Beyond Building Models:
Using WEAP to inform climate change adaptation policy in Guatemala

Sarah Harris
Goldman School of Public Policy
University of California, Berkeley

May 9, 2007

The author conducted this study as part of the program of professional education at the Goldman School of Public Policy, University of California at Berkeley. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgments and conclusions are solely those of the author, and are not necessarily endorsed by the Goldman School of Public Policy, by the University of California or by any other agency.

Acknowledgements

I would like to thank the Stockholm Environment Institute for offering me the opportunity and the financial assistance to conduct this research. This paper was prepared for the Advanced Policy Analysis (APA) requirement for the Goldman School of Public Policy Master's degree from the University of California, Berkeley. I would especially like to thank David Purkey of SEI-US and Sebastian Vicuña of UC Berkeley for their guidance and advice. The author is also grateful to the PNCC team in Guatemala for their assistance during the author's site visit to the country in February of 2007. Thanks especially to Ing. Carlos Mansilla, Ing. Jeffrey Rivera, Ing. Claudio Castañón, and Inga. Mercedes España. Finally, I am thankful to GSPP Professor Gene Bardach for his insightful questions and comments throughout the process.

Figure 1: Antigua, Guatemala

Table of Contents

Abstract 4
Introduction: The Problem 5
WEAP can predict the effects of climate change on water resources 7
Accounting for climate change in water resource models 7
WEAP modeling in Guatemala 8
Involving stakeholders in the adaptation policy dialogue 11
Raising public awareness about climate change 11
Motivating stakeholders to adapt 12
Building trust in PNCC 13
Accepting the model as an analytic tool 15
Using WEAP to inform adaptation policy-making 17
Guatemala's legislative framework 17
Finding the right policy processes for WEAP results 18
Policy outreach recommendations 20
Summary of Recommendations 22
References 25
Appendix A: Project Background 27
Appendix B: Climate Change Outreach Posters from Peru 28
Appendix C: Sketch of Proposed "Storyboard" 29
Appendix D: Proposal of Measures for Adaptation to Vulnerability 30
Appendix E: Suggested Adaptation Strategies by Policy Category 33

Abstract

Guatemala's National Program on Climate Change is assessing the vulnerability of the country's water resources to climate change using a techno-scientific hydrologic modeling system called WEAP. The ultimate goal of their work is to develop adaptation strategies that will help Guatemala cope with the predicted impacts of climate change. This document recommends outreach strategies that will help ensure that the results of the hydrologic modeling work are used to inform stakeholder dialogues and the adaptation policy-making process. After describing WEAP and its capacity to inform decision-making, this document reviews the literature on the use of techno-scientific models in participatory decision-making processes to identify common pitfalls and best practices. The document also analyzes Guatemala's existing water policy framework to recommend appropriate cross-sector policy collaborations.

Introduction: The Problem

The *Programa Nacional de Cambio Climatico* (PNCC), a program within the Environment Ministry of Guatemala, is charged with assessing the risks of climate change in Guatemala and recommending steps the government can take to reduce the country's vulnerability to these risks. PNCC has chosen to focus on Guatemala's water resources, and is using an innovative software system called WEAP (Water Evaluation and Planning System) to model the hydrologic impacts that a changing climate will have in two of the country's river basins. The developer of the software, an international organization called the Stockholm Environment Institute, is providing technical assistance to PNCC as the team works to develop accurate hydrologic models. The Dutch government is funding the project through an NGO in the Netherlands called ETC International, and is interested not only in accurate hydrologic models, but also in *ensuring that the information developed by the models is used to improve adaptation policy-making*. This document is the policy component of the technical assistance provided by SEI-US, and suggests both a public and institutional outreach strategy that will help ensure that the project's policy goals are met.[1]

In the broadest sense, the overall problem is that global climate change will negatively affect Guatemala's water resources. With rising global temperatures, the already dry regions of Guatemala will experience longer and more intense spells of drought. On the other hand, already wet regions in Guatemala may experience stronger and more frequent hurricanes, storms, flood events, and landslides. The country's recent experiences with a severe drought in 2001 and Hurricane Stan in 2005 demonstrated that government institutions and existing infrastructure are ill-prepared to handle these types of natural disasters today.[2] Even the United States, considered a wealthy and advanced country, was not adequately able to cope with Hurricane Katrina in 2005. With greater levels of poverty, weaker government institutions and far fewer resources than the U.S., how can Guatemala be expected to rebound from the increasingly frequent and more intense natural disasters that climate change could bring?

Building the necessary governmental capacity, infrastructure, and community resilience to deal with environmental change is not only prohibitively expensive for a developing economy like Guatemala, but also politically risky. Politicians will not be able to justify their expensive actions in the face of great uncertainty without some sort of credible and trustworthy evidence of the threat that climate change poses. PNCC's work in projecting the impacts of climate change and in educating the public about the subject might reduce the perceived riskiness of taking political action, thus increasing politicians' willingness to make these difficult resource allocation choices.

The WEAP analysis will project how climate change might affect water resources in order to understand what types of adaptation policies would be most likely to reduce the country's vulnerability. PNCC is modeling two river basins, one prone to flooding and the other prone to drought. Once built, the WEAP models can be used to predict the water availability and quality

[1] More project background can be found in Appendix A: Project Background.

[2] Hurricane Stan hit Guatemala's west coast in October 2005, affecting 1/3 of the national territory with flooding and landslides. The storm directly affected almost half a million people and demonstrated high levels of food insecurity as many of those affected were subsistence farmers whose livelihoods were destroyed (Perfil Ambiental 2006).

outcomes of various scenarios, such as increased population, the construction of new infrastructure, or the implementation of a new policy.

Beyond simply constructing hydrologic models, however, PNCC's objective is to inform policy dialogues at the local and national levels. Climate change is an issue that affects multiple sectors, so the adaptation policy-making process will have to be a collaborative one. At a minimum, Guatemala's environment, agriculture, and disaster planning institutions will be involved in this process, as they all have a stake in the management and use of the country's water resources. The entire effort, therefore, will take far more work than just the construction of the models; PNCC also needs a strategy for outreach and for the incorporation of WEAP into existing policy-making processes.

After describing WEAP and its capacity to inform decision-making, this document reviews the literature on the use of techno-scientific models in stakeholder-based decision-making processes to identify common pitfalls and best practices. The document suggests public outreach strategies as well as appropriate cross-sector collaborative efforts. Methodology involves both a review of the literature and an analysis of Guatemala's existing water policy structures.

Figure 2: A Guatemalan weaver

WEAP can predict the effects of climate change on water resources

A water resource model is a conceptual representation of an actual water system that allows us to explore how the system might change in response to a range of assumptions. Because models are conceptual, they are not able to predict exactly what will happen under various proposed scenarios, but instead allow the modeler to compare the outcomes of different scenarios to each other. For example, scenarios might include different assumptions about population growth, the adoption of new technology, changes in the economy, the construction of infrastructure, or the implementation of new environmental regulations. Typically, one scenario is developed based on business as usual assumptions, which provides a point of reference against which other scenarios can be compared (Purkey, personal communication).

Accounting for climate change in water resource models

Commonly, inputs to water planning models include historic data on water supplies, such as streamflow and groundwater recharge, and water demand, such as urban consumption and irrigation. This type of model compares the impacts of various scenarios by assuming that the timing, magnitude and duration of historic hydrologic patterns remain stationary. Because the historic hydrologic data is used as model input, a standard model of this kind would be capable of comparing the outcomes of different scenarios in terms of water availability and/or quality, but wouldn't be able to account for a changing climate (Purkey, personal communication).

The challenge with modeling climate change is that scientists expect climate change to alter hydrologic patterns. Climate change could result in more or less rain, changing temperatures, and rising ocean levels. These variables will alter the hydrologic cycle, which will change hydrologic patterns on the ground where water resource management decisions are made. Adding climate change into the picture renders inadequate the use of historic hydrologic patterns as input.

WEAP (Water Evaluation and Planning) is a unique water resources planning software system that allows the modeler to account for a changing climate through an internal rainfall run-off module which simulates hydrologic patterns based on climatic input. This ability to include climate change in the development of future scenarios makes it a potentially powerful tool for informing climate adaptation policy-making (Purkey, personal communication). As opposed to historic hydrologic inputs, WEAP uses inputs such as precipitation, temperature, humidity, and wind speed. These inputs can be derived from global climate change scenarios, and are used to calculate how much of the precipitation that falls in a particular area ends up as run-off into streams, recharge to groundwater, or evapotranspiration through vegetation. With this capability, the WEAP user can build scenarios that assume, for example, higher temperatures or heavier rainfall, along with assumptions about water demand, infrastructure, and environmental regulation. These human activities are the elements that can be adapted in the future in response to climate change. For example, we might model a scenario with restricted water demand to try to minimize the predicted water shortage or improve the predicted water quality.

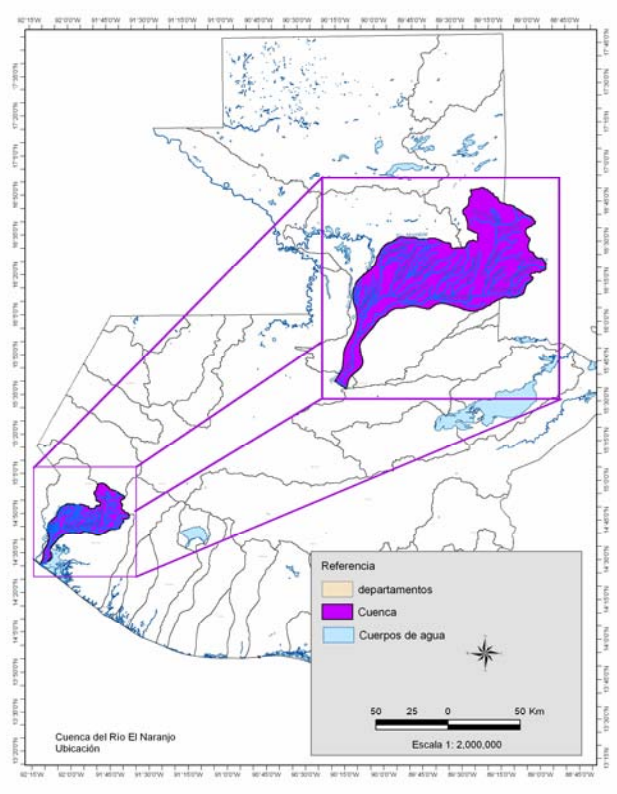
WEAP produces results that demonstrate whether water demand is met during a particular month, the degree of water shortage if there are shortfalls, levels of storage in reservoirs for future use, and measures of water quality. WEAP also assesses the sufficiency of environmental water flows, the

level of hydropower generation capacity, and the evolution of soil moisture, evapotranspiration rates, surface run-off volume, and the rate of groundwater recharge (Purkey, personal communication).

WEAP modeling in Guatemala

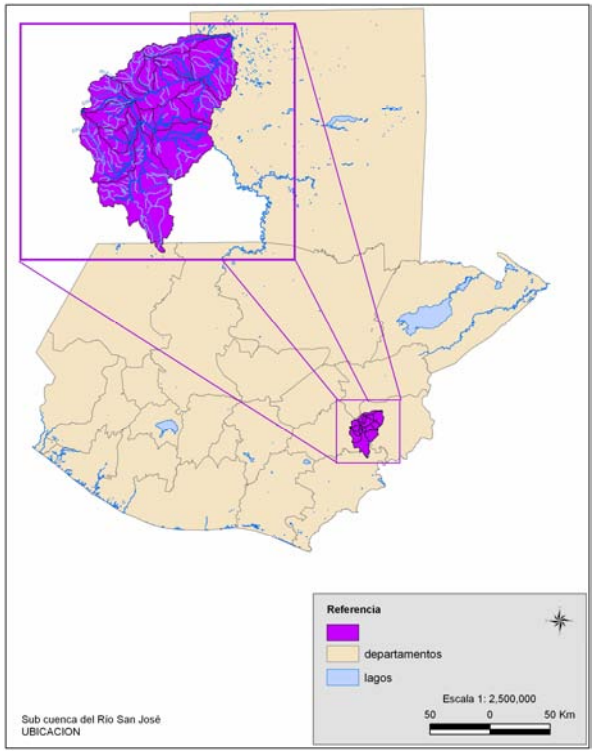
PNCC analysts began building WEAP models for two river basins in Guatemala in late 2006.[3] Two influential events that affected the choice of these particular basins were a severe drought in 2001 that disturbed crop productivity and Hurricane Stan in 2005, which caused flooding, landslides, and casualties. The two basins chosen are representative of Guatemala's varied climate as characterized by these two events: one is prone to drought (San Jose), and the other is prone to flooding (Naranjo).

Although most precipitation falls during Guatemala's six-month rainy season from June to September, rainfall patterns in the country vary greatly based on elevation and distance from the ocean (Situación del Recurso Hídrico 2005). The portion of the Sierra Madre mountain range that runs west to east on the Pacific side of Guatemala captures most of the moisture as it moves in from the ocean, so the Naranjo basin on the west slope of the highlands is typical of the wetter side of the country. The San Jose basin, east of the highlands, is typical of the semi-arid region of the country. Figures 3 and 4 below are maps of Guatemala highlighting the location of the river basins currently being modeled by PNCC.



Source: Ing. Jeffrey Rivera, PNCC

Figure 3: Location of Naranjo River basin



Source: Ing. Jeffrey Rivera, PNCC

Figure 4: Location of San Jose River basin

[3] See Appendix A: Project Background for more information on how PNCC chose to use WEAP.

PNCC analysts are primarily using data collected by INSIVUMEH,[4] the national hydrologic research institute (Castañón, personal communication). They expect to have their first round of preliminary results by the end of May 2007 (Vicuña, personal communication). Screen captures of the WEAP models under development are shown below in Figures 5 and 6. The blue lines represent streams and rivers, red dots represent demand sites, green dots represent catchements where rainfall run-off routines are used to simulate river flow, groundwater recharge, and evapotranspiration, and the arrows refer to the direction of water transmission, either to or from the river.

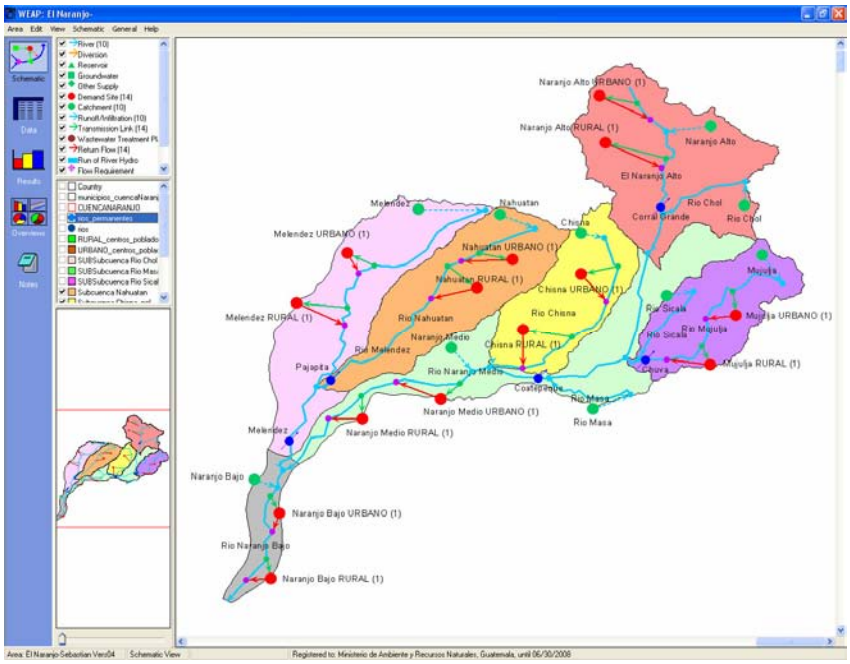


Figure 5: WEAP model of Naranjo basin

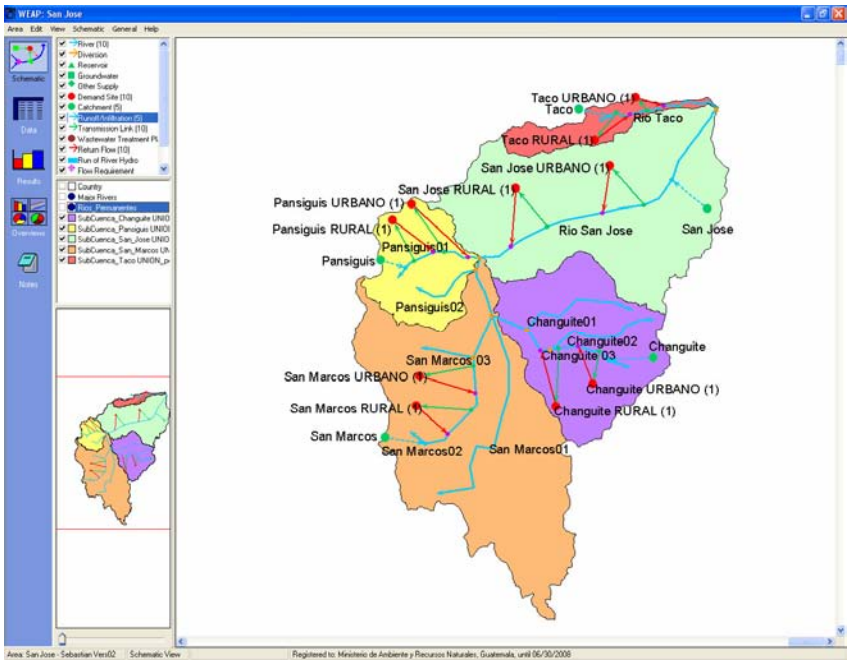


Figure 6: WEAP model of San Jose basin

[4] INSIVUMEH stands for Instituto Nacional de Sismología, Vulcanología, Meteorología, e Hidrológica.

Beyond the construction of accurate models, one of the challenges facing PNCC analysts is to establish the credibility and legitimacy of the WEAP model and its output as information that can be used to support decision-making. Another challenge for PNCC is to determine how to focus its limited time and effort in order to most wisely support the development of adaptation policy at the national level. The remainder of this report focuses on offering recommendations on how to accomplish these two goals.

Involving stakeholders in the adaptation policy dialogue

While WEAP is a technical tool that can predict the effects of climate change on water resources, simply building the tool will not result in an adequate outcome. The modeling tool is only one of many components needed to reduce Guatemala's vulnerability to climate change. The most basic component needed to achieve the overall goal is public awareness and education about climate change. Once people know about climate change, they need to be motivated to adapt to the threats climate change poses. A third component is trust in PNCC and its analysts. The last necessary component is acceptance of the modeling tool as an unbiased and accurate analytical device. These steps are all inter-related and therefore recommended strategies to accomplish one component often affect the others.

Raising public awareness about climate change

A major obstacle in Guatemala to environmental protection and the sustainable use of resources has been a lack of environmental awareness among the public, and especially among the poor and undereducated. Therefore a main goal of the country's National Environmental Education Policy is to raise consciousness about environmental issues and to create a culture of respect and appreciation for the ecosystem and natural processes.[5] To raise public awareness and initiate public dialogue about climate change, PNCC should be aggressively proactive in informing Guatemala's population about its work. People will begin to care about climate change when they understand how increasing temperatures and changing rainfall patterns can affect individual livelihoods and the frequency and intensity of natural disasters. By educating the public about climate change and its possible effects, PNCC will also increase public pressure on governmental officials to act in proposing adaptation measures.

Efforts to raise public awareness about climate change in other countries can inform PNCC about possible outreach strategies. In the Piura river basin in Peru, 120 stakeholders from four regions and 36 municipal governments developed an outreach campaign to familiarize people with climate change. The campaign's slogan read: "The climate is changing; so should we." The slogan appeared in radio spots, on posters, and in the local press to reach at least 1 million people (Garcia 2006). Posters focused on how climate change might affect the individual livelihoods of local farmers and fisherman: What if there were no more mangoes? What if there were no more anchovies? Pictures of these posters are included in Appendix B.

Another effort in Peru in the Mantaro river basin focused on generating popular awareness of climate change through an aggressive press campaign. The goal of the campaign was to stimulate popular demand for the regional government to take action. Subsequently, the regional government signed a law creating a climate change technical group and developed a regional adaptation strategy (Garcia 2006).

As in Peru, PNCC should develop an easily remembered climate change slogan for all of its outreach efforts. One already proposed is "¡Actuemos ya!"[6] roughly, "Let's act already!" This slogan conveys an understanding that the climate is already changing and people need to pay attention and pressure

[5] Política Nacional de Educación Ambiental, Introducción.

[6] This slogan was discussed at the January 2007 NCAP meeting in Santa Marta, Colombia (Vicuña, personal communication).

their government to act. The chosen slogan should be employed on all of PNCC's printed outreach materials and in any radio or television outreach efforts.

PNCC could develop posters similar to the ones developed in Peru (in Appendix B) or it might decide to further develop its "storyboard" concept.[7] An image of a rough sketch of one of three proposed storyboards is included in Appendix C. The first would tell a general story about climate change in Guatemala and PNCC's work with WEAP. Another would be more technical for scientific audiences, and a third would be tailored to each river basin for specific community outreach efforts. These storyboards could be employed as posters, billboards, magazine spreads, or television advertisements, depending on the target audience and the available funding.

In addition to its technical modeling capacity, WEAP might also play a role as an educational tool. Research into the public perception of models suggests that most people consider models effective educational tools, due to a model's ability to describe complex natural systems in a simplified and visual way (Cockerill et. al. 2004). Presentations of WEAP at community meetings could result in a common understanding of the problem and its possible effects, even if people have different ideas about the best solutions. In her study of the use of WEAP in Spain's Upper Guadiana River basin, for example, Chiara Sorisi reports that environmental NGOs thought that the models could be useful in public awareness raising campaigns, mainly to achieve educational purposes (Sorisi 2006).

Motivating stakeholders to adapt

The next step beyond raising awareness is motivating local actors and government officials to want to adapt to climate change. Educating the public will help to increase pressure on government actors, but PNCC must take additional steps to increase the likelihood that change truly is made. Paul Steinberg (2003) emphasizes the importance of "transnational" actors in achieving environmental policy change in developing countries. With his spheres of influence framework, he argues that the introduction of policy is successful when international ideas and funding overlap with domestic political know-how. This most often happens due to the efforts of a transnational actor: someone who lives in the developing country and understands its complex political and social systems, but who has spent time traveling and visiting wealthy countries where he has absorbed important scientific and technical knowledge and developed financial contacts. When the right time arises for the introduction of a new policy proposal, sometimes known as a "policy window," the transnational actor is ready to present the ideas he has "translated" from abroad (Steinberg 2003).

According to this framework, PNCC needs a transnational champion to motivate policy change. This person needs to be a long-time resident of the country and be involved in Guatemala's political scene. He or she also needs to be conversant in the climate change adaptation strategies being discussed in other parts of the world and familiar with international financial mechanisms. This person is PNCC's director, Ing. Carlos Mansilla. He is "conversant in international ideas, and [has] ready access to international scientific and financial networks, but [is] at the same time deeply engaged in the domestic policy processes of [his] home country" (Steinberg 2003). Steinberg calls

[7] The storyboard idea was initiated during the January 2007 NCAP meeting in Santa Marta, Colombia (Vicuña, personal communication).

this type of person a "bilateral activist" in the sense that he works in both domestic and international spheres and is a government actor pushing for policy change.[8]

One way in which PNCC's director is actively motivating policy change is through his participation in CONRED, Guatemala's cross-sector disaster planning network. PNCC's presence at CONRED meetings increases awareness about climate change and its possible effects on natural disasters among high-ranking officials. Participating organizations include Guatemala's forest fire fighters, the agriculture ministry, the national hydrologic research institute, and the secretary of nutrition and food security. The expected effects of climate change that concern CONRED members include hotter forest fires, more floods, longer droughts, and stronger hurricanes. The transnational actor's participation helps to motivate other ministry level officials to act on the multiple threats of climate change.

Importantly, even as domestic policy-makers are beginning to pay more attention to climate change, PNCC's director must maintain his international contacts in order to keep up with scientific advances abroad and possibilities for project funding. PNCC's goals won't be achieved in a matter of a few years, so the organization needs to continue to take advantage of the funding and expertise available from international organizations such as ETS International and SEI-US.

Building trust in PNCC

We need to ensure that PNCC and its analysts are trusted to make sound recommendations for adaptation strategies. Without confidence in the organization conducting climate change research, Guatemala's community leaders and policy makers will lack trustworthy information upon which to base their adaptation decisions. Research into the public perception of models has shown that models such as WEAP are not useful when stakeholders and decision-makers don't trust the organizations that developed them. Furthermore, some researchers suggest that using models as a strategy for gaining institutional trust is not effective (Cockerill et. al. 2004). Fortunately, PNCC is a relatively well-established entity with national and even international recognition and presence.

For her Master's thesis at Oxford University in England, Chiara Sorisi conducted a study in Spain's Upper Guadiana River basin about the potential of WEAP to foster public participation in local water management decision-making. Sorisi found that stakeholders doubted the model's usefulness because they were wary of its accuracy, as it had been developed by foreigners unfamiliar with the river basin, and they questioned the reliability, transparency, and consistency of the data inputs (Sorisi 2006). Because a domestic program and not a foreign entity is building the WEAP models in Guatemala, stakeholders ought not be concerned that the modelers are unfamiliar with Guatemala and its water resources. However, PNCC analysts may be perceived as techno-scientific bureaucrats who live and work in the country's capital rather than locals from the rural river basins they are modeling.[9] Furthermore, although most of the data inputs for WEAP come from INSIVUMEH, the national hydrologic institute, one of the main concerns identified by local stakeholders at a

[8] During her visit to Guatemala in February 2007, the author witnessed Ing. Mansilla's dual domestic and international influence at a multi-country renewable energy conference. The conference brought together Central American government officials, NGOs, and European funding sources.

[9] During her site visits to the two river basins in February 2007, the author witnessed local actors questioning PNCC staff about their modeling work and data sources during a WEAP presentation.

preliminary presentation of WEAP in the Rio San Jose basin was the unreliability and inaccuracy of this data.[10] This particular concern can be addressed during the calibration phase of model building, when the model's predictions are compared to actual field data and the model's assumptions and parameters adjusted accordingly.

PNCC is aware of its status as a relatively new and little-known organization. To open lines of communication with community members, PNCC has already initiated an ongoing dialogue with local environmental leaders in both river basins.[11] To further build public trust and support, I recommend that PNCC sponsor one-day workshops in each basin for local stakeholders with the goal of public education. The topics covered should include climate change, PNCC's research into vulnerabilities and intrinsic adaptations to climate change, and their WEAP modeling work. PNCC should take care to know who its audience is so that its presentations can focus on climate change impacts and consequences of various adaptation strategies in terms that are important to each specific audience (Maguire 2003). Importantly, PNCC's analysts must avoid using scientific jargon during meetings and their intention should be to educate stakeholders rather than flaunt their expertise (Maguire 2003). During the workshops, PNCC should allow participants to use WEAP to analyze the outcomes of scenarios during the meeting, and provide the assistance of a WEAP expert. This will enhance the transparency of the process while minimizing the frustration stakeholders might experience due to lack of experience using the technology (Reitsma et. al. 1996). PNCC should encourage community leaders who express interest in WEAP to obtain a copy of the software for their own use, as it is free software for nonprofits and governments in developing countries.

Perhaps as a precursor to the workshops, PNCC should develop and publicly announce partnerships with respected local environmental organizations. These are groups that meet regularly and are already trusted by the local community to make local land use and natural resource decisions.[12] In the Upper Naranjo basin, this includes both the local representative of the Environment Ministry and a community group focused on natural resources called Mancuerna. IUCN (The World Conservation Union) is also involved in natural resource and sustainable development issues in this region. In the lower Narajo basin, Mandimu is a community group that works on environmental issues. In the San Jose basin, the groups most interested in climate change and most active in land use and natural resource planning are the local representative of the Environment Ministry and ASORECH, a local peasant/farmer's association. Other key organizations in this basin include Mujeres Campesinos, a rural women's organization, and CODEMA, the departmental environmental commission.

[10] February 13, 2007 meeting at ASORECH in Quetzaltepeque, Guatemala. Meeting participants agreed that much of the required data remains to be collected from the field.

[11] The author participated in two introductory meetings where PNCC presented its adaptation work and WEAP modeling in each river basin in February 2007. Since those two meetings, PNCC has re-visited each river basin at least once for follow-up discussions (Castañón, personal communication).

[12] Names of representatives from these groups can be found in the references section.

Accepting the model as an analytic tool

Beyond building trust in PNCC, an outreach strategy must ensure that stakeholders accept the model as a trustworthy tool for analysis. Literature studying public and stakeholder perceptions of decision support systems (DSS) identify best practices and barriers to the acceptance and successful use of models in participatory decision-making. Unfortunately, PNCC failed to involve local actors in the initial selection of parameters and assumptions for the overall development of the models. However, there are numerous other strategies that PNCC can employ to convince stakeholders of the accuracy and usefulness of the models (Maguire 2003).

To accept the model as a valid analytical tool, stakeholders need to know that it is not biased towards the solutions favored by the model developers (Maguire 2003). The calibration phase, May to December 2007, offers an excellent opportunity for PNCC to demonstrate that the model produces accurate and unbiased results (Stave 2003). After comparing the model's preliminary predictions to actual field measurements, PNCC analysts can change certain assumptions and parameters within the model so that it more closely matches reality. By involving stakeholders in this process of fine-tuning the model through information sharing and joint-fact-finding, PNCC can increase the believability of the model and the sense of "ownership" stakeholders feel in the process (Maguire 2003).

The model must be portrayed as a tool for comparing the outcomes of various proposed scenarios rather than a final "solution." (Olsson and Andersson 2007). Confidence that the tool is unbiased and objective will allow stakeholders who might hold conflicting interests to separate their personal beliefs and positions from the policy problem (Reitsma et. al. 1996). The ultimate "solution" will be found when policy makers decide which of the stakeholders' criteria to weight most heavily (availability of irrigation, economic equity, environmental protection, etc.) and evaluate the model-derived outcomes of different alternatives against these metrics.

Olsson and Andersson (2007) note that stakeholders are influenced to accept or disregard a scientific model's results based not only on its accuracy, but also on a number of political, economic, and social factors. For example, if a stakeholder believes his personal interests are adversely affected by the information generated by the model, the stakeholder will most likely express skepticism of the modeling process. For example, Cockerill et. at. (2004) found that in situations where model results contradicted an individual's beliefs about how the natural system worked, the stakeholder was more apt to question the model's validity than to question his own beliefs about the operation of the natural system.

Olsson and Andersson (2007) further identify economic and social factors that influence the public's acceptance of models. Stakeholders with economic constraints will be motivated more by factors affecting their economic welfare than by environmental concerns, and will ignore or disregard a model that fails to account for economic equity. Fairness and justice within a community will often be important factors as well, as communities want the burden and/or benefits of policy changes to be equally shared rather than allowing for free rider behavior. Those stakeholders with more local knowledge, such as farmers who are accustomed to dealing with changing environmental conditions, are more likely to criticize the model on the grounds that it doesn't accurately represent natural processes (Olsson and Andersson 2007).

Understanding that political, economic, and social factors all affect stakeholder acceptance of models means that PNCC needs to know its audience. To generate interest in using the model as a discussion tool, PNCC must tailor the dialogue to the topics that the present stakeholders care about. For example, an audience of policy-makers will want to see quantified costs and benefits associated with specific scenarios instead of just environmental outcomes. A group of farmers, on the other hand, are accustomed to dealing with uncertainty in their occupational lives and will understand and be interested in the model's uncertainties. Presenters should thus be prepared to discuss the imperfections and uncertainties of the model in order to increase transparency, though not to such a degree as to induce confusion (Olsson and Andersson 2007).

Finally, adequate time must be given to the dialogue. Stakeholder involvement is not simply a step along the way that needs to be accomplished and checked off the list. PNCC must invest the necessary time to educate stakeholders about climate change, local hydrologic patterns, and WEAP so that everyone can start the dialogue with the same basic level of understanding of the problem. The ensuing two-way conversation, based on mutual respect, will serve two purposes: it will improve the quality of data and accuracy of parameters used in the model, thus improving the quality of the model's predictions, and it will improve the chances that stakeholders will use model results to inform their adaptation dialogue (Olsson and Andersson 2007). This strategy simultaneously builds trust in PNCC and improves the accuracy and usefulness of the model.

The more trust stakeholders have in PNCC and the more confident they are that the model's results are accurate and unbiased, the more success PNCC will have in educating and engaging stakeholders in the dialogue about adaptation policy. And, with more understanding about the problem of climate change and the consequences of various decisions, stakeholders are more likely to fully support the policy results (Stave 2003).

Using WEAP to inform adaptation policy-making

Adaptation strategies differ by region so there can be no one size fits all policy solution. Developing adaptation strategies is made more difficult by the fact that national-level adaptation policy is a new concept and that no standard process for its adoption exists. Furthermore, climate change affects decision-making across multiple sectors.

In an ideal world, the framework for making water resource management decisions across sectors would be clear and adaptation policy could be layered onto these already-existing processes. In Guatemala, however, the water resource decision-making framework is full of holes and overlaps. Even in this unclear and complicated situation, however, decisions are made regarding the management and use of water resources. As messy as it may be, we must determine where the adaptation dialogue and the use of WEAP can be mapped onto the existing framework. Even if the framework remains complicated and unclear, at least we can improve the quality of the decisions made today by beginning to account for ways that climate change might affect future water resources.

Guatemala's legislative framework

Based on a broad survey of the country's water laws and policies, Guatemala lacks a strong and well-defined legal framework within which water resource management decisions are made. The weakness of the legal framework for the governance of water resources increases a coutry's vulnerability to climate change (Levina 2006). Part of the complication is that many national and local level organizations and agencies have overlapping responsibilities for overseeing water resources (US Army Corps of Engineers 2000). For example, the Agriculture Ministry oversees irrigation, the Energy and Mining Ministry oversees the use of water for hydroelectric use, the Public Health Ministry is in charge of monitoring water quality and sanitation, and the Environment Ministry is charged with protecting natural resources, including water. An entirely different organization is charged with hydrologic data collection and research, and its work is made difficult by the loss of important and expensive monitoring stations and equipment during Guatemala's civil war conflicts in the 1980s (Situación del Recurso Hídrico 2005). Other national policies that overlap with the issue of water resources include a national protected areas law,[13] a national environmental protection policy,[14] wastewater regulations passed in 2006[15] and a national policy on solid waste.[16]

According to Guatemala's constitution, the country's water resources belong to the people (US Army Corps of Engineers 2000). Guatemala's legislators have tried three times to pass comprehensive water law, but so far none have succeeded. The most recent attempt in 2005 reached impasse in Congress (Situación del Recurso Hídrico 2005). A newly formed water resources and basins unit within the Environment Ministry[17] is now charged with the difficult task of formulating Guatemala's national water policy (Presentación de Unidad de Recursos Hídricos). This group was

[13] Ley de Áreas Protegidas, Decreto 4-89.
[14] Política de Conservación, Protección, y Mejoramiento del Ambiente y los Recursos Naturales (2006).
[15] Reglamento de las Descargas y Reuso de Aguas Residuales y de la Disposición de Lodos, Acuerdo Gubernativo 236-2006.
[16] Política Nacional para el Manejo Integral de los Residuos y Desechos Sólidos, Acuerdo Gubernativo 111-2005.
[17] The Unidad de Recursos Hídricos y Cuencas was officially formed in 2005. (Descripción de Unidades Administrativas)

successful in negotiating new wastewater regulations last year,[18] which involved intense negotiations with both the industrial sector and with municipalities (Descripción de Unidades Administrativas). A similarly complex negotiation is expected in the development of national water law as those entities already operating under the existing system of free water are greatly invested in the status quo.

One of the fundamental legal elements missing in Guatemala's water resources management framework is the provision of water abstraction rights. According to the Organisation for Economic Co-operation and Development, the provision of water abstraction rights is essential for sound water management policy because it "authorizes the use of water which is a common good, and…sets principles (conditions and requirements) for water use" (Levina 2006). Basic economic argument warns that common or public goods will be overused without effective regulation. Without a clear understanding of who owns water resources and who is entitled to use them, at least 15 agencies develop separate water use plans without regard to upstream or downstream uses (Situación del Recurso Hídrico 2005). On a smaller scale, subsistence farmers build their own mini-irrigation systems that transport water from streams to their small plots without regard to upstream activities that may pollute the water or downstream users who might also need the water.[19]

The OECD also highlights transboundary water issues as another essential component of a successful legal framework for adaptation to climate change (Levina 2006). Sixty five percent of Guatemala's river basins drain to Mexico, Honduras, El Salvador, or Belize (Noticias del MARN), so transboundary water issues are clearly a major issue of concern; however, this topic is beyond the scope of this report.

With climate change, we can expect that existing conflicts over water use will only become exacerbated. This knowledge increases the urgency for the development of a clear water resources management structure that includes the provision of water abstraction rights. PNCC should support the development and implementation of a national water policy, and should insist that this policy account for climate change. In other words, the new policy framework must demand that water resource management decisions take into account changing climatic factors. PNCC can work to accomplish this by sharing its WEAP expertise with the newly formed water resources and basins unit and by offering political support to the promoters of the new national policy.

Finding the right policy processes for WEAP results

In the absence of a clear framework for water resource management, we analyzed Guatemala's existing policy structures to determine where it makes most sense to overlay the discussion about adaptation policy. To develop our recommendations, we first analyzed the types of adaptation strategies that may be proposed and thought critically about how WEAP results might inform decisions made about those types of strategies. We then researched which institutions in Guatemala currently make those specific types of decisions in order to determine an appropriate audience for PNCC's modeling results.

[18] Reglamento de las Descargas y Reuso de Aguas Residuales y de la Disposición de Lodos, Acuerdo Gubernativo 236-2006.

[19] The author observed small-scale "water piracy" from Guatemala's central highway. Farmers had haphazardly installed white plastic tubing that criss-crossed streams in order to irrigate their plots.

Based on vulnerability studies and research into existing intrinsic adaptation techniques (Evaluación 2006 and Evaluación 2007),[20] PNCC has developed a preliminary list of suggested adaptation strategies for further consideration (Síntesis DRAFT). A translated list of these strategies can be found in Appendix D. For each of the suggested techniques, WEAP developer and expert David Purkey helped determine if information from WEAP modeling results would help policy-makers to make better decisions. For example, we considered the proposed adaptation strategy to conduct an evaluation of river related risks to infrastructure and populations. WEAP can predict rainy season river run-off that may overflow the river's natural banks, causing damage to populations along the river as well as infrastructure. By quantifying flows at various points along the drainage basin, WEAP can predict whether that damage may occur along the entire river, or only in specific reaches of the river. Using this method of qualitative analysis, we identified 28 out of the 64 suggested adaptation strategies where we believe WEAP derived results could be helpful to decision-makers.

We then aggregated the 28 identified adaptation strategies into four categories by policy type:

1. Agro-silvo-pastoral based water productivity analysis
2. Reduction of flood risk through watershed rehabilitation
3. Reduction of flood risk through system operations
4. IWRM (Integrated Water Resources Management) for equitable water allocation

A list of adaptation strategies by category can be found in Appendix E.[21] To most efficiently allocate its limited time and resources, PNCC should concentrate its outreach efforts to the national level policy-making institutions that already make decisions in these four areas. The addition of WEAP results to their already existing repertoire of data and information will help these institutions make better, more-informed decisions about the management and use of water resources.

Guatemala's Agriculture Ministry (MAGA) oversees irrigation and researches farming and crop productivity. Specifically, the water basin unit within MAGA focuses on integrated development at the water basin level with emphasis on soil conservation and other crop productivity projects (Noticias del MARN). With WEAP results, we expect that MAGA can improve its decision-making with regards to agro-silvo-forestry based water productivity analysis.

Guatemala's national forestry institute (INAB) promotes reforestation and works to prevent deforestation through its PINFOR program.[22] We believe WEAP results would enhance the institution's ability to sustainably manage watersheds in order to reduce flood risk.

Guatemala's national disaster planning network (CONRED) is made up of various institutions that have an interest in preventing damage from storms, floods, forest fires, droughts, and other natural disasters. We believe WEAP results could improve CONRED's collective decision-making ability regarding flood prevention through system operations.

[20] PNCC has commissioned consultants to conduct studies regarding future vulnerabilities and existing intrinsic adaptation techniques in the two river basins. The preliminary list of adaptation strategies is a compilation of findings from these consultant studies.

[21] A few of the suggested strategies fall into more than one category and are therefore listed twice.

[22] PINFOR stands for Programa de Incentivos Forestales. Information accessed online 5/7/07 at INAB's website: http://www.inab.gob.gt/.

The establishment in 2005 of the water resources and basins unit ("basin unit") within the country's Environment Ministry provides a viable option for the IWRM application of WEAP. The basin unit is charged with water and wastewater planning, monitoring, and management at the national level. One of its stated activities is integrated water resources management (IWRM) (Presentación de Unidad de Recursos Hídricos).

Policy outreach recommendations

The present, May 2007, is the perfect time for PNCC to begin its institutional outreach efforts. PNCC has almost completed construction of its WEAP models and expects to have a first round of results by the end of this month. The institutional outreach efforts should certainly begin before PNCC begins to calibrate the models, so that the collaborating institutions can be involved in refining the accuracy of the models. Having identified the most likely policy areas where WEAP results will actually inform decision-making, PNCC should hold workshops with each of the identified institutions to share preliminary results and to begin ongoing discussions about the likely effects of climate change on the institutions' decision-making processes. These workshops will be more technical and policy-oriented than the public outreach workshops envisioned for each basin.

With their on-the-ground knowledge and personal contacts, PNCC staff will have to identify the most appropriate individuals within each of the institutions to contact about holding WEAP workshops. In their initial communication, PNCC staff should explain the NCAP project and WEAP's capabilities, noting especially that this political analysis document has identified four specific policy areas where we believe WEAP can help decision-makers make better policies.

Despite our belief that WEAP can improve the quality of decision-making, however, studies have shown that decision-makers often use models and other decisions support system (DSS) tools such as WEAP to conserve effort and save time rather than to actually improve their decision-making (Todd and Benbasat 1992). PNCC should promote WEAP as a tool to help analysts make better decisions in a shorter amount of time than high quality decisions would otherwise require. The four identified institutions will be more likely to participate and devote their scarce time and resources to the project if they understand specifically what they stand to gain.

Each workshop should consist of a day-long or half day-long training on WEAP software, plus a discussion of possible adaptation measures the institution might consider in future decision-making. As WEAP is free software for government, educational, and nonprofit institutions in developing countries, each institution should be invited to register for its own copy of the software. Additionally, PNCC must clarify that the workshop is only step one of an ongoing collaboration, and that the preliminary WEAP results and adaptation strategy suggestions are by no means the final solution. Rather than informing these institutions about how to adapt to climate change, PNCC is simply jumpstarting the dialogue on what needs to be a collective and dynamic process.

One way PNCC can emphasize the collaborative aspect of this effort is by establishing strong reciprocal ties across organizations. For example, the water resources and basins unit within the Environment Ministry plans to perform modeling work in eight of Guatemala's 38 river basins, but so far has not begun any modeling work nor chosen the river basins it will model (Castañón, personal communication). Since PNCC is already working in two river basins, it seems sensible for

the basin unit to piggyback on PNCC's work and adopt the already-developed models instead of re-inventing the wheel or duplicating work efforts.

A secondary benefit of the proposed cooperation across and among ministries and departments is that collaborations build institutional capacity, improve policy-making and reduce duplicate work efforts (US Army Corps 2000). Increasing institutional capacity reduces vulnerability by better enabling governmental bodies to plan for, manage, and recover from natural disasters. Reducing vulnerability in this way thus increases Guatemala's chances for successfully adapting to climate change (Burton, et. al. 2006).

Summary of Recommendations

PNCC's overall goal is to help Guatemala adapt to climate change. To do this, PNCC is using WEAP as a tool to study the effects climate change might have on Guatemala's water resources. For WEAP to play a helpful role in adaptation policy-setting, PNCC must do much more than simply build and run the models. PNCC must also raise the level of awareness in Guatemala about climate change, motivate the public and decision-makers to adapt, invoke the trust of stakeholders, and convince the involved parties to accept WEAP as an analytical tool. PNCC should also collaborate with institutions that currently govern water resources in different sectors in order to overlay the adaptation policy dialogue onto already existing policy-making processes. This document tries to narrow the scope of PNCC's outreach efforts to a manageable level while ensuring that WEAP is gainfully employed as a tool in the quest to reduce Guatemala's vulnerability to climate change.

To raise the level of awareness about climate change in Guatemala, we can learn from successful initiatives abroad. PNCC should develop an easily remembered climate change slogan for all of its public outreach materials. One already proposed is "¡Actuemos ya!" roughly, "Let's act already!" This slogan conveys an understanding that the climate is already changing, so people need to pay attention and pressure their government to act. The chosen slogan should be employed on all of PNCC's printed outreach materials and in any radio or television outreach efforts.

PNCC might also decide to further develop its "storyboard" concept. One storyboard tells a general story about climate change in Guatemala and PNCC's work with WEAP; another is more technical for scientific audiences; and a third is tailored to each river basin for specific community outreach efforts. These storyboards could be employed as posters, billboards, magazine spreads, or television advertisements, depending on the target audience and the available funding.

To motivate policy change in a developing country such as Guatemala, the "spheres of influence framework" suggests that PNCC needs a transnational actor to draw on international scientific and funding networks while maintaining a domestic political presence. Even as domestic policy-makers begin to pay more attention to climate change, PNCC's director must maintain his international contacts in order to keep up with scientific advances abroad and possibilities for project funding. PNCC's goals won't be achieved in a matter of a few years, so the organization needs to continue to take advantage of the funding and expertise available from international organizations such as ETS International and SEI-US.

To build trust among stakeholders, PNCC should sponsor workshops in each basin for local stakeholders to learn about climate change, PNCC's work, and WEAP. PNCC should take care to know who its audience is so that the dialogue can be focused on climate change impacts and consequences that are important to the present stakeholders. Importantly, PNCC's analysts must avoid using scientific jargon during meetings and their intention should be to educate stakeholders rather than flaunt their expertise. During the workshops, PNCC should provide the assistance of a WEAP expert to help participants use the WEAP models to analyze the outcomes of various scenarios.

Perhaps as a precursor to these workshops, PNCC should develop and publicly announce partnerships with respected local environmental organizations. These are groups that meet regularly

and are already trusted by the local community to make local land use and natural resource decisions.

To convince stakeholders that WEAP is a valid analytical tool, PNCC should aim to demonstrate that the model produces accurate and unbiased results during the calibration phase, May to December 2007. After comparing the model's preliminary predictions to actual field measurements, PNCC analysts can change certain assumptions and parameters within the model so that it more closely matches reality. By involving stakeholders in this process of fine-tuning the model through information sharing and joint fact-finding, PNCC can increase the believability of the model and the sense of "ownership" stakeholders feel in the process.

Importantly, the model must be portrayed as a tool for comparing the outcomes of various proposed scenarios rather than a final "solution." Confidence that the tool is unbiased and objective will allow stakeholders who might have conflicting interests to separate their personal beliefs and positions from the policy problem.

The more trust stakeholders have in PNCC and the more confident they are that the model's results are accurate and unbiased, the more success PNCC will have in educating and engaging stakeholders in the dialogue about adaptation policy. And, with more understanding about the problem of climate change and the consequences of various decisions, stakeholders are more likely to fully support the policy results.

With climate change, existing conflicts over water use will probably become exacerbated. This threat increases the urgency for the development of a clear management structure to govern Guatemala's water resources. PNCC should support the development and implementation of a national water policy, and should insist that this policy account for climate change. PNCC can work to accomplish this by sharing its WEAP expertise with the newly formed water resources and basins unit in the Environment Ministry and by offering political support to the promoters of the new national policy.

Despite the present lack of a clear and complete legal framework for water resources policy-making, decisions about the management and use of water resources nonetheless are made by multiple institutions. To overlay the adaptation dialogue onto already-existing water resource policy-making processes, PNCC should work with MAGA's water basin unit, INAB's PINFOR program, CONRED's disaster planning network, and MARN's water basin unit. These four institutions already make decisions in the four policy areas identified by this paper's analysis and categorization of suggested adaptation strategies:

1. Agro-silvo-pastoral based water productivity analysis
2. Reduction of flood risk through watershed rehabilitation
3. Reduction of flood risk through system operations
4. IWRM for equitable water allocation

PNCC should begin immediate institutional outreach efforts to introduce the consideration of climate change into these existing policy processes. PNCC can jumpstart these collaborations by planning one-day or half-day workshops with each organization before the models are calibrated but after developing the first set of preliminary results. The workshops should include training on WEAP,

discussion of preliminary model results, and conversation about climate change vulnerability and adaptation.

A secondary benefit of the proposed cooperation across and among ministries and departments is that collaborations build institutional capacity, improve policy-making and reduce duplicate work efforts. Increasing institutional capacity reduces vulnerability by better enabling governmental bodies to plan for, manage, and recover from natural disasters. Reducing vulnerability in this way thus increases the likelihood that Guatemala will be able to successfully adapt to climate change.

References

Ministerio de Ambiente y Recursos Naturales, Republica de Guatemala

Descripción de Unidades Administrativas: *Recursos Hídricos y Cuencas Hidrográficas*. http://www.marn.gob.gt/remodelmarn/u_cuencashid.htm; accessed online 4/4/07.

Evaluación de la adaptación autóctona a efecto de las inundaciones en Guatemala (2006). Proyecto RLA/01/G31: Fomento de las capacidades para la etapa II de adaptación al cambio climático en Centroamérica, México y Cuba.

Evaluación de la adaptación autóctona a efecto de las sequías en Guatemala (2007). Proyecto RLA/01/G31: Fomento de las capacidades para la etapa II de adaptación al cambio climático en Centroamérica, México y Cuba. Autor: Ing. Eduardo Javier Moreira Arana.

Noticias del MARN: *Encuentro Nacional sobre la Gestión de Microcuencas Hidrográficas*. http://www.marn.gob.gt/remodelmarn/noticia_rec_005.htm; accessed online 4/4/07.

Política de Conservación, Protección y Mejoramiento del Ambiente y los Recursos Naturales (2006).

Política Marco de Gestión Ambiental (2003).

Política Nacional de Educación Ambiental (2003).

Política Nacional para el Manejo Integral de los Residuos y Desechos Sólidos (2005).

Presentación de Unidad de Recursos Hídricos y Cuencas. Powerpoint presentation introducing the functions and activities of the water resources and basins unit of the Environment Ministry. http://www.marn.gob.gt/REMODELMARN/inicio.htm; accessed online 4/4/07.

Síntesis de Vulnerabilidad Futura, Propuesta de Medidas de Adaptación y Estrategia de Adaptación al Cambio Climatico (DRAFT). Programa Nacional de Cambio Climatico.

Other Literature

Burton, I., Diringer, E., and Smith, J. (2006). *Adaptation to Climate Change: International Policy Options*. Pew Center on Global Climate Change.

Cockerill, K., Tidwell, V. and Passell, H. (2004). *Assessing Public Perceptions of Computer-Based Models*. Environmental Management Vol. 34. No. 5, pp. 609-619.

Garcia, Julio (2006). *Country Experience in bottom-up approach in V&A Assessments*. Presentation at CGE Hands-on Training Workshop on V&A Assessments, Paraguay 2006, Day 1. http://unfccc.int/national_reports/non-annex_i_natcom/cge/items/3775.php, accessed online 3/9/07.

Levina, E. (2006). *Domestic Policy Frameworks for Adaptation to Climate Change in the Water Sector. Part II: Non-Annex I Countries: Lessons Learned from Mexico, India, Argentina, and Zimbabwe*. Organisation for Economic Co-Operation and Development and International Energy Agency.

Maguire, L. A. (2003). *Interplay of Science and Stakeholder Values in Neuse River Total Maximum Daily Load Process*. Journal of Water Resources Planning and Management July/August: 261-270.

Olsson, J. A., and Andersson, L. (2007). "Possibilities and problems with the use of models as a communication tool in water resource management." Water Resources Management 21: 97-110.

Perfil Ambiental de Guatemala 2006: Tendencias y Reflexiones sobre la Gestión Ambiental. La Universidad Rafael Landivar, Guatemala.

Reitsma, R., Zigurs, I., Lewis C., Wilson V., and Sloane, A. (1996). *Experiment with Simulation Models in Water-Resources Negotiations*. Journal of Water Resources Planning and Management January/February: 64-70.

Situación del Recurso Hídrico en Guatemala (2005). Documento Técnico del Perfil Ambiental de Guatemala, Universidad Rafael Landivar, Guatemala.

Sorisi, Chiara (2006). *Public Participation and Adaptive Water Management: Assessing the Role of System Dynamic Models in the Upper Guadiana Basin in Spain*. Stockholm Environment Institute, Risk and Vulnerability Programme.

Stave, Krystyna A. (2003). *A system dynamics model to facilitate public understanding of water management options in Las Vegas, Nevada*. Journal of Environmental Management 67: 303-313.

Steinberg, Paul F. (2003). "Understanding Policy Change in Developing Countries: The Spheres of Influence Framework." Global Environmental Politics 3(1):11-32.

Todd, P., and Benbasat, I. (1992). *The Use of Information in Decision Making: An Experimental Investigation of the Impact of Computer-Based Decision Aids*. MIS Quarterly September: 373-393.

United States Army Corps of Engineers, Mobile District & Topographic Engineering Center (2000). *Water Resources Assessment of Guatemala*.

Organizational Representatives

Bravo, Julio Soto, representative of Mancuerna (Mancomunidad de municipalidades de la Cuenca del Río Naranjo).

Escobar, Silben, MARN representative in San Marcos.

Herrera, Nora, Social Development Specialist, IUCN (The World Conservation Union).

Padilla, Ingeniero Estuardo Johann Suchini, MARN representative in Chiquimula.

Programa Nacional de Cambio Climatico, Ministerio del Ambiente y Recursos Naturales, Guatemala
Castañón, Claudio, Engineer
España, Mercedes, Engineer
Mansilla, Carlos, Engineer, Program Director
Rivera, Jeffrey, Engineer

Purkey, David, Senior Scientist. Stockholm Environment Institute – US.

Rodríguez, Roel Tovar, representative of Mancuerna (Mancomunidad de municipalidades de la Cuenca del Río Naranjo).

Soto, Jenner, MARN representative in San Marcos.

Téllez, Amilcar Ruiz, MARN representative in San Marcos.

Vicuña, Sebastian, Research Associate. Stockholm Environment Institute – US.

Appendix A: Project Background

Due to its location at the mouth of numerous European rivers and its low elevation, the Netherlands is particularly concerned about the effects of climate change on its population and economy. As one of the world's wealthier countries, both governmental and non-governmental organizations in the Netherlands have taken a special interest in funding adaptation research in developing countries around the world. The Netherlands Climate Assistance Project (NCAP) works under the assumption that the global climate is already changing, and that developing countries need to develop adaptation policies to best deal with these inevitable changes.

ETC International is a nongovernmental consulting organization in the Netherlands that is being funded through the Dutch government as the facilitator of NCAP. NCAP is working on climate change adaptation research in 15 developing countries, including Guatemala, Mali, Bolivia, and Colombia. The focus of the NCAP work varies by country; some are assessing vulnerability associated with sea level rise while others are focusing on risk management, public health, or water resources. In Guatemala, NCAP research is targeted at determining the effects of climate change on the country's water resources, and developing adaptation policies that reduce the vulnerability of poor communities. Two of the motivations behind choosing to focus on water resources were a devastating flood in 2001 and extensive damage and casualties cause by Hurricane Stan in 2005.

In Guatemala, the organization charged with conducting research under the NCAP program is the National Program on Climate Change (PNCC), a division of the national Environment Ministry (MARN). PNCC's director is Engineer Carlos Mansilla, who is not a permanent Environment Ministry employee. Mr. Mansilla hires consultants on a yearly basis to complete specific aspects of the overall study. Most of the consultants are also engineers, and work on developing various reports that will inform the final study. Currently, Mr. Mansilla has a staff of about 5 people who are working full-time on the NCAP project.

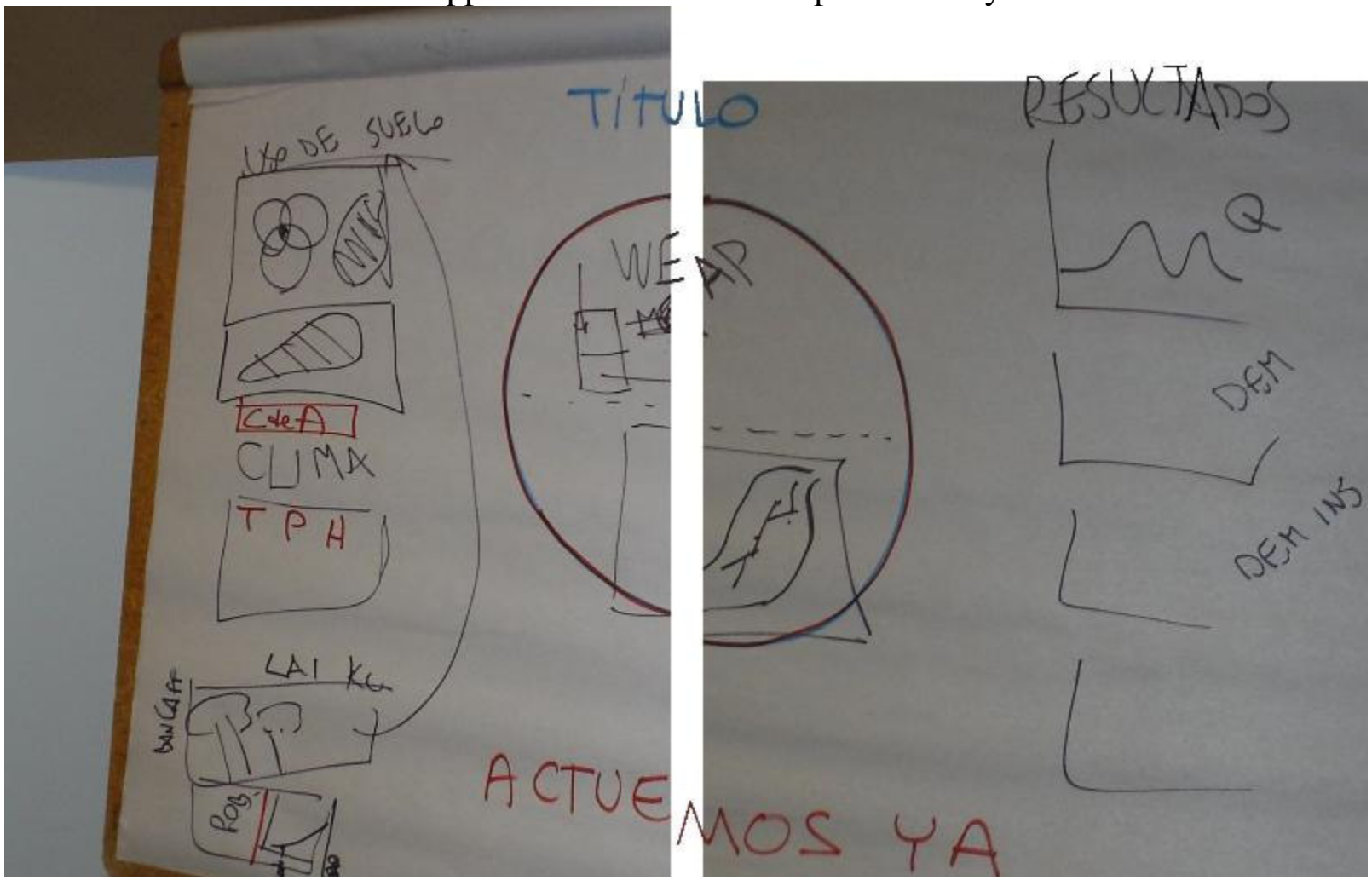
The Guatemala NCAP project has two components: a technical and a policy component. This report is the first step of the policy component, while technical component takes up the time of most of Mr. Mansilla's engineering consultants. Mr. Mansilla first learned about Water Evaluation and Planning software (WEAP) at a conference in Panama, where SEI-US was presenting the software system's capabilities as part of a different project. Mr. Mansilla chose to use WEAP as a tool to help PNCC model the potential effects of climate change on Guatemala's water resources. The climate change team will then use this information to inform water management and adaptation policy-making at both the national and local levels.

Data-gathering for WEAP model-building began in November 2006 and continues today. By the end of May 2007, the climate change team expects to have gathered all of its baseline supply and demand data and will be able to calibrate the model using known (real) data points. Once the model is calibrated, the team will run various climate, socio-economic, and adaptation scenarios. The team expects to have final results, including measures of water quality, by December 2007.

Appendix B: Climate Change Outreach Posters from Peru

The posters shown above were used in a public consciousness raising campaign in Peru. They illustrate the effects climate change might have on individual lives and livelihoods. One depicts empty anchovy nets, and asks, “What work will you have if there aren’t any anchovies?” Another depicts an empty mango crate and asks “And if there stopped being mangoes?” All three posters end with the campaign’s slogan: “The climate is changing, so should we,” and lists the website people can visit for more information (Garcia 2006).

Appendix C: Sketch of Proposed "Storyboard"



This is a rough sketch of one of the three proposed "storyboards" that might be further developed as part of PNCC's outreach efforts. This sketch was developed by the PNCC group attending the Santa Marta NCAP meeting in Colombia in late January, 2007. The storyboard includes the group's proposed slogan "Actuemos ya." Thanks to Ing. Jeffrey Rivera, PNCC for this photo.

Appendix D: Proposal of Measures for Adaptation to Vulnerability

Translated from: Síntesis de Vulnerabilidad Futura, Propuesta de Medidas de Adaptación y Estrategia de Adaptación al Cambio Climatico (DRAFT), PNCC.

Flood prevention

- Planning for the arrangement and regulation of human settlements and housing
- Planning for the prevention of natural disasters that affect water and sanitation systems
- Dredge riverbeds in dry seasons
- Implementation of infrastructure structural measures adequate for flood prevention
- Evaluation of river related risks to infrastructure and populations
- Stabilization of hillsides and controlled landslides
- Placement of retaining walls and ditches in critical points along riverbanks
- Elaborate national and local contingency plans for the rainy season
- Update, divulge, and implement the nutrition and food guide for emergency situations
- Divulge information and training about what to do in emergency situations
- Conduct vulnerability evaluations of health services with respect to risk management
- Spread to the large-scale public published information about preparedness for flood or landslides
- Strengthen the capacity of different systems that monitor extreme events
- Gather and retain statistics, baseline data, and technical workers with previous experience and knowledge about the operation of existing early alert systems
- Strengthen the capacity of local institutions responsible for natural disaster prevention
- Systemize acquired experience in different early alert systems for replication in other localities
- Implementation of disaster preparedness policy adopted by the Red Cross and Red Crescent
- Develop a Strategic Framework for the Reduction of Vulnerability and Disasters in Central America
- Adopt the GTZ/FEMID proposal for a work concept around local management of risk in Central America
- Update and develop new work on the estimation of threats induced by hydro-meteorological events
- Strengthen compliance to the standard requiring inclusion of risk management in public investment projects and standardize the regulation of private investment
- Promote assistance schemes for the conservation of forests preferably via the development of an environmental services market

Flood rehabilitation

- Infrastructure reconstruction and rehabilitation with a focus on risk management
- Cleaning of the riverbeds
- Deposit of landslide material removed in upper and middle parts of the basin to an adequate location in the lower part of the river basin
- Develop environmental sanitation campaigns
- Divulge home-made methods of ensuring clean water to drink

- Attention to demands on medical services, medicines, and hospital infrastructure
- Standardize processes to quantify harm and information about the impacts associated with floods
- Promote the consideration of risk management, territorial arrangement, and natural environment and social conditions in the reconstruction process
- Promote citizen participation in the process of evaluation of causes and decision-making for the prevention of the effects associated with floods

During a flood

- Improve instruments developed to evaluate the harms, measure the effects, and report the existing needs caused by flooding
- Develop strategies for ensuring humanitarian help and first aid for those injured or harmed by flooding
- Strategic deployment of machinery convoys for opportune repair or rehabilitation of road infrastructure
- Rely on equipped and trained bodies of assistance and immediate response
- Update instruments for the rapid evaluation of the emergency situation and the necessities it provokes

Drought prevention

- Soil and water conservation practices
- Planning for the arrangement and regulation of human settlements and housing
- Establishment of agroforestry plantations and systems
- Improvement of social and productivity infrastructure, training, and organizational strengthening
- Develop environmental reforestation campaigns
- Identify high risk zones: prioritize zones with recurring forest fires and help with prevention and fire-fighting
- Extension of options to access new technologies and financing-mechanisms for conservation and management of natural resources
- Reinforce Guatemala's food security program
- Update, divulge, and implement the nutrition and food guide for emergency situations
- Organizational strengthening
- Divulge information and training about what to do in emergency situations
- Conduct vulnerability evaluations of health services with respect to risk management
- Gather and retain statistics, baseline data, and technical workers with previous experience and knowledge about the operation of existing early alert systems (best practice)
- Take advantage of the climate and physical conditions to establish production systems: selection of genetic material, diversity in cultivation, soil conservation, combination of chemical and organic fertilizers, rational use of water
- Consideration of gender in local social organization
- Strengthen local structures: administrators of micro-projects count on the help and participation of local groups to identify and implement initiatives jointly and in a coordinated manner

- Transfer project execution to local stakeholders: micro-project administrators should delegate projects that permit the development of administrative, technical, and communication capacity
- Participation of community groups: independent of the particular focus of each one, work towards integration and coordination, in addition integrate across COCODES and take advantage of existing resources for mutual benefit
- Linking across municipalities

Post-drought rehabilitation

- Develop environmental campaigns for reforestation
- Employ the tree as an element of protection for water supplies
- Generate income and rural employment in food production activities
- Assistance services for food production
- Strengthen commercialization, health, and environmental sanitation
- Participation of national level government institutions
- Integrated participation of government institutions, municipalities, civic and community organizations that work towards common objectives and endorse micro-projects, offering a planning process where all the stakeholders hold an important role in the analysis of risk and the solution to problems
- Consider the tree a productive element: establish agroforestry systems that combine crops with fruit trees

Appendix E: Suggested Adaptation Strategies by Policy Category

Agro-silvo-pastoral based water productivity analysis

- Promote assistance schemes for the conservation of forests preferably via the development of an environmental services market
- Promote the consideration of risk management, territorial arrangement, and natural environment and social conditions in the reconstruction process
- Soil and water conservation practices
- Establishment of agroforestry plantations and systems
- Improvement of social and productivity infrastructure, training, and organizational strengthening
- Develop environmental reforestation campaigns
- Take advantage of the climate and physical conditions to establish production systems: selection of genetic material, diversity in cultivation, soil conservation, combination of chemical and organic fertilizers, rational use of water
- Consider the tree a productive element: establish agroforestry systems that combine crops with fruit trees

Reduction of flood risk through watershed rehabilitation

- Promote assistance schemes for the conservation of forests preferably via the development of an environmental services market
- Develop environmental reforestation campaigns
- Soil and water conservation practices
- Update and develop new work on the estimation of threats induced by hydro-meteorological events
- Infrastructure reconstruction and rehabilitation with a focus on risk management
- Develop environmental sanitation campaigns
- Promote citizen participation in the process of evaluation of causes and decision-making for the prevention of the effects associated with floods

Reduction of flood risk through system operations

- Planning for the prevention of natural disasters that affect water and sanitation systems
- Evaluation of river related risks to infrastructure and populations
- Elaborate national and local contingency plans for the rainy season
- Strengthen the capacity of different systems that monitor extreme events
- Strengthen the capacity of local institutions responsible for natural disaster prevention
- Develop a Strategic Framework for the Reduction of Vulnerability and Disasters in Central America
- Strengthen compliance to the standard requiring inclusion of risk management in public investment projects and standardize the regulation of private investment

- Gather and retain statistics, baseline data, and technical workers with previous experience and knowledge about the operation of existing early alert systems

IWRM for equitable water allocation

- Organizational strengthening
- Consideration of gender in local social organization
- Strengthen local structures: administrators of micro-projects count on the help and participation of local groups to identify and implement initiatives jointly and in a coordinated manner
- Transfer project execution to local stakeholders: micro-project administrators should delegate projects that permit the development of administrative, technical, and communication capacity
- Participation of community groups: independent of the particular focus of each one, work towards integration and coordination, in addition integrate across COCODES and take advantage of existing resources for mutual benefit
- Linking across municipalities
- Participation of national level government institutions
- Integrated participation of government institutions, municipalities, civic and community organizations that work towards common objectives and endorse micro-projects, offering a planning process where all the stakeholders hold an important role in the analysis of risk and the solution to problems