

Conf-9311289--1

PNL-SA-25062

IMPACTS OF CLIMATE CHANGE ON HUMAN SETTLEMENTS:
GUIDELINES FOR ASSESSING IMPACTS

M. J. Scott

November 1993

Presented at the
UNEP - Canada Workshop on Impacts & Adaptation To
Climate Variability & Change
November 29 - December 3, 1993
Toronto, Canada

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

wh

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Impacts of Climate Change on Human Settlements: Guidelines for Assessing Impacts

1.0 Human Settlements Sector

The impacts of climate change on human settlements can come from one of three sources: indirect socioeconomic economic impacts of changes in resource-dependent sectors such as agriculture and fisheries that are directly affected by climate; direct impacts of climate on infrastructure and the population; and exacerbation or mitigation of regional or national demographic, technological, economic, and social trends.

1.1 Types of Settlements

For purposes of climate change analysis, human settlements can be categorized into three types. The first type consists mostly of smaller rural communities that are directly dependent upon some resource that in turn could be affected by climate (e.g. agricultural market towns and villages, fishing communities, timber production towns, communities dependent on the tourist trade). These communities' fundamental economic reason for existence can be reinforced or threatened by changes in climate, which will interact with changes in markets, population and technology trends and other factors influencing community growth. These communities can grow, decline, or cease to exist as a result of climate influences on their fundamental economic function. The second type of settlement can be of any size. These communities continue to serve an economic function under climate change, but may have the quality of life in them affected by climate change. For example, water supplies may be enhanced or threatened, human health may be affected by new disease organisms, or coastal flooding may occur, threatening infrastructure investments. In such cases, the settlement would continue to exist with its economic function intact, but new investments might be made either to defend infrastructure and population against environmental threat or to take advantage of new environmental circumstances. The third type of human settlement provides general economic support for an entire region and tends to be large in size -- from several thousand up to several million people. This type of settlement rarely would be directly threatened economically by climate change. While it might be threatened by climate effects on infrastructure, the scale of the investment committed to the location is likely to be large enough that the city would be defended from sea level rise or supplied with water from new sources, and so on. The largest impact on larger communities could be the effects of rural-to-urban migration of populations, including whatever push is given to the process by climate change. While this migration supplies willing hands for industry, acceleration of this migration trend could overtax infrastructure and the social fabric.

1.2 Assessment Methodologies

Regardless of the cause of climate impacts in human settlements of interest, a useful first step is to conduct a vulnerability analysis to identify settlements that are most likely to be affected by climate change. This is a screening activity in which the analyst attempts in an array in which settlements are recorded by name or by type on one axis. On the other axis are entered potential climate impacts. Based on whatever information is available, including quantitative data, literature, and expert opinion, the analyst gives each cell in the table a qualitative rating both as to the likely size of the effect and the likelihood of the effect-- e.g., villages in the example table are very vulnerable to loss of farm production through drought, which is considered unlikely, but are not vulnerable to effects of flooding, which is considered likely.

Use of a qualitative screening analysis provides a useful first step in that it helps identify and classify the climate vulnerability problems of human settlements that require further investigation. The number and type of

classifications used in this screening tool are not fixed; however, all likely categories of impact expected to have more than a trivial effect anywhere in the region of interest should be included.

Settlement	CLIMATE VULNERABILITY RATING (Examples)			
	Drought Effects on Agriculture	Drought Effects on Water Supply	Flooding Effects on Buildings	Rural Urban Migration
Region:NE region of country X				
Villages <500 people	1, U	2, U	4, L	2, L
Market towns, 500-10000 people	2, U	2, U	4, L	2, U
City A	4, U	3, U	2, L	1, L

Ratings: 1= Large or very important, 5 = Trivial
L= Likely U= Unlikely

For small, resource-dependent communities, analysis of the impact of climate change is largely a case study of the resource-dependent sectors and the remaining sectors and populations dependent on them. Likewise, adaptation is largely the story of the resource sector on which the community depends. For example, a number of small farming villages and market towns may not continue to exist if a region is changes from rain-fed agriculture to grazing, with its often-lower requirements for economic support sectors. However, the same region may gain population and human settlements grow in size and wealth if intensive irrigation of high-valued crops replaces, say, rain-fed subsistence agriculture. In either case, the effect on human settlements is estimated by an integrated assessment of the region, with emphasis on understanding the secondary and tertiary sectors and the populations necessary to sustain them.

Examples of assessment tools include economic base models, input-output models, community network analyses. The most critical variables would be the economic changes in the resource sectors affected by climate and the number and characteristics of the people entering or leaving the community as a result of a) forces such as demographic and technological change and b) climate change.

The second type of human settlement usually has its infrastructure needs affected in some way by climate change, and this is the principal effect of climate change. This could take the form of additional flood protection in a river floodplain community, for example, or a disease protection program. The community's key economic function is not threatened or enhanced by climate change (e.g., the settlement is a small manufacturing city or trade center); however, the key question regards infrastructure--whether it most cost-effective to a) supply services at the old level degraded by climate change, b) somehow change the level of services (e.g. by digging deeper wells, building higher levees, etc.), or move the community to a location where it is easier to provide services (e.g., prohibitions on building in certain types of floodplains). Cost-effectiveness and cost-benefit analysis will be important needs of the second type of community.

Examples of tools that may be helpful to the second type of community include water project evaluation models; building energy simulation models and utility planning models; geographic information systems with information on settlement patterns, land use, resource constraints (such as locations of floodplains), and institutional constraints (zoning restrictions or areas that will not be supplied with services as a matter of government policy--this is characteristic of some informal communities in large cities of some developing countries).

While impacts on community infrastructure can be important for larger communities, the relatively large size of cities usually means a) their economic reason for existence would not be threatened by climate change to the point where the settlement's existence would be called into doubt; b) the settlement's infrastructure would likely be improved to meet the demands of the community with climate change; c) analysis of climate impacts would reach beyond the immediate settlement to incorporate questions of major national or regional social trends, and may rise to the level of a regional/national assessment of factors like the national distribution of income, trade policies, health and population policies, housing and agricultural policies. At the scale of major cities, climate change is only one of several factors that make the human settlement an agreeable or disagreeable place to live. Analysis of climate change effects and adaptations future urban populations can only be estimated if an integrated analysis is done that takes the broader national and regional trends into account.

Examples of tools of integrated assessment may include population models, migration models, national macroeconomic models, and epidemiological models, as well as the specific sector models and analyses and the cost-benefit and cost-effectiveness models used on the other two settlement types.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Human Settlements- Sample "Dangerous Climate Interference" Thresholds

There is no particular level of temperature or precipitation that constitutes a ready threshold value for human settlements effects. Most such effects are indirect and arise out of impacts in the primary resource affected by climate change. Also, many of the effects that are unacceptable thresholds relate to frequency and severity of extreme events. While the following examples are illustrative only, they capture the spirit of the problem.

Impact Pathway	Small, Resource-dependent Settlement	Infrastructure-Affected	Major Cities
Drought-Agriculture	Loss of two successive crops	None	Immigration of greater than X%
Drought Effects on Water Supply	Loss of Water for Livestock in any year, Loss of irrigation for two years	Loss of Water Supply for More than 1 Month in Any Decade	Loss of Water Supply for More than 1 Week in Any Year
Flooding Effects on Buildings	None	Loss of More than 10% of Structures, Damage to More than 30% in Any Decade	Loss of More than 10% of Structures, Damage to More than 30% in Any 3 Decades
Rural-Urban Migration	Loss of More than 5% of the Labour Force in Any Year	Loss of More than 5% of the Labour Force in Any Year	Gain of Population of More than 5% in Any Year
Effects of Warming on Energy Demand	Growth Exceeding 10% per year in Peak Demand for Electricity or for Fuels	Same as at Left	Same as at Left
Waste Management	Loss of Water Supply, Solid Waste Sites, and/or Significant Health-Threatening Episodes	See Left	See Left

CLIMATE VULNERABILITY RATING (Examples)				
Settlement	Drought Effects on Agriculture	Drought Effects on Water Supply	Flooding Effects on Buildings	Rural Urban Migration
Region:NE region of country X				
Villages <500 people	1, U	2, U	4, L	2, L
Market towns, 500-10000 people	2, U	2, U	4, L	2, U
City A	4, U	3, U	2, L	1, L

Ratings: 1 = Large or very important, 5 = Trivial

L = Likely U = Unlikely

Sector Characteristics, Incl. non-Climate Factors

- **Population growth**
- **Urbanization (rural and urban settlements, industrial and non-industrial)**
- **Technology in sector**
 - Buildings**
 - Waste management**
- **Agricultural sector actions**
- **Government land actions and development activities**

Climate Factors

- **Water availability (pattern of precipitation, recharge)**
- **Temperature (high, lows)**
- **Humidity**
- **Sea level**
- **Variation in all of the above**
- **Extreme events**

Impacts and Ranges of Sensitivities to Climate Change

- **Energy demand (res., comm., govt.) and supply systems**
- **Landslides**
- **Waste management possibilities (air, water, land)**
- **Health effects**
- **Infrastructure loss or replacement required**
- **Insect migration**
- **Population relocation (weather events, agr. prod., desertification)**
- **Infiltration of sea water**
- **Water availability, pollution**

Adaptive Responses

- **Improved sanitation programmes; inoculation; improved health services health and relief services emergency response; improved pollution control,**
- **Fire suppression/management**
- **Pest suppression/management**
- **Ocean flood barriers; flood plain management**
- **Immigration/emigration controls**
- **Economic redevelopment/dislocation programmes**
- **Building codes for wind/flood/fire protection**
- **Water supply and waste management**