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THE AS25 PROJECT: METHODOLOGIES AND RESEARCH ACTIVITIES

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ABSTRACT: This paper presents an integrated assessment (IA) approach that integrates climate change impact assessment/vulnerability identification, adaptation option evaluation, and multi-stakeholder participation. The integrated approach was designed for the project titled "Integrated Assessment of Vulnerabilities and Adaptation to Climate Variability and Change in the Western Region of China" (AS25 project) which is a sub-project of the Assessments of Impacts of and Adaptation to Climate Change in Multiple Regions and Sectors (AIACC). The IA approach has been applied in the Heihe River Basin of China for identifying desirable adaptation options to reduce climate change vulnerabilities. The case study provides some articulation on how the integrated approach can provide an effective means for climate vulnerability assessment and the synthetic evaluation of the general desirability levels of a set of adaptation options through a multi-criteria and multi-stakeholder decision making process. Thus, the case study contributes to the science on climate vulnerability assessment and adaptation option evaluation.

Key words: climate vulnerability, adaptation policy evaluation, integrated assessment, AS25 project, AIACC, Heihe River region, China

1. Introduction

The Assessments of Impacts of and Adaptation to Climate Change in multiple regions and sectors (AIACC) is a global project funded by the Global Environmental Facility (GEF) and implemented by the United Nations Environment Programme (UNEP), for enhancing the scientific and technical capacities in developing countries to assess the impacts of climate change, and to design cost-effective adaptation response options, which are needed to formulate national adaptation policy options and prepare national communications. The AIACC decided to fund a number of studies assessing the impacts of climate change on a range of socio-economic sectors and ecological systems at the regional and national scale and the development of a range of adaptation response options.

In response to a "Call for pre-proposals for Regional or National Assessment Projects" distributed by AIACC in early 2001, a pre-proposal was prepared by the author and submitted to AIACC. Approximately 50 out of 150 project teams whose pre-proposals best met the evaluation criteria were invited to submit full proposals. A full proposal entitled "Integrated Assessments of Vulnerabilities and Adaptation to Climate Variability and Change in the Western Region of China" (AS25 project) was submitted and was selected for an award by AIACC. After a long delay by the Chinese GEF Office, the AS25 project eventually received the Chinese government's endorsement and held its first team and Steering Committee meeting on 25 November 2003 in Beijing, China.

2. Brief Description of the AS25 Project

The purpose of the project is to develop an integrated assessment (IA) approach for identifying regional vulnerabilities to climate variations and change, and for prioritizing adaptation options to deal with climate change vulnerability. The IA will be used to examine societal vulnerabilities to climate variations and change, and to evaluate alternative adaptation options for alleviating vulnerabilities in Western China. The IA can provide a research framework that integrates climate change scenarios, socio-economic scenarios, current climate vulnerability identification, climate change impact assessment, sustainability indicator specification, adaptation option evaluation, and multi-stakeholder participation. The IA can provide an effective means for the synthetic assessment of climate vulnerabilities and evaluation of the general performance levels of a set of adaptation options through a multi-criteria and multi-stakeholder decision-making process. Thus, the research will contribute to science on regional vulnerability assessment and adaptation evaluation. In particular, the study attempts to:

- design an integrated assessment (IA) approach to identify the societal vulnerabilities to climate change scenarios (focus will be on food supply, water shortage, land use conflicts, and ecosystem health);
- use the IA capacity to assess current and future climate vulnerability and risks, and to prioritize a number of adaptation options that could be undertaken to reduce vulnerabilities associated with climate variation and change in the Heihe River regions of China;
- facilitate the participation of regional stakeholders in climate change vulnerability and adaptation option studies;

- suggest desirable and practical adaptation options and/or policies to handle climate change impacts effectively and to ensure sustainable development;
- train and enable scientists in the region to design and apply IA methods in a real world context; and
- prepare a final report of the project and publish at least ten peer-reviewed journal articles to provide scientific information to other parts of the world.

Western China includes predominantly arid and semi-arid areas in the north and is dominated by mountains in the south. With barriers such as extremely fragile ecological conditions, fewer financial resources, poorer infrastructure, lower levels of education, and lesser access to technology and markets, the region has been suffering from climate variations and will experience severer impacts of climate change on food production, water resources, and ecosystem health. Moreover, the region's adaptive capacity is lower than in the coastal region of China. People in the Western region are facing substantial and multiple stresses, including rapidly growing demands for food and water, large populations at risk to poverty and infectious diseases, degradation of land and water quality, and other issues that may be amplified by climate change.

In Western China, the extremely limited water and land resources have to provide a number of competing users with a range of different and often conflicting functions to meet their demands. While the demands for water and land resources increase dramatically as population and economic grow, the availability and the inherent functions of water and land resources are being reduced by climate variation and change, water pollution, salinization, rapid urban expansion, and environmental degradation. Unsustainable resource uses have created a sharp decline in natural resource availability and increase in water and land use conflicts. Water shortage, already a problem in northern China, may be exacerbated by climate change.

Under climate change conditions, periods of drought are likely to become more frequent and severe, and water shortages may increase water use conflicts. Land degradation problems and limited water supplies restrict present agricultural production and threaten the food security of the region. Climate change may cause negative impacts on food and fibre production in the region. In addition, decreases in water availability and food production would lead to indirect impacts on human health.

The project will enhance the regional capacity of integrated assessment (IA). Science capacity building is a primary concern of the project. The regional climate change impact and adaptation study has been undertaken by local scientists in partnership with U.S.A. and Canadian experts. This can improve local scientific capacity and provide expertise available in Canada and the U.S.A. The expected study results will include a digital database containing better socio-economic and ecological data, capacity building training, information to improve decision making, publications and IA tools that can be used in other regions in China or elsewhere.

3. The Integrated Assessment (IA) Approach

The study is built on many years of research experience of the investigators in integrated climate change impact and adaptation studies in the Georgia Basin (Yin, 2001), the Mackenzie River Basin (Yin and Cohen, 1994; Yin et al, 2000), and Great Lakes Basin in Canada (Qi et al, 2000), the Western China region (Kang et al, 1999; Kang, 2000), Yangtze Delta (Yin et al, 1999; Yin et al, 2003; Yin, forthcoming) and other regions in China (Cheng, 1997; Shi, 1995; Yin and Wang, 2004).

The IA approach is consistent with the Intergovernmental Panel on Climate Change (IPCC) Technical Guidelines for Assessing Climate Impacts and Adaptations (Carter et al., 1994), and takes consideration of research directions suggested by the UNDP-GEF (2001) Adaptation Policy Framework. The IA approach combines computer modelling and non-model based methods including a series of training workshops, survey, expert judgement, community engagement, multi-stakeholder consultation, applications of ecological simulation modelling, geographical information system (GIS), remote sensing, multicriteria decision making (MCDM), as well as methods suggested by the Technical Committee of AIACC. In particular, the project will address the following questions:

1. How vulnerable is Western China to current climate variations and future climate change in some key sectors?
2. What can the vulnerabilities of these key sectors to present climate variations teach us about future vulnerability? and
3. What are the desirable adaptation options to deal effectively with future climate changes?

The IA framework facilitates the participation of regional stakeholders in the whole IA process. Workshops have been undertaken by as many local scientists as possible. In partnership with scientists from North American universities and institutions, the project can provide valuable assistance to enable local scientists to conduct high quality research in integrated assessment. Figure 1 shows the general approach of the study.

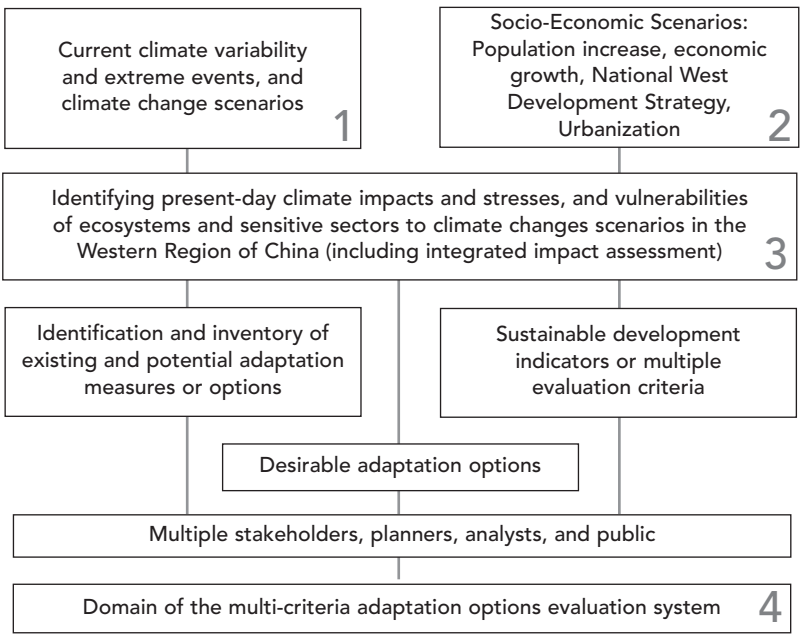

FIGURE 1

Flow-chart showing the research structure of the proposal

3.1 Climate Variation and Change Scenarios (STEP 1)

In identifying present-day climate risks, and conducting the climate change impact assessment and adaptation option evaluation study, existing climate variation patterns and future climate change scenarios need to be specified to examine their economic, social, and environmental impacts. In developing climate change scenarios, the study identifies a set of baseline assumptions and conditions. Thus, climate change scenario specification for this study represents the possible future climate conditions under various assumptions.

Ding (2001) and his research group have been developing a regional climate model (Ncc/RegCM2) nested with a coupled GCM (NCCT63L16/T63L30) and Hadley Center model (HadCM2). The research team is part of the AS25 project responsible for providing climate change scenarios.

3.2 Socio-Economic Scenarios (STEP 2)

Changes in socioeconomic conditions, such as population, income, technology, consumption rates, and China's new Western Region Development Strategy, have been taken into consideration in developing baseline socio-economic scenarios. Various methods have been used to set future population increase and economic growth scenarios. AIACC suggests that the IPCC Special Report of Emission Scenarios (SRES) scenarios be used as the basis for creating future socio-economic scenarios. Chinese government development strategies and plans will be reviewed to collect additional data for socio-economic scenario design. To improve quality of scenarios, workshops and community consultations with multi-stakeholders in the region have been held to identify regional concerns related to socio-economic scenarios. Those economic sectors (agriculture, water and land resources, and fragile ecological systems) sensitive to climate change in the region are included in the integrated assessment.

3.3 Identifying Present-day Climate Impacts and Vulnerabilities to Climate Change (STEP 3)

Step 3 can be further divided into two parts. While Part One examines present-day climate impacts or stresses of various key sectors in the region, Part Two identifies societal vulnerabilities to future climate change scenarios. In particular, the vulnerability assessment examines the effects of climate variations and change scenarios on food supply, water shortage, land use conflicts, and ecosystem health.

Results of Part One of Step 3 will establish a baseline set of measurements and observations that can be used to measure progress toward reducing vulnerability to future climate change. Once these vulnerability measures are identified for each economic, ecological, and social vulnerability indicator, they can be applied to project potential vulnerabilities of the sensitive sectors to future climate change scenarios. Thus, the research on present vulnerabilities and adaptive capacities of human and ecological systems will provide insights into potential impacts and vulnerabilities associated with future climate change. A set of existing adaptation options to deal with

current vulnerabilities to climate variations and extremes will be identified for current adaptation capacity evaluation.

3.4 Domain of the Multi-criteria Adaptation Options Evaluation System (STEP 4)

There is an evident need for new research approaches and tools that are able to evaluate alternative adaptation strategies or policies, which many impact assessment methods are not appropriate to do. IPCC (2001b) suggests a list of high priorities for narrowing gaps in vulnerability and adaptation research. Among them is to integrate scientific information on impacts, vulnerability, and adaptation in decision making processes, risk management, and sustainable development initiatives. In this respect, Step 4 focuses on methodology development to link impact assessment with sustainability evaluation assisted by multi-criteria policy analysis and multi-stakeholder consultation in Western China. Main tasks of Step 4 include: 1) the sustainability indicators identification, 2) multi-stakeholder consultation, and 3) adaptation policy evaluation.

4. Implementation of the AS25 Project

4.1 The First Meeting of AS25 Project Committees and Research Team

The first meeting of the AS25 Project Steering Committee (SC), Expert Committee (EC) and research team was held on 25 November 2003 at the Chinese National Climate Center in Beijing, China. SC members were briefed about the project progress. After hearing reports of the status, work plans, and research activities for each research groups, SC and EC members made some constructive comments and suggestions to the project team. The meeting agreed that the AS25 project was an innovative and special project with clear thoughts of research. The expected research delivery may support Chinese government international activities in global climate changes and provide strong scientific support for the 4th IPCC Assessment Report.

4.2 Climate Change Scenario

The climate change scenario setting in 50 years over Western China has been conducted by the National Climate Center (NCC) of the Chinese Meteorological Administration (CMA) using the model simulation results provided by the IPCC data distribution center. Climate scenarios for this study focus on temperature and precipitation projection under various IPCC socio-economic scenarios (IS92a and SRES). Meanwhile, the simulation experiments

have been conducted using the global atmospheric-oceanic coupled model of China National Climate Center (noted as NCC/IAPT63) under the SRES A2 and B2 scenarios. The purpose of the simulation is to analyze the climate change over Western China, especially in the Northwestern China and the Tibetan Plateau region. Some simulations have been conducted to provide a scientific base for estimating the melting of permafrost zone where the Qinghai-Tibetan railway will be constructed. The global climate model results have also been processed to provide the initial and boundary fields for climate prediction in Northwestern China with a regional climate model (RCM). Up to now, the ten-year control run and hindcast experiments have been completed with the regional climate model. The simulation of using variable vegetation and the study of vegetation change impact on the climate in Western China using the RCM are still under way. In addition, the study will combine dynamical downscaling results with a statistical downscaling strategy to get more reasonable results.

Based on results of seven GCMs used in the IPCC (2001a) Third Scientific Assessment Report and the NCC/IAPT63 model, the study estimates climate change over Western China during the 21st century. The results show that the temperature will increase continuously with the increase of atmospheric greenhouse gas (GHG) concentrations, but the magnitude of temperature increase is larger than that in Eastern China. The precipitation will have an increasing trend for the next 100 years, especially in Western and Northwestern China, while the increase is not so obvious in Southwestern China. The simulation results were used to set future climate change scenarios for the Qinghai-Tibet region in the next 100 years. Variation of the mean temperature, precipitation and maximum and minimum temperature at stations along the Qinghai-Tibetan railway line is of particular interest.

Considering the uncertainty of the GCM output, especially in precipitation projection, further scenarios study has been carried out using both GCM and RCM results. In particular, dynamical downscaling simulation using RCM with the boundary conditions provided by the global model will project various episodes in 21st Century. Downscaling results will be used as input for a hydrological model to simulate a future hydrological cycle over Western China. In addition, climate change scenarios from the RCM will be used for impacts and vulnerability assessment of the AS25 project.

4.3 Climate Vulnerability and Impact Assessment

Assessment of current resource system vulnerability and analyses of social, economic, and environmental impacts (negative and positive) of alternative climate change scenarios for different economic sectors have been undertaken for key sectors that are sensitive to climate change. In vulnerability and impact assessment, expert judgement, vulnerability indicators, and various crop models, ecological simulation or statistical models, GIS, developed for other climate impact studies and for studies in Western China have been employed to identify the impacts of climate change scenarios (Yin and Wang 2004; Yin et al., 2003; Yin et al., 2000; Yin et al., 1999; Kang et al., 1999; and Cheng, 1997).

The main goal of vulnerability assessment is to develop effective methods to measure vulnerability and to assess the environmental risks in dealing with climate stresses. In this study, several major factors that influence resource system vulnerability in the Heihe River region of China will be considered. In other words, resource vulnerability is a function of these factors including: climate, economic activities in the region, land users, size of resource use activities, resource use efficiency, the price elasticity of supply and demand, environmental protection, policy options (economical, technical, or policy), lifestyle associated with income increasing, and population growth.

The vulnerability assessment focuses on methodology development for estimating land and water system vulnerability. The study adopts approaches for the formulation of indicators for agricultural land and water resource system vulnerability to climate variation and change. Indicators are selected in relation to their specificity, descriptive power, thresholds, and capacity for geographic allocation using ancillary or modeled data. Each system is addressed individually, with a description of applicable indicators, literature references, and geo-spatial data requirements for the mapping of the indicators.

Data required include meteorological, hydrological, soil, prices of products, costs of production, average yields, areas of different types of land, water supply and demand, erosion, desertification and salinization rates, pollutant emission rates, and other impacts data. The data collected also have spatial and temporal dimensions. The model variables and parameters differ among sub-regions, and vary between the present and the future (changed climate condition). Thus, the database consists of information for each land unit

under both current and future conditions. Remote sensing image processing technology will be used for collecting and updating land cover and land use information. Specific computer software technologies for satellite image processing will be employed to extract, enhance, and classify digital images (Gong et al., 1999; Qi et al., 2000; Gong, 2000).

One task of the study is to determine whether alternative adaptation options or policies can lead to a reduction in damages or taking advantage of opportunities associated with climate change. The adaptation evaluation in this study will apply two approaches. The first approach examines the effectiveness of alternative short term or autonomous adaptation options by using impact assessment modelling (Carter et al., 1994). Another approach deals with anticipatory or planned adaptation strategies and government policies. And thus the tools used for the second approach are related to policy evaluation or analysis (Stratus Consulting Inc. 1999). The first approach will be associated with impact assessment. Impact assessment models will be run with different climate change scenarios coupled with or without certain adaptation options. Results generated from climate impact assessment will be used for public consultation and adaptation evaluation processes.

The following sections present the importance of indicator setting in adaptation evaluation research and the approach to identify indicators. Then, the IA system assisted by analytic hierarchy process (AHP), a multi-criteria decision making (MCDM) technique, is introduced to illustrate how sustainability indicators and climate change vulnerabilities can be represented in the analytical system to link climate change impacts, adaptation, and regional sustainability evaluation.

4.4 Adaptation Policy Evaluation

A set of existing and possible adaptation options to deal with vulnerabilities of climate variation and change will be identified for multi-stakeholder consultation and multi-criteria evaluation. An inventory of existing and potential adaptation options will be developed. The options inventory will include descriptions of the options and relevant information. Numerous potential adaptation options are available for dealing with vulnerabilities to climate change. An initial screening process will be conducted to reduce the number of options for further detailed evaluation. The multi-stakeholder consultation will help to arrive at a collective group recommendation on the selection of adaptation options for further multi-criteria evaluation.

4.4.1 Design Indicators to Measure Regional Sustainability

The research procedure follows with an identification of sustainability indicators. In this study, indicators are evaluation criteria or standards by which the effects of climate change and/or the efficiency of alternative adaptation options can be measured. Indicators of the economic, social, and environmental dimensions of regional sustainable development (RSD) will be identified. Successful implementation of the sustainability concept will require new approaches that link the climate change impact assessment and the sustainability evaluation. Thus, sustainability goals and indicators must be set and impacts of climate variation and change on these indicators must be identified.

There are several general frameworks that can be adopted for developing sustainability indicators. The first is a domain-based framework that groups indicators into three main dimensions of sustainability (economic, environmental, and social). The three-dimensional nature of sustainability and the need to make trade-offs (e.g. between economic growth and environmental quality) require maintaining these three components in a dynamic balance. Sustainability indicators thus, should include economic, social, and environmental information in an integrated manner. Another important framework is a goal-based indicator system. Goals usually reflect the major development concerns of a nation or a region. For example, some concerns represent national or regional objectives of economic viability, maintenance of the resource base, and minimizing the impacts of climate change on natural ecosystems. Each goal is composed of a number of attributes or indicators that are measurable by using existing sources of information in most cases. Other types of indicator frameworks include sector-based, issue-based, cause-effect, and combination ones. No single indicator would be sufficient enough to determine sustainability or non-sustainability of a region or a system. A set of goals and/or indicators is required in sustainability evaluation. Notwithstanding the risks in using aggregated indicators, there are also risks in using too many indicators.

4.4.2 Multi-Stakeholder Consultation and Multi-Criteria Evaluation of Adaptation Options

Multi-criteria options evaluation (MCOE) of adaptation measures is one of the major components of the study. The MCOE will be used to identify desirable adaptation measures by which decision makers can alleviate the vulnerabilities and to take advantage of positive impacts associated with climate change in the region.

To select desirable measures among alternatives, multi-stakeholder consultation (MSC) and MCOE will be used to relate impact information to decision making requiring subjective judgement and interpretation. In this study, alternative options will be evaluated by relating their various impacts to a number of relevant indicators. The results of various impacts generated in the previous step will be used as references for ranking the performance of each adaptation option against each sustainability indicator. These indicators are used as multi-criteria by which the strengths and weaknesses of the various adaptation options can be evaluated. The analytic hierarchy process (AHP) developed by Saaty (1980), a multi-criteria decision making (MCDM) technique, will be adopted to develop an adaptation evaluation tool to identify the priorities of sustainability goals/indicators, and to rank desirability of adaptation options (Yin, 2001).

The approach AHP takes is to ask stakeholders to determine his/her preference between two options of how it contributes to each criterion (sustainability indicator) given certain impacts of the options. In this exercise, a stakeholder compares two options at a time (pairwise comparison). Then stakeholders will specify their judgements about the relative importance of each option in terms of its contribution to the achievement of the overall goal. That is, in our case, to alleviate the adverse consequence of climate change. It is expected that the AHP method will provide an effective means for the synthetic evaluation of general performance levels of alternative adaptation options based on a multitude of evaluation criteria. The result of the AHP is a prioritized ranking indicating the overall preference for each of the adaptation options.

Yin (2001) developed an IA approach, assisted by AHP, to evaluate a number of adaptation options that could be undertaken to reduce vulnerabilities associated with climate change in the coastal region and communities of Georgia Basin (GB) in Canada. The AHP application in the GB study included a series of workshops and internet based surveys with participation of a broad range of public and private stakeholders, and policymakers from different affected sectors to identify sustainability indicator priorities, as well as a series of desirable adaptation policies. The AHP facilitated the participation of regional stakeholders in climate change impact and adaptation option evaluation. Results of the AHP analysis are presented in the project final report (Yin, 2001).

5. Capacity Building and Stakeholder Participation

The project has been building committed partnerships with multi-stakeholders in the process of the project. An essential part of the stakeholder engagement strategy is the establishment and participation of the Chinese Steering Committee (SC) and Expert Committee (EC) consisting of key government agencies and experts responsible for China's international cooperation on climate change issues and national communications. The Chinese agencies and experts in SC and EC are also playing important roles in coordinating AS25 activities with other international collaboration projects in China (Canada-China Cooperation in Climate Change, C5 and UK-China projects). The C5 project is funded by the Canadian International Development Agency (CIDA) under the Canada Climate Change Development Fund. The UK-China joint project focuses on assessing potential impacts of climate change on Chinese agriculture.

The IA approach requires multi-stakeholder participation, and thus workshops, survey, and community engagement methods have been employed to involve multiple stakeholders, policymakers, and experts in the project implement process. An internet website of the AS25 was established to provide an effective way to reach a large number of stakeholders, and can be found at http://210.28.133.139/AIACC/website/index.htm.

To engage stakeholder and provide capacity building, individuals have been contacted and workshops have been held aimed to improve local policy makers and scientists' knowledge on climate vulnerabilities and adaptation capacity. For example, a workshop and training was organized in August 2002 at Lanzhou, China. At the workshop, a team of interested parties developed a conceptual integrated assessment framework. Through presentations by researchers and stakeholder representatives and group discussion, the workshop reached a common understanding regarding the methods among the investigating partners, and the stakeholders. The workshop-training course enabled local scientists and stakeholders to have a better understanding of integrated assessment and policy evaluation. Main contents covered in the training course included climate change, resource use conflicts, IA methodologies, economic analysis methods, multi-criteria decision making techniques, multi-stakeholder consultation, sustainable development, and gender and equality issues.

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