs, data, and the model visualization and analysis system can be directly observed and assessed. Training also provides users with the opportunity to see how specific services fit into the larger context of available models and data. Because of budget limitations, SEDAC will continue its first-year approach by taking advantage of low-cost opportunities to provide training as they become available, e.g., professional meetings in which many global climate change users participate.

5.2.8 Assessment of Effectiveness

It is important to assess the overall effectiveness of the model visualization and analysis system on a continuing basis. This will be accomplished through:

- definition, collection, and regular analysis of user statistics;
- requests for user feedback on the usefulness of the system and the IAM data via electronic mail, online response forms (e.g., using the WWW hypertext protocol), and direct contact with task personnel and SEDAC User Services;
- demonstrations and other direct contacts with users and with the IAM development community; and
- regular efforts to follow up with users and interview them regarding their use of data, satisfaction with SEDAC products and services, and additional needs and preferences.

The model visualization and analysis system will be extended to generate appropriate and accurate user statistics on a timely basis. Such statistics are expected to include the frequency and timing of access, types of queries, use of different system features, system response time, and other indicators of system usage.

In the case of these services, it may also be possible to utilize the Science Citation Index to try to track actual citations of the model guides, generated graphics, and other services in the published research literature. To facilitate this effort, clear and prominent suggestions need to be given to users on how to cite the referenced data and information properly.

Continuing feedback on the IAMs and associated datasets provided through SEDAC is also vital. Of particular interest are the ways in which users utilize such data and models—including especially data and information derived using the model visualization and analysis system—to address actual decisions. No automated system can provide this type of information. Therefore, it is important that the system design include accessible and user friendly mechanisms for asking users to provide information about how they are using the data. Similarly, SEDAC Users Services will proactively follow up with selected users to ascertain their satisfaction with the data and services obtained and to learn more about the actual use of the derived data, information, and models in relevant applications.

Users will also be asked to cite SEDAC in all publications that are based on the models and associated data obtained through SEDAC data archives and/or the model visualization and analysis service. This will permit tracking of citations through standard indices and searches.

5.2.9 Anticipated Schedule

A modest level of planning and data assessment has been undertaken for this task in order to ensure adequate preparation for implementing the planned activities

and to keep on top of ongoing developments in the field. Key milestones specific to this task are:

• Formal beta testing of Year 1 products and services	Sept.-October 1995
• NATO Advanced Research Workshop	October 1995
• Revision of SEDAC Requirements Analysis Report	November 1995
• Revision of SEDAC Functional Specification	December 1995
• Revisions to SEDAC System Design Document	January 1996
• Additional model, data, & guides available	March 1996
• Revised Policy Exercise Plan	April 1996
• Production of report on available IAMs	May 1996
• Prototype visualization services for uncertainty analysis	May 1996
• Unrestricted availability of Year 2 products and services	June 1996

It is expected that continued updating and expansion of the model scenarios and versions will occur as appropriate, as provided for in updates to the DADP and other relevant documents. The milestones are subject to review and revision by the UWG. Additional milestones will be added in future option years based on development and operating experience and user feedback.

5.3 Environmental Treaties and Resource Indicators

Successful utilization of results from USGCRP and MTPE science programs will require integration of those results with information about the environmental status and political behavior of nation-states: the political units that take primary responsibility for organizing the human response to global environmental change. This new applications development task responds to MTPE science priorities, addresses the difficult problems involved in integrating Earth science information with information about national policies and behaviors, and complements other MTPE services.

This task will expand upon prior SEDAC exploratory work to develop a WWW-accessible relational database that integrates national-level natural science, environmental, and socioeconomic "resource indicators" with text, status, and summary information about environmental treaties and other related policy instruments that implement national responses to global environmental issues. The resource indicators, discussed in detail below, will include widely accepted measures of environmental quality and standard indicators of economic activity. The environmental treaties and other policy instruments include information already online about more than 120 international environmental agreements related to global environmental change and will be expanded to include other national response documents. Since this task will be building on several proven technologies and capabilities, it is anticipated that the resources needed for this task will be relatively modest.

5.3.1 Specific Problem

International environmental agreements are a key mechanism by which nations manage natural resources and deal with an environment that varies greatly across space and time. These agreements enable nations to search for equitable and efficient solutions to problems that arise from the intersection of natural and human systems which transcend national boundaries. Because nation-states are, and will continue to be, the primary political units forced to deal with MTPE priorities such as global climate change, land use and land cover patterns, stratospheric ozone, and other global environmental issues, the need for future international environmental agreements is likely to be substantial and continuing.

Furthermore, the implementation of existing agreements is also extremely important, especially as the need for international cooperation on global environmental change increases with the connectivity and complexity of global environmental, economic, and political systems. Thus, international environmental agreements are increasing in importance as tools to help promote equitable and efficient strategies to mitigate the adverse effects of global climate change, stratospheric ozone depletion, and changes in land-use/land-cover patterns. Until the development of this SEDAC service, there was no integrated resource for obtaining information about the range of international environmental agreements[19] that might be applicable to a particular country or set of countries, nor any systematic way to track the progress of the ratification and implementation process across multiple agreements. What is still lacking is the ability to link the status of such agreements with relevant national-level indicators and information about national responses to particular global environmental problems.

The current prototype PIDB demonstrates that relational queries involving both treaty data and socioeconomic data of different types (e.g., GDP) are possible. Work is clearly needed to expand the range of indicators that can be related to various aspects of economic development and to refine the ways in which meaningful queries can be constructed. Such queries, if done properly, could provide a powerful means of linking disparate data sources to shed light on interrelationships between international environmental agreements and actual environmental and socioeconomic conditions.

For example, researchers interested in why particular nations do or do not ratify particular treaties would be able to link directly to data on environmental and socioeconomic indicators relevant to the particular countries, treaties, and time periods of interest. In the past, these kinds of queries would have taken extensive library work or complex and expensive online searches using disparate databases. The increased availability of indicators of national behavior related to various

[19]For convenience, the terms "treaties" and "policy instruments" are used interchangeably with "international agreements" in this document, with the understanding that this is a shorthand convenience that may gloss over some technical distinctions.

agreements is likely to be a useful tool for many different parties involved in the development and implementation of international environmental agreements.

Similarly, information about differing national policy responses to global environmental issues has been identified as critical for understanding the international and national context in which the scientific results of global change research are applied.

It is also noteworthy that many international environmental agreements require participating nations to work to increase awareness of data and information relevant to the monitoring and implementation of the agreements. For example, Article 4 of the Framework Convention on Climate Change commits the parties to "promote and cooperate in the full, open, and prompt exchange of relevant scientific, technological, socioeconomic and legal information related to the climate system and climate change, and to the economic and social consequences of various response strategies." Similar provisions for promoting "public awareness" and national "research, development, and exchange of information" are found in Article 9 of the Montreal Protocol and Articles 12 and 13 of the Convention on Biodiversity[20]. Many international environmental agreements also call for special attention or support for the information needs of developing nations.

Some international environmental agreements have specific requirements regarding the reporting of national behavior and, in a few cases, evaluation of such behavior through monitoring. A 1992 General Accounting Office report on "Strengthening the Implementation of Environmental Agreements" found that national compliance with international environmental agreements is not well monitored for a variety of reasons, including the lack of resources available to developing nations and treaty secretariats. Remote sensing data provided by NASA and other organizations are expected to be an important asset in the monitoring and verification process. For example, NASA data on stratospheric ozone concentrations have clearly played a key role in the development and implementation of protocols to control CFC emissions. Remote sensing data on deforestation rates and land cover change may serve as benchmarks in developing protocols related to biodiversity and greenhouse gas emissions.

However, it must be noted that the integration of NASA Earth science data with information about national environmental resources and policy responses raises many complex and challenging issues. For example, the NASA TOMS and Greenhouse Effect Detection Experiment (GEDEX) data are not aggregated at the national level. The data are global in nature and are not referenced to national boundaries. Such data would have to be aggregated to the national level in a scientifically sound and defensible manner.

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[20] Policy Instruments Database, WWW URL http://sedac.ciesin.org/pidb/texts-home.html.

5.3.2 Target Users

Target users for this task are those individuals and organizations involved in developing, implementing, monitoring, and verifying international environmental agreements relevant to global climate change. This community includes:

- analysts supporting national efforts to negotiate and implement such agreements (including, in the U.S., staff of the U.S. Congress and its support agencies and relevant U.S. Executive Branch offices);
- relevant staff of the United Nations and its specialized agencies;
- journalists concerned with international environmental issues;
- nongovernmental organizations with a focus on national and international environmental issues;
- international planners and businesses concerned with applicable environmental treaties;
- students and scholars interested in the legal and policy aspects of international environmental agreements and resource management;
- law librarians and other information specialists concerned with international environmental law and policy; and
- natural scientists interested in applications of remote sensing and other national resource data in decision making.

A key strategy for reaching this broad range of users will be to take advantage of the existence of popular, active Internet mailing lists such as INT-LAW and INFOTERRA, Usenet groups such as sci.environment and sci.geo.eos, and WWW switchboards such as Yahoo, Lycos, and the W3 Consortium Virtual Library. Outreach efforts will also build on the already large and rapidly growing user base for this service, and will additionally attempt to tap into potential users in the natural sciences, media, business, and other arenas.

5.3.3 Planned Products and Services

The proposed task will build upon the basic functionality of the existing service through the following activities:

Updating and expanding the base of international agreements

The database currently contains information on more than 120 major environmental agreements. However, more than 3,000 international agreements on a variety of topics exist.[21] Initial users have pointed out some gaps in current PIDB coverage, especially with respect to the somewhat broader issues associated with the intersection of economic development and land-use/land-cover, stratospheric

[21] John King Gamble, personal communication.

ozone, and global climate change. In addition, some treaties require updating of treaty texts, ratification information, or other relevant data.

Adding selected resource indicators

A key task is to review the vast number of available resource indicators and develop a useful, representative selection of such indicators, including some derived from remotely sensed data. SEDAC will work closely with selected users and with MTPE priorities in mind to identify the indicators of greatest interest. Particular attention will be necessary to construct queries which can be structured in such a manner as to ensure relevancy to the indicators themselves. This will allow meaningful, and not misleading, responses to user inputs. In this regard, the task will selectively improve and enhance the existing set of "basic questions" in the service and explore the addition of features to allow users to construct more sophisticated queries. The primary focus will be on national-level indicators, though in some cases regional or subnational data may be appropriate (e.g., with treaties that deal with common-property resources such as Antarctica or that have a regional focus such as the Mediterranean).

Adding national response information

Since nations continue to be a primary organizing focus for human social and political activity, information about how different nations respond to international environmental issues and the agreements framed to address them is critical for understanding the human response to global environmental change. SEDAC will make it possible to use the relational database to navigate to information about how different nations are responding to particular international environmental issues and agreements. The service will provide access to distributed national response information, primarily but not exclusively textual, residing elsewhere on the Internet; for example, National Action Plans filed online at the secretariat for the United Nations Framework Convention for Climate Change. In the next year, the objective will be to develop and demonstrate a generalizable context-sensitive capability with a handful of representative national response data sets.

Preparation of an online WWW guide

SEDAC will prepare a WWW-based online guide that provides additional context, background, and pointers on the theme of integrating information about national resources and national policy responses to global climate change with Earth science data. Specifically, the guide will include:

- an essay discussing how policy-oriented users can discover and use relevant NASA, USGCRP, and other earth science data;
- automated resource discovery tools such as a "URL sifter" and an interface to the GCMD;

- an annotated directory of NASA and USGCRP research programs relevant to particular international environmental agreements; and
- selective bibliographies (including the full text of key articles, where possible) on resource indicators, on national policy responses, and on integrating earth science data with socioeconomic and environmental data.

The guide will take advantage of existing CIESIN information resources such as the Thematic Guide on Political Institutions and the SEDAC Information Gateway.

Demonstrate integration of NASA global data with national response and resource information.

SEDAC will conduct a very simple proof-of-concept demonstration of the integration of NASA global data—currently not aggregated at the national level—with data about national environmental resources and national policy responses. The demonstration will be coordinated with other SEDAC exploratory efforts that are utilizing remote sensing data, such as the stratospheric ozone depeletion and human health project.

Development of an e-mail-to-WWW gateway

The service is currently implemented using a WWW form-based interface, which is only available to a limited subset of users mostly based in developed countries. To promote access to treaty information by those in developing countries, SEDAC will implement an e-mail-to-WWW gateway. This will permit users with limited Internet access to submit queries via electronic mail. One option is for the gateway to return a file in HyperText Markup Language (html) format to the user via e-mail, which the user could then read locally using a WWW browser.

Development of a WWW-to-Database interface

The current PIDB WWW interface has a number of limitations including its static nature. SEDAC will work to develop a more dynamic, context-sensitive interface, drawing on tools developed for the SEDAC Model Visualization and Analysis System. Such an interface would, for example, permit more flexible queries based on the specific characteristics of an agreement rather than on just those characteristics common to all agreements.

5.3.4 User Scenarios

This section provides some examples of how users are likely to interact with the products and services described above.

Analysts at national and international organizations

Analysts at national and international organizations will in many instances access the enhanced service directly using WWW over the Internet. They would generate a query using either the preconfigured set of "basic questions" or by selecting from parameters available in the database. Based on the query results, the analysts could then access the relevant treaty texts, summaries, and status information, e.g., to find a model for a future treaty or a clause within a treaty relevant to a problem of concern. The availability of the e-mail-to-WWW server would increase the number of potential users at such organizations around the world who could take advantage of these services.

Interdisciplinary researchers and reference librarians

Researchers and librarians are likely to discover SEDAC's online resources through the growing number of Internet information discovery tools such as Lycos, Yahoo, and the Open Text Web Index and through pointers from other relevant WWW sites. These will likely link users directly to key elements of SEDAC's WWW pages, e.g., the online WWW guide to international environmental agreements and national resource indicators. Users will be able to enter, browse, save "hot links" or "bookmarks", search for specified text, print selected pages, etc. in much the same way as they use other WWW resources. The WWW guide will be particularly useful to those users who are either: *1)* seeking an overview of the subject and available resources; or *2)* seeking a convenient reference list of online treaty information. Careful design of the WWW resources should ensure that users are steered to the resources most appropriate for addressing their needs.

Students

An increasing number of students from grade school through graduate school are gaining access to the Internet and learning to utilize Internet resources in their learning and research activities. Whereas only a limited number of students have access to a major research library that would have a reasonable subset of treaty texts and related information, virtually any student with Internet access could have the full text of international environmental agreements at their fingertips. Teachers in college-level courses on international law or environmental issues could thus ask students to select a treaty and investigate its legislative history, social and political context, and environmental background. Students doing research on a particular environmental issue such as deforestation, global warming, or stratospheric ozone depletion could easily identify their own country's involvement in relevant international agreements, obtain information on progress in treaty ratification and implementation, and access other relevant literature and information.

Users without WWW access

Users who do not have direct WWW access will still be able to access basic information about international treaties by sending electronic mail requests directly

to the SEDAC e-mail-to-WWW server. This is an extremely important service because most developing countries presently do not have high-speed Internet access, though many do provide some e-mail access to the Internet via either slow Internet links (9.6 kbps) or low-cost store-and-forward systems such as Fido and UUCP. For example, UNDP—one of the more technologically advanced United Nations organizations—has 136 country offices of which 127 have e-mail, but only 14 presently have full Internet connectivity.[22] At present, e-mail users will be limited in their access, but it may be possible in the long run to expand access through more sophisticated e-mail-to-WWW gateways developed by the Internet community and/or SEDAC staff.

5.3.5 Required Data and Information Inputs

The following input data and information will be required:

- The text of significant new international environmental agreements, amendments, and protocols related to global climate change, resource management, and socioeconomic development, especially with regard to the MTPE priority areas of land-cover change and global productivity, long-term climate variability, and atmospheric ozone;
- Continuing updates of treaty status and ratification information from external data providers (e.g., IUCN, UNEP);
- National-level resource indicators obtained on an ongoing basis from data provided by NASA, NOAA, WRI, the World Bank, and other organizations;
- Information on national policy responses to global environmental issues, including documents already available online elsewhere; and
- Access to relevant literature, data, metadata, and other resources needed for the online guide.

Table 4 provides some examples of possible national-level resource indicators corresponding to the main issues covered in the current service. Ultimately, a broad set of indicators for each issue area should be included in the database. However, an incremental approach is more prudent at this time. SEDAC will initially identify a set of indicators that provide reasonable depth with regard to the MTPE priority areas of land-cover change and global productivity, long-term climate variability, and atmospheric ozone, while also providing reasonable breadth by selecting one or two representative indicators for other identified global environmental issues, to serve as a foundation for adding additional indicators in the future. The indicators will reflect a mix of socioeconomic, environmental, and Earth science data, especially remote sensing data. The SEDAC UWG will provide guidance on this mix. SEDAC may also convene user focus groups to discuss the software functionality required and the selection of national indicators and treaty data.

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[22]Allen Hammond, World Resources Institute, CIESIN Information Cooperative Activities Plan.

Table 4. List of possible national-level resource indicators.

Current Service Issue Area	National-Level Resource Indicators
Global Climate Change	Greenhouse Gas Emissions
Stratospheric Ozone Depletion	CFC Emissions
Desertification and Land Cover Change	Fresh Water Resources
Deforestation	Annual Change in Forest Cover
Biodiversity	Habitat Extent and Change
Transboundary Air Pollution	Sulfur and Nitrogen Emissions
Protection of the Oceans	Marine Fisheries Yield and Potential
Trade/Industry and the Environment	Energy Production and Consumption
Populations dynamics	Size and Growth of Population Fertility Rates Life Expectancy and Age Structure

In addition to the environmental data identified above, general socioeconomic data will also be provided. In particular, if we assume that users are interested in comparative international research, the inclusion of basic economic data is necessary to facilitate that type of research. The following national-level economic indicators[23] are suggested:

- Gross National Product (GNP)
- Gross Domestic Product (GDP)
- Average Annual Growth Rate (In Terms of GDP)
- Purchase Power Parity (PPP)
- Annualized Inflation Data

Most comparative international research, whether environmentally based or not, use basic economic data as a foundation for comparison. We believe that it is imperative to offer these data as a basis for the fundamental comparison with environmental data as well. CIESIN currently has permission to redistribute the World Bank's Social Indicators of Development dataset in an online query system (see http://www.ciesin.org/IC/wbank/sid-home.html). Through its Information Cooperative partnership with the World Bank, this dataset should be available for integration. Other data sets may be sought as necessary.

National response information will be needed for initial demonstration purposes; a handful of national response data sets will be selected from the MTPE priority areas of land-cover change and global productivity, long-term climate variability, and atmospheric ozone.

[23] All data are available from the World Bank.

5.3.6 Other Required Resources

This task will require personnel with substantive knowledge of international environmental agreements to interact with the target user community and to guide database development and enhancement. A moderate level of participation from personnel with substantive knowledge of natural science issues in stratospheric ozone, land-use/land-cover, and global climate change will be necessary to support the guide activity and the demonstration of integration of global NASA data. In addition, guidance will be needed from both internal and external experts on the selection and integration of socioeconomic, environmental, and other resource indicators.

The development of network-accessible relational databases will require software designers and programmers with strong background in relational database technology and linkage to WWW interfaces. Such personnel will also be needed to supervise ingest of data into the relational database; personnel with basic familiarity with relational databases will be needed to carry out data conditioning and ingest.

Setting up an e-mail to WWW gateway and adding forms functionality will require programmers with strong WWW and systems administration skills; maintaining the interface will require a moderate level of effort from SEDAC systems administration staff.

A moderate level of support will be needed in the maintenance, global modification, and configuration control of extensive collections of WWW information.

Support from Metadata Administration (SEDAC task 5.2) will be required to ensure that metadata including online guides comply with appropriate metadata and quality control standards. Data ingest will be carried out by the SEDAC data acquisitions and archiving task (5.4).

Support will also be required for development and maintenance of relationships with organizations that can provide treaty text, status, and summary of information, e.g., IUCN and UNEP's Global Resource Information Database (GRID). Some of these relationships are currently maintained under the aegis of the SEDAC Information Gateway.

5.3.7 User Involvement and Testing

An informal group of experts from the policy research community has been involved in the design of the PIDB since its inception. This group has communicated primarily through a listserver. To expand this group and its user representation, participation in the listserver will be opened up and its focus broadened somewhat to encompass the development and use of national resource indicators in relationship to international environmental agreements. Several UWG members were involved in these earlier activities and will serve as liaisons to the UWG.

SEDAC has also sought to involve key users in the development and testing of the PIDB. For example, interactions with personnel at the World Bank led to the addition of the query "To which environmental agreements is country X a party?" to the PIDB. User response to the public "beta" release of the PIDB in late August 1995 has been positive and very constructive in terms of pointing out gaps, problems, and possible improvements.

SEDAC plans to continue and expand its interactions with target users through a variety of channels. For example, task personnel will participate in key fora for discussion of international environmental agreements such as the American Society for International Law (ASIL) annual meetings. Information specialists from selected university libraries and law libraries will be specifically asked to test and evaluate key SEDAC products and services.[24] Feedback will be sought through various Internet discussion lists such as INT-LAW and INFOTERRA and through selected publications such as the Earth Negotiations Bulletin, *Environment* magazine, and various climate/global change newsletters.

5.3.8 Assessment of Effectiveness

The effectiveness of the service will be measured by collection and regular assessment of user statistics, including analysis of system logs, including referrer logs; by direct feedback from test users and the UWG; by demonstrations and other direct contacts with users from key organizations; and by follow-up surveys and interviews with selected users. In addition, it will be important for SEDAC to play an active role in the development and submission of peer-reviewed publications that draw on SEDAC-provided products and services. As with other SEDAC services, it will be important to encourage users to cite SEDAC products and services properly, among other things to facilitate a Science Citation Index search for references.

5.3.9 Anticipated Schedule

Proposed milestones for this task are:

- Define specifications and requirements for indicators, database functionality, and user interface — October 1995
- Identify initial set of national resource indicators — November 1995
- Biannual acquisition and ingest of updated treaty text, summary, and status information — December 1995, June 1996
- E-mail to web interface — January 1996
- Acquire and ingest initial set of indicators — January 1996
- Begin testing user interface redesign and context-sensitive database search functionality: — February 1996

[24] For example, T. Parris, a former SEDAC staff person involved in the development of the PIDB, is now an Environmental Resource Librarian at Harvard University and has already promoted linkages with key law librarians at Harvard.

• GCMD resource discovery tool for guide	March 1996
• Alpha release of indicators functionality	April 1996
• Demonstrate generalizable links to distributed national response indicators	April 1996
• Beta release of indicators functionality	May 1996
• URL-sifter resource discovery tool for guide	May 1996
• Release guide	June 1996

5.4 Stratospheric Ozone Depletion and Human Health

SEDAC proposes to continue active exploration of the potential for developing a new applications development effort on the subject of stratospheric ozone depletion and health. Although it is too early to define in detail a set of operational products and services that would demonstrably benefit a large set of users in significant ways, it is not too early to begin to develop some basic infrastructure and information resources that could serve to:

1) identify the relevant user communities and begin to assess their primary needs and constraints relative to data access and use;

2) locate existing sources of data and information and evaluate their strengths and limitations;

3) help demonstrate the potential of a new suite of products and services in meeting user needs or overcoming user constraints; and

4) establish basic relationships with data sources, the research community, and key users that could be used in future applications development.

With these considerations in mind, SEDAC has developed some initial plans for exploration of applications related to stratospheric ozone depletion and human health.

5.4.1 Specific Problem

As noted in Section 4, exposure to ultraviolet radiation has long been known to be involved in initiating keratoses and certain forms of skin cancers. However, it was not until the 1970s when emissions from supersonic transport (SST) planes and CFCs were thought to be potentially damaging to the stratospheric ozone layer that UV exposure was identified as a potentially serious environmental concern. More recently, the role of UV radiation in immune suppression and eye disorders has been recognized. A large body of literature exists on the effects of UV radiation on human and ecosystem health and the potential impacts of stratospheric ozone depletion.

An important challenge facing researchers, analysts, and decision makers concerned with stratospheric ozone depletion and health is finding and accessing the large volume of published literature and supporting data that exist in a variety of

disciplines. These data and information resources cut across the natural, social, and health sciences and differ greatly in their underlying terminology, assumptions, scales, and approaches. For example, epidemiological studies of UV health effects tend to be drawn from relatively small study populations, so it is often necessary to extrapolate the results of such studies to larger national- or global-scale populations using crude methods. With the paucity of UV monitoring stations in the U.S. and around the world, and the almost complete lack of locations having any long-term time series, public health researchers have not had access to the historical information on biologically effective surface UV radiation doses that could be used to improve estimates of human exposure to UV. Nor have they had easy access to models that attempt to estimate such doses for past, present, or future periods. In addition, they may not be aware of the variety of geographically referenced demographic and socioeconomic data that could be used as the basis for more systematic extrapolation and estimation. This suggests the need for a new information resource that pulls together a number of different functions.

5.4.2 Target Users

In this exploratory phase of the project, the primary target users are researchers in the UV/ozone depletion impacts fields including epidemiologists, dermatologists, ophthalmologists, immunologists, biostatisticians, atmospheric scientists, terrestrial and aquatic ecosystem scientists, and risk assessment scientists involved in integrating information from these areas. In many instances, the research community is closely connected with decision makers, as is the case with many public health researchers. A related set of users are those public health researchers and officials concerned with AIDS, since AIDS patients may be especially vulnerable to the immunosuppression effects of UV exposure.

Another group of researchers of particular interest are those directly involved in formal reviews and assessments of the scientific issues surrounding stratospheric ozone depletion and its human health impacts. In particular, the UNEP Panel on the Environmental Effects of Ozone Depletion has just begun a four-year assessment cycle. Dr. Robert Worrest of CIESIN's Washington DC office staff and Dr. Janice Longstreth of the SEDAC UWG are both members of this panel.

In the long run, the target user community may be expanded to include educators, planners, scientists, engineers, and others interested in environmental impacts of UV radiation. However, after consultation with Drs. Worrest and Longstreth, it was felt that the first priority should be to work with the public health and scientific community in order to pin down the basic scientific and decision making context and assess the best opportunities for future SEDAC applications development.

5.4.3 Planned Products and Services

The planned products for this task include:

Bibliographic database on stratospheric ozone depletion, UV radiation, and human health

This database will contain bibliographic references for refereed journal articles, workshop reports, conference proceedings reports, international assessment reports, and other sources of information related to UV radiation, ozone depletion, and biological impacts of UV radiation. Research fields of interest include atmospheric science, epidemiology, dermatology, ophthalmology, immunology, tropical diseases, and marine and terrestrial biology. Entries will be accessible by author, subject, or keyword search using appropriate query engines. Abstracts may be provided pending authorization from appropriate copyright holders. The entire database will also be available for users to download to local machines via ftp. As this is an ever-changing field with new information becoming available on a near-daily basis, updates to the database will be made periodically based on available funds and personnel support. It is expected that development of the database will build on past work by Dr. William B. Grant of LaRC and Dr. Longstreth.

Access to relevant health datasets

Data relevant to the UV radiation and human health issue are scattered widely. SEDAC will develop metadata for relevant datasets and, in some cases, work to improve access to key underutilized datasets. Relevant datasets may include morbidity statistics for melanoma skin cancer from the Surveillance, Epidemiology, and End Results (SEER) program, melanoma incidence rates from the International Agency for Research on Cancer (IARC), nonmelanoma skin cancer and cataract incidence from local registries and health maintenance organizations such as Kaiser-Permanente located in Oregon, national cancer registries such as those available through Information Cooperative country nodes, data on AIDS prevalence, and data from the First National Health and Nutrition Examination Survey (NHANES). SEDAC will also identify various state, local, and regional registries as well as medical databases that provide information on the incidence and costs related to UV-induced skin cancer and eye disorders. Metadata development efforts will conform to SEDAC, NASA, and CIESIN metadata standards and will be coordinated with SEDAC's Information Gateway activities. Metadata will be made available through the Gateway software, the GCMD, and appropriate WWW mechanisms.

Online WWW guide

An online WWW guide to relevant resources will be developed that provides direct links to data, information, and tools related to ozone depletion, UV radiation, and human health. This effort will build upon the existing thematic guides on "Ozone Depletion and Global Environmental Change" (http://www.ciesin.org/TG/OZ/oz-home.html) and "Human Health and Global Environmental Change" (http://www.ciesin.org/TG/HH/hh-home.html). It may also link to some new visualization and analysis tools such as a set of animations developed in

collaboration with the Centers for Disease Control and Prevention (CDC) and the National Cancer Institute (NCI) on weekly AIDS mortality (see http://www.ciesin.org/datasets/cdc-nci/cdc-nci.html).

Historical UV dose database

As a "proof of concept" activity, SEDAC plans to create an interactive hypertext-based program to permit users to access historical estimates of biologically effective UV radiation dose levels for selected locations in the U.S. This model utilizes satellite-derived input data for ozone and cloud parameters along with surface-based measurements and observations of boundary layer aerosol, ozone, and cloud cover.

An important step in developing this historical dataset is validating the model results with currently accepted models in the user community. Intercomparisons will be made with published results from models developed by Dr. Sasha Madronich at the National Center for Atmospheric Research (NCAR) and Dr. John Frederick at the University of Chicago. This model utilizes satellite-derived input data for ozone and cloud parameters along with surface-based measurements and observations of boundary layer aerosol, ozone, and cloud cover. Selected results from this model will be compared with the results from other available models described in the peer-reviewed scientific literature.

Integrated historical UV and population data

A second "proof of concept" effort will be to investigate the integration of historical UV database (measurements and model values) with population and land use data developed under SEDAC Task 2.2. Such integration would allow matching of estimated UV dose levels for selected regions with demographic and health data for the corresponding region. Key elements would be the addition of ethnicity, occupation, and migration data from the U.S. Census. Initial efforts will focus primarily on defining a possible prototype service and dealing a number of technical and scientific questions, e.g., the appropriate time periods, complexities related to occupation and migration, and treatment of uncertainty. The UWG will be given the opportunity to review plans before any actual prototyping work proceeds.

5.4.4 User Scenarios

Since the target users are scattered widely in different disciplines and countries, they will generally access the above products and services over the Internet. As in the case of other SEDAC services, efforts will be made to ensure that various indexes, search tools, catalogs, and other information discovery resources point to appropriate SEDAC entry points.

Some of the products and services will be made available directly to the UNEP Environmental Effects Panel. Panel members could employ this service to find recent publications and access studies involving key datasets. SEDAC will coordinate its efforts in support of this Panel through Drs. Worrest and Longstreth.

Public health researchers would be able to use the integrated historical UV and population database in several ways. For example, epidemiologists interested in reconstructing an individual's past history of exposure could access the historical database and estimate previous dose levels based on the individual's residence history. This could provide a better estimate of exposure than, for example, patient recall of exposure behavior at younger ages. It could also address the question of migration, a serious limitation in evaluating an individual's risk of skin cancer. Alternatively, epidemiologists could look at recent UV levels in a user-defined area and obtain information on the demographic characteristics of the population in that area (e.g., age, gender, ethnicity, and occupation). This could help identify certain segments of the population that may be at risk in the future to the health effects of UV exposure. The same approach could be used in the terrestrial and aquatic ecosystem community to address impacts of UV exposure to crops, vegetation, and marine environments.

5.4.5 Required Data and Information Inputs

Two primary sources for bibliographic records are a set of references created by Dr. Grant of LaRC and Dr. Longstreth. Over the past several years Dr. Grant has compiled more than 2,900 journal and report references dating back to the early 1900s that focus on UV, ozone, and related atmospheric science topics. Dr. Longstreth also has an extensive bibiographic reference dataset developed for the EPA that focuses on health-related topics relevant to the ozone depletion issue. Discussions have been initiated to obtain these datasets.

To update this database, SEDAC will utilize various health and medical reference sources such as Medline and Cancerlit. Cancerlit is a CD-ROM database produced by the NCI containing references and abstracts on all areas related to cancer research; this source would be used for skin cancer and related skin disorder references. Medline is an on-line service provided by the National Library of Medicine (NLM) that can be used to find information on other health effect research references such as cataracts, immune suppression, and infectious diseases. The information contained in these data sources may have copyright restrictions; appropriate steps will be taken to obtain permission to disseminate selected information from these sources as needed.

A number of datasets have already been identified as being potentially useful to the UV effects and research community:

- *Surveillance, Epidemiology, and End Results (SEER) Cases Diagnosed 1973-91* provides counts and rates of incident (new) cases of cancer by a single by-variable: age, gender, year, state and county of residence, or ICD code. Source: NCI Division of Cancer Prevention and Control. Geographic Identifiers: state and county of residence.

- *U.S. Cancer Counts, 1950-1979* provides death counts by five-year age groups ending with age 85 and older by county, state, and the U..S, by race-sex (white/non-white for male, female) for 35 groupings of cancers, for each year from 1950 through 1979. Source: U.S. EPA/National Technical Information Service. Years: 1950-1979. Geographic Identifiers: county, state, and US.

- *First National Health and Nutrition Examination Survey (NHANES I), 1971-75, Ophthalmology, ages 1-74 (Tape No. 4161)* includes demographic characteristics, ocular histories, and standardized eye examinations. Source: NCHS. Years: 1971-1975. Geographic identifiers: first 35 locations of NHANES I.

- *First National Health and Nutrition Examination Survey (NHANES I), 1971-75; Dermatology, ages 1-74 (Tape No. 4151)* documents the deleterious effect of ultraviolet radiation on selected skin and eye conditions. It also includes demographic characteristics and information on type and adequacy of medical care sought. Source: NCHS. Years: 1971-1975.

- *Cancer Incidence in Five Continents* is the best source of data on worldwide cancer incidence. Source: IARC.

- Ozone measurements from Dobson instrument stations may be used for estimates of surface UV prior to 1979. Projected UV dose estimates out to the year 2000 based on current ozone trends would also be available.

Many datasets in the area of atmospheric science that are useful in evaluating the amount of UV radiation reaching the surface can be accessed through various atmospheric and climate data centers across the country, including several DAACs and NOAA's NCDC. Links to related Internet resources will also be created to provide supplementary information on UV and health topics.

5.4.6 Other Required Resources

This project will draw upon resources and expertise already available at CIESIN. These include the thematic guides and multiple scattering radiative transfer model mentioned previously. Individuals with experience in database configuration and manipulation will be required to archive and configure datasets for rapid access. The two prototyping efforts would require assistance from SEDAC design, programming, prototyping, and product generation staff to develop appropriate interfaces and assist in data integration using existing tools and software.

5.4.7 User Involvement and Testing

User involvement and testing will be sought at all stages of this task. For example, SEDAC staff have already been in contact with epidemiologists interested in UV exposure at the University of Michigan, Brown University, and the Henry Ford Health Sciences Center (a large health maintenance organization in the Detroit, Michigan area) concerning their data needs. An informal e-mail survey of a number

of leading epidemiologists concerned with skin cancer from around the world has been conducted by Dr. Marvin Weinstock of Brown University at the request of SEDAC staff. Contacts are also being developed with CDC, NCHS, NCI, and other National Institute of Health centers. Selected UWG members and the UWG as a whole will review progress and provide guidance.

Online databases and prototypes will incorporate forms for user feedback, including reporting of errors and submission of suggestions. It is expected that a listserver will be established to facilitate discussion of the products and services as they develop as well as those relevant products and services developed by other organizations. This may be an especially important vehicle for making sure the bibliographic database and pointers to Internet resources are kept as up to date as possible. SEDAC will also participate in other relevant discussion lists and online publications such as the POPENV-L mailing list, the World Bank's PHNFLASH newsletter, the GreenDisk Paperless Environmental Journal, and the British Medical Journal's Medicine and Global Survival online publication (http: //www.bmj.com/ bmj/mgs/index.html). In addition, SEDAC's user modeling effort will be broadened to include assessment of the potential user base and follow-up of initial users.

5.4.8 Assessment of Effectiveness

Effectiveness of delivered products and services ultimately depends not only on how many and how often individuals in the user community access the system, but also on how they actually use the information in their particular line of work or activity. Assessing effectiveness can be accomplished in the following manner:

- collection and analysis of user statistics;
- requests for comments and suggestions on data content, completeness, and usefulness of the on-line service though electronic mail, on-line response forms, and contact with task personnel and SEDAC User Services;
- demonstrations and other direct contact with the user community; and
- active follow-up with selected users to ascertain their actual use of data and information, satisfaction with delivered products and services and with user support, and additional needs and preferences.

In the case of these services, it may also be possible to utilize the Science Citation Index to try to track actual citations of data, bibliography, and prototypes in the published research literature. To facilitate this effort, clear and prominent suggestions need to be given to users on how to cite the referenced data and information properly.

C-2

5.4.9 Anticipated Schedule

This exploratory activity is designed as a short-term undertaking to be completed within 9-12 months. A partial list of intermediate milestones is given below, subject to change in design concept and resource availability:

- Continue informal solicitation of user community for initial concept design and data requirements — October 1995
- Identify and acquire bibliographic and health datasets — December 1995
- Document and archive health datasets — January 1996
- Incorporate satellite data into UV radiative transfer model — January 1996
- Prototype bibliographic database, guide, and Internet links with basic functionality — March 1996
- Completion of UV modeling data for prototype region — April 1996
- Link prototype of UV historical data with population census variables and spatial client — June 1996

5.5 Population and Land Use/Cover Change in China

SEDAC proposes to continue active exploration of a possible new applications development effort on the subject of population and land use/cover change in China. Although it is too early to define in detail a set of operational products and services that would demonstrably benefit a large set of users in significant ways, it is not too early to begin to develop some basic infrastructure and information resources that could serve to:

1) identify the relevant user communities and begin to assess their primary needs and constraints relative to data access and use;

2) locate existing sources of data and information and evaluate their strengths and limitations;

3) help demonstrate the potential of a new suite of products and services in meeting user needs or overcoming user constraints; and

4) establish basic relationships with data sources, the research community, and key users that could be used in future applications development.

With these considerations in mind, SEDAC has developed some initial plans for exploration of population and land use/cover change in China.

5.5.1 Specific Problem

China is experiencing rapid economic growth as a result of market reforms in the last decade. Industrialization and growth of the urban business place is drawing Chinese away from traditional agrarian lifestyles and placing ever increasing demands on agricultural productivity, urban infrastructure, and environmental resources. The dynamics of increasing and more affluent population and rapidly

changing environment and land use have stimulated great interest in China's potential contributions to global climate change. Industrial growth to date has occurred without significant regulatory efforts to control environmental impacts and ensure sustainable development. Recognition of the need for better environmental and land use management is growing and various levels of government are beginning to respond. At the same time, however, decisions are already being made that could have significant impacts on land use and environment in China. The construction of a major dam across the Yangtze River, which has engendered major debates both within and outside of China regarding its environmental risks and social and economic costs and benefits, is a case in point (e.g., Topping, 1995).

Equally significant is the impact China will have on global economic and social development. As a nation with one third the natural resources of the U.S. yet five times the population, China's future growth will depend on increased imports of material resources as well as increased exports of manufactured products and other goods. This prominent role in the global economy will have important ramifications worldwide.

These rapid changes increase the need for good data and information about key economic, social, and environmental trends in China on the part of decision makers both within and outside of China. Unfortunately, geographically detailed and reliable data and information about China are very limited. Few resources exist that bring together socioeconomic and environmental data on China and make them widely available. In general, the research and decision making communities rely heavily on consultants with expert knowledge, personal contacts with individuals in Chinese institutions, and other disparate sources of data and information. Coordinated efforts are needed to integrate various types of spatial and temporal data in ways that could support decision making.

5.5.2 Target Users

In light of the wide range of potential users both within and outside of China, it is important for SEDAC to focus more tightly on a limited set of target users who could benefit significantly from some modest initial efforts to develop useful products and services. Such users need to be reasonably sophisticated in the use of data and information in a decision making context. If SEDAC can serve these users successfully, it will have a solid base for expansion of products and services to a wider range of users in the future.

Three main category of user have been identified for near-term SEDAC efforts:

1) Selected global environmental change researchers interested in China;

2) Multinational organizations involved in development planning and environmental management such as the World Bank and UNDP; and

3) Planners and analysts from China and other countries and in both the public and private sectors who are involved in GIS applications, database development and management, and decision support systems.

Contacts have been made with representative users from all three of these groups. For example, under a previous NASA Grant, CIESIN initiated and supported the CITAS project, which includes scholars from a variety of fields interested in the coordinated development of China data resources, including an integrated GIS. Several natural scientists working with CITAS have submitted proposals to the U.S. National Science Foundation and NASA for research on nitrogen cycles in China. SEDAC staff have close contacts with CPGIS, an association of Chinese professionals involved in GIS. Through CIESIN's Information Cooperative, SEDAC can access several key national institutions involved in remote sensing, mapping, planning, and development within China, as well as relevant multinational organizations.

5.5.3 Planned Products and Services

The data products presented below are in order of priority. The extent to which new products (4 and 5) and incremental improvements of existing products (1, 2, and 3) are carried out will depend on available resources, user feedback, and UWG guidance.

1) *An integrated GIS database of socioeconomic and environmental variables of China.* The GIS database will be based on the previously developed CITAS collection which includes a variety of variables from the period 1980-1990. The GIS will be augmented to include remotely sensed data products from the 1-kilometer Advanced Very High Resolution Radiometer (AVHRR) Pathfinder project and the best available categorization of land use/land cover. Sources for land use/cover data include a digitized version of the 1985 Land Use Map of China (LUMC). Efforts are currently under way in China to update the LUMC using remote sensing. Access to these products will require negotiation with China data sources.

2) *Online access to Chinese Census microdata samples using the Ulysses tabulation system.* Efforts have begun to acquire the 1990 microsample dataset to be added to Ulysses. The availability of two decades of China Census microdata will permit detailed examination of population dynamics during this very active period.

3) *Online access to time series macroeconomic data.* Online access to time series macroeconomic data covering the period 1949 to present would be provided using the time series interactive browser developed by CIESIN under a previous NASA Grant. These data are available through the Chinese Economic Monitoring Center and at this time are available exclusively to SEDAC for distribution and incorporation into applications.

4) *AVHRR change-detection products.* In cooperation with EDC and the Chinese National Meteorological Organization, SEDAC will explore the use of time series AVHRR data to map annual biomass development and to identify land cover change over a period of five years.

5) *Rasterized China population maps.* In cooperation with the Chinese Population Information and Research Center (CPIRC), SEDAC will explore the development of a georeferenced (raster) China population database comparable to that under development for North America.

5.5.4 User Scenarios

The scenarios presented below describe how the users targeted by this task could make use of SEDAC systems and services to accomplish their objectives:

Global Change Modeler

A physical science researcher at the University of Virginia Department of Environmental Sciences is engaged in developing a model of nitrogen cycling in China. During the first year the team is interested in acquiring data on industrial and agricultural productivity and quantitative estimates of fertilizer use. The project will focus in its second year on integrating population statistics and selected socioeconomic data at the national level, but finer resolution is desirable and is being sought. SEDAC currently offers the dataset "Agricultural Statistics for the People's Republic of China," which covers land use, gross value of agricultural output, agricultural investment, crop production, crop sown area, consumption of agricultural commodities, and other variables at the national level and at the provincial level when available. The CITAS GIS planned for release in late 1995 will also fulfill some of these data needs. One benefit from this user relationship with SEDAC is that, once completed, significant parts of the model can be incorporated into the CITAS GIS product.

Multinational Organization

Multilateral donor agencies such as the World Bank maintain technical assistance staff that require georeferenced data linked with socioeconomic information as part of the process of project appraisal for financing. The Bank-funded project appraisal report includes data on a sustainable environmental setting for the long-term economic and social development of a given province in China. This report includes data on water treatment and quality, waste and environmental management, historic sites and monuments, urban infrastructure, and other socioeconomic variables. SEDAC can provide such users with a number of valuable datasets, including the integrated CITAS GIS, the China Macroeconomic Database, and the 1% Census microsample. Moreover, by linking these datasets with online access tools such as the Ulysses tabulation system, SEDAC can improve the ability of such analysts to derive necessary information quickly and easily compared with traditional methods.

Planners and Analysts

AMWAY International is a major investor in China and has been asked by China's government to help in the assessment of the environmental impacts caused by China's rapid growth. The research department of this company needs georeferenced data, overlaid with environmental and other information and with subnational boundary data, in order to assess environmental changes in the rural landscape and suggest desirable growth patterns. The Digital Chart of China offers a solid foundation for this type of analysis. This dataset consists of six layers containing spatial data on roads, railroads, drainage systems, populated places, urbanized areas, and contours The integrated GIS to be developed in this task would provide additional variables of interest for the period 1980-1990 and offers the best available categorization of land use and land cover at this time.

5.5.5 Required Data and Information Inputs

Sources of data and information include CITAS, EDC, and various Chinese institutions. Several Chinese institutions are already active members of the CIESIN Information Cooperative, including the Chinese Academy of Sciences, Peking University, the CEMC, the Chinese Academy for Surveying and Mapping, and CPIRC. These institutions have contributed to CIESIN's present collection of data about China which will be an important resource for this effort.

Required databases include:

1) *CITAS GIS Database.* This database is to be delivered to CIESIN by the University of Washington in September 1995 in fulfillment of a previous contractual obligation. CIESIN has arranged to receive updates of this collection from the source organizations. The GIS includes a variety of socioeconomic data referenced against a unique county-level administrative geography for the period 1980 - 1990.

2) *1982 and 1990 Census microdata 1% samples*: These databases are available through the CPIRC and the National Statistical Bureau. CIESIN has obtained permission to disseminate the 1982 data at this time. Access to the 1990 dataset is under negotiation.

3) *1949-1994 Macroeconomic database of China.* The CEMC maintains this database including monthly statistics for hundreds of nationwide economic variables and indicators. CEMC has provided SEDAC with data up to 1990. Arrangements are being discussed for the regular provision of updates to this dataset by CEMC. Fees may be required.

4) *Digitized land use boundaries derived from the 1985 Land Use Map of China.* This dataset has been digitized at Griffith University in Australia. Use of the data depends upon agreement with Chinese organizations holding copyright.

5) *1992 Monthly Composites AVHRR 1-kilometer Pathfinder database.* The AVHRR database is available through EDC.

6) *Various AVHRR and Multispectral Scanner (MSS) datasets.* AVHRR and MSS datasets are available from EDC and the China NMO for a fee.

7) *Various annual statistical yearbooks and map collections.* These are available from the China National Bureau of Statistics, Institute of Geography, and other sources.

5.5.6 Other Required Resources

Software and hardware tools required will include:

1) Arc/Info GIS system for a UNIX platform and a GIS (to be determined) for a personal computer platform plus a large format scanner;

2) SEDAC/CIESIN developed software tools including the Ulysses Tabulation System and the Time Series Interactive Browser;

3) Remote sensing data processing toolkit;

4) Internet toolkit including WAIS and WWW browser; and

5) Access to the Change Vector Analysis software processing system operated by ERIM (a CIESIN Consortium member).

In addition, SEDAC will draw on its internal professional staff, which includes several individuals fluent in Chinese and familiar with Chinese GIS and demographic data in general and the CITAS data in particular.

5.5.7 User Involvement and Testing

A primary objective of this initial activity is to develop an understanding of user needs and to assess user response to the products and services made available. As a means to achieve a focused evaluation, it is suggested that selected users from each of the three designated target groups be invited to participate in an applications product working group. This approach would allow a focused and sustained review of prototype products as they become available. The working group would coordinate their review with the SEDAC UWG. The primary means of interaction would be via a listserver. A WWW home page would be constructed to provide this working group and other testers a continuously updated information source. Several products would be available online to the working group. The CITAS GIS would be available at CIESINs Saginaw, Michigan headquarters and Washington, D.C. office, or could be installed at user sites, if appropriate equipment were available.

5.5.8 Assessment of Effectiveness

This initial activity will emphasize hands-on use of the product by a working group. The group would be asked specifically to evaluate the effectiveness of the products relative to their respective domains of interest. As is standard for all SEDAC products, SEDAC will monitor user statistics and actively solicit user feedback through various channels.

5.5.9 Anticipated Schedule

Preliminary assessment of AVHRR database	September 1995
Receipt of CITAS GIS	October 1995
Online availability of microsample data	January 1996
Integration of remote sensing and land use data in GIS	February 1996
Biomass development, land use change detection reports	May 1996

5.6 Task Management

As discussed in Section 4, a flexible approach to management of the applications development tasks is needed to ensure that SEDAC continues to be innovative and responsive to user needs yet also consistent and reliable in the services it provides. Task management, SEDAC Task 2.1, is therefore an important activity in its own right. The objectives of Task 2.1 are to:

- plan, manage, and coordinate applications development activities;
- identify, investigate, assess, and monitor opportunities for applications development;
- identify, investigate, assess, and monitor user needs and other aspects of the global climate change community;
- help develop cooperative and collaborative relationships with key scientific, data, and technological personnel and institutions that may contribute to present or future applications development; and
- prepare and update the DADP, provide inputs into other key deliverables, and inform other parts of SEDAC about applications development task activities and outputs.

These objectives are the responsibility of the DADT working with the SEDAC Project Scientist and other relevant SEDAC staff. The DADT is responsible for coordinating all applications development activities. The DADT will also be SEDAC's primary contact with the global climate change community.

5.6.1 Specific Problem

A primary function of Task 2.1 is to identify and investigate new applications development activities. Task 2.1 will focus on issues that fall within the three main categories outlined in Section 2: global climate change, stratospheric ozone depletion, and land use and ecosystem change. Other related problems will be considered on a case-by-case basis. During the coming year, this task will oversee the exploratory work proposed for Stratospheric ozone depletion and human health and Population and land use/cover change in China. It will also investigate possible new applications tasks, including possibly some basic work on vulnerability to climate extremes in the U.S. The DADT will work closely with the global change community and the UWG in investigating and evaluating new applications development activities.

5.6.2 Target Users

In order to investigate and identify new application activities, it is important that SEDAC staff are informed about relevant issues and engaged with the user community. Task 2.1 will be flexible in addressing the broad user community (as described in Section 3) and their diverse needs, but will generally seek to identify a narrower target audience for particular applications development opportunities. In particular, Task 2.1 will build collaborative relationships with specific target users when investigating new applications development tasks. For example, efforts to define a possible project on vulnerability to climate extremes in the U.S. might involve developing contacts with government agencies such as the Federal Emergency Management Agency (FEMA) and relevant state, regional, and local governments and with the insurance industry, relief organizations, and other relevant groups. This level of coordination will ensure that any new applications development activity will be responsive to the needs of one or more specific target users. It will also ensure sensible selection of target users based on an assessment of the range of possible users and their needs.

5.6.3 Planned Products and Services

Task 2.1 coordinates preparation and update of the DADP and also provides important inputs to requirements analyses, IGP, SDP, Architecture and Operations Concept Document, Annual Work Plan and other key SEDAC deliverables. It also works closely with other SEDAC tasks to make sure that design, prototyping, testing, and operational implementation of actual applications are conducted in a coherent and cost-effective way.

As part of the continuing monitoring and assessment process, Task 2.1 will interact with the user community and solicit information on user needs in conjunction with Task 3.3. Within available resource constraints, it will seek to educate potential users and contributors about SEDAC applications development through publications, exhibits, presentations, meetings, and other outreach activities. In this regard, a simple but informative SEDAC brochure will be very important to help

introduce potential users to SEDAC services and capabilities in a professional manner. In a few instances, it may develop examples of integrated datasets as illustrations of potential opportunities for applications development. Such activities can also help build working relationships with other important data sources and institutions.

As part of the need to identify new applications development opportunities, Task 2.1 will produce an annual summary report that reviews what applications development activities have been investigated. This summary report will identify the specific problem that is being addressed, the product or service that will be produced, and the possible and recommended target users. It will provide an evaluation of each proposed activity based on input from the target user community. The criteria outlined in Section 4.3 and inputs from the UWG will be used to evaluate proposed new applications development opportunities. Opportunities will be selected in consultation with the UWG and NASA, and selection decisions will be reflected in the updated DADP and Annual Work Plan.

5.6.4 User Scenarios

Users interested in global climate change issues are likely to hear about SEDAC through colleagues, Internet services, conferences, the SEDAC brochure, or other information sources. They may contact User Services or perhaps a particular person on the DADT. The role of Task 2.1 is to solicit information about the user and his or her needs. Similarly, an earth scientist or social scientist may initiate a contact through the Information Gateway or directly to SEDAC. The role of Task 2.1 is then to determine if there might be some useful contributions to ongoing or possible future applications development initiatives.

5.6.5 Required Data and Information Inputs

The primary inputs needed to carry out this task are knowledge of the user community, understanding of the key issues, and technical knowledge about possible applications development opportunities involving both SEDAC resources and external collaborators. The task will also benefit from the continuing refinement of the SEDAC User Model under Task 3.3.

As part of the exploration and assessment of new applications development opportunities, it will be important to have access to data resources and analytic tools that may be useful in developing services responsive to user needs. For example, it may be necessary to obtain samples of key earth and social science datasets to assess what forms of data integration are possible. In some cases, data integration may require models or other analytic software developed by others that could be made available directly to users. In other cases, it may be important to build long-term relationships with key data institutions in order to gain access to important data resources needed for applications development. These alternatives highlight the importance of coordination between Task 2.1 and Information Gateway activities.

5.6.6 Other Required Resources

This task requires personnel who are very familiar with the decision making community and the key issues and who have some technical skills related to data integration and data analysis and interpretation. Coordination is needed with the SEDAC Project Scientist and with Task 3.3, the development of the user model. Travel funds are needed to support active interaction with users at key meetings.

In the course of DADT interactions with the policy and data communities, it is expected that SEDAC staff will discover the existence of many different datasets of high potential interest and value to the user community, including earth and social scientists working on issues. Coordination is needed with Task 5.2, Catalog Development, to ensure that metadata about such datasets are captured and placed in the SEDAC Catalog.

5.6.7 User Involvement and Testing

The UWG will oversee task management and will review the DADP and other related documents on an annual or more frequent basis. Other user involvement will occur through various Task 2.1 planning activities. Interaction with new target users will be an essential component of Task 2.1. For example, input from users will be solicited in the evaluation of proposed new applications development activities as described in Section 5.3.3.

The participation of Task 2.1 staff at key conferences and meetings involving the global climate change community will be an important means of involvement and interaction with the user community. Participation at such meetings and conferences is particularly important given the limited travel budget for bringing target users to SEDAC's office in Saginaw. Relevant meetings and conferences include sessions of the Harvard Commission on Global Environmental Change Policy and the IPCC First Special Workshop on Article 2 of the U.N. Framework Convention on Climate Change. It is expected that new opportunities for interaction will emerge in the course of exploring new applications development possibilities.

5.6.8 Assessment of Effectiveness

Again, the UWG will have a key role in assessing whether Task 2.1 activities are effective in monitoring user needs and responsive to new opportunities for applications development. The UWG, NASA, and others will provide feedback on the DADP and other outputs of this task. In addition, input will be solicited from specific user groups that are potential targets of new applications development activities as described in Sections 5.3.2 and 5.3.3.

5.6.9 Anticipated Schedule

Task 2.1 is an ongoing task. Key milestones specific to the task are:

Summary report or presentation on new opportunities	May 1996
• Updated draft DADP for UWG review	August 1996

These milestones are subject to review and revision by the UWG. Additional milestones will be added in future option years based on experience and user feedback.

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Acronyms and Abbreviations

AIDS	Acquired Immune Deficiency Syndrome
APDU	Association of Public Data Users
ASIL	American Society for International Law
AVHRR	Advanced Very High Resolution Radiometer
CAS	Chinese Academy of Sciences
CBO	Congressional Budget Office
CDC	Centers for Disease Control and Prevention
CD-ROM	Compact Disk-Read Only Memory
CEMC	Chinese Economic Monitoring Center
CENRR	Committee on Environment and Natural Resources Research
CFC	chlorofluorocarbon
CGIAR	Consultative Group on International Agricultural Research
CIESIN	Consortium for International Earth Science Information Network
CITAS	China in Time and Space
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COP	Conference of the Parties
COTR	Contracting Officer Technical Representative
CO_2	carbon dioxide
CPIRC	China Population Information and Research Center
CRS	Congressional Research Service
DAAC	Distributed Active Archive Center (EOSDIS)
DADP	Data and Applications Development Plan (SEDAC)
DADS	Data Archive and Distribution System (SEDAC)
DADT	Data and Applications Development Team (SEDAC)
DICE	Dynamic Integrated Model of Climate Change and Its Effects on the Economy
DOE	Department of Energy
EAS-L	Emergency Alert System on the Internet
EDC	EROS Data Center
EISIL/IDI	Electronic Information System for International Law/Informatique de droit international
EMF14	Study Group 14 of the Energy Modeling Forum
EOS	Earth Observing System (NASA)
EOSDIS	Earth Observing System Data and Information System (NASA)
EPA	Environmental Protection Agency (U.S.)
EPRI	Electric Power Research Institute
ERIM	Environmental Research Institute of Michigan
FEMA	Federal Emergency Management Agency (U.S.)
FY	fiscal year
GAO	General Accounting Office (U.S.)
GB	gigabytes
GCAM	Global Change Assessment Model (Battelle)
GCM	general circulation model
GCMD	Global Change Master Directory
GDP	Gross Domestic Product
GEDEX	Greenhouse Effect Detection Experiment
GEF	Global Environmental Facility

GEOCOR	Geographic Correspondence
GIS	geographic information system
GISS	Goddard Institute for Space Studies (NASA)
GNP	Gross National Product
GRID	Global Resource Information Database (UNEP)
GSFC	Goddard Space Flight Center
HDP	Human Dimensions of Global Environmental Change Programme
HDP-DIS	HDP Data and Information System
html	HyperText Markup Language
IAI	Inter-American Institute for Global Change Research
IAM	integrated assessment model
IARC	International Agency for Research on Cancer
ICAM	Integrated Climate Assessment Model (Carnegie-Mellon Univ.)
IGBP	International Geosphere-Biosphere Programme
IGBP-DIS	IGBP Data and Information System
IGP	Information Gateway Plan (SEDAC)
IIASA	International Institute for Applied Systems Analysis
IMAGE	Integrated Model to Assess the Greenhouse Effect
INC	Intergovernmental Negotiating Committee
IPCC	Intergovernmental Panel on Climate Change
IPUMS	Integrated Public Use Microdata Sample
ISAS	Interactive System for Analysis Services
IUCN	World Conservation Union
LaRC	Langley Research Center (NASA)
LUCC	Land-Use and Land-Cover Change (HDP/IGBP)
LUMC	Land Use Map of China
MABLE	Master Area Block Level Equivalency
MECCA	Model Evaluation Consortium for Climate Assessment
MIT	Massachusetts Institute of Technology
MoU	Memorandum of Understanding
MSS	Multispectral Scanner
MTPE	Mission to Planet Earth (NASA)
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center (NOAA)
NCGIA	National Center for Geographic Information and Analysis
NCHS	National Center for Health Statistics
NCI	National Cancer Institute
NGO	nongovernmental organization
NHANES	First National Health and Nutrition Examination Survey
NIES	National Institute for Environmental Studies (Japan)
NLM	National Library of Medicine (US)
NMO	China National Meteorological Organization
NOAA	National Oceanic and Atmospheric Administration (U.S. Dept. of Commerce)
NRC	National Research Council
NSF	National Science Foundation
OECD	Organization for Economic Cooperation and Development
OMB	Office of Management and Budget
ORNL	Oak Ridge National Laboratory
OTA	Office of Technology Assessment
PIDB	Policy Instruments Database
PNL	Pacific Northwest Laboratories
PPP	Purchasing Power Parity

PUMA	Public Use Microdata Area (U.S. Census)
PUMS	Public Use Microdata Samples (U.S. Census)
RIVM	National Institute on Public Health and Environmental Protection (The Netherlands)
SASPAC-L	SAS Public Access Consortium list
SDC	State Data Center
SDN	Sustainable Development Network (UNDP)
SDP	Science Data Plan (SEDAC)
SEDAC	Socioeconomic Data and Applications Center
SEER	Surveillance, Epidemiology, and End Results
SOSDATA-L	Social Science Data list
SPF	sun protection factor
SST	supersonic transport
STF	Summary Tape Files (U.S. Census)
TIGER	Topologically Integrated Geographic Encoding and Referencing
TOMS	Total Ozone Mapping Spectrometer
UCAR	University Corporation for Atmospheric Research
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
URL	Uniform Resource Locator
USDA	U.S. Department of Agriculture
USGCRP	U.S. Global Change Research Program
UV	ultraviolet radiation
UWG	User Working Group (SEDAC)
WAIS	Wide Area Information Server
WRI	World Resources Institute
WWW	World Wide Web

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Robert S. Chen
Principal Investigator - compiler

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Consortium for International Earth Science Information Network
2250 Pierce Rd.
University Center, MI 48710

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2250 Pierce Road University Center, MI 48710 USA
Phone: (517)797-2700 Fax: (517)797-2622

1968 Green Road P.O. Box 134003 Ann Arbor, MI 48113 USA
Phone: (313)663-5650 Fax: (313)663-6622

1825 K Street, N.W., Suite 805 Washington, D.C. 20006 USA
Phone: (202)775-6600 Fax: (202)775-6622