THE SCIENCE-POLICY INTERFACE FOR DEVELOPING CLIMATE CHANGE
ADAPTATION STRATEGIES IN MARYLAND, USA

by

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ABSTRACT

THE SCIENCE-POLICY INTERFACE FOR DEVELOPING CLIMATE CHANGE ADAPTATION STRATEGIES IN MARYLAND

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Climate change is causing perturbation to ecosystems worldwide and ongoing damages to communities necessitating the need to adapt by building resilience and reducing the vulnerabilities of people and infrastructure. Accordingly, policy-makers must sufficiently understand the effects of climate change and the communities' resilience capacities to it. This can be achieved by an efficient science-policy interface with respect to climate change adaptation planning. This type of interface would better position both scientists and decision-makers to more effectively address the priorities of communities impacted by climate change.

This dissertation examines the science-policy interface during the development of Maryland's climate change adaptation strategies and the incorporation of these strategies into PlanMaryland. This dissertation also presents a science-policy model founded on social capital that could lead to better-informed policies.

CHAPTER ONE: INTRODUCTION

Background

Public policies aimed at climate change adaptation address the impacts of climate change by adopting and implementing climate risk management strategies. These strategies are designed to reduce vulnerability and enhance the resilience of communities to adverse effects of climate change.

Development of risk management strategies requires identification and incorporation of uncertainty into the decision-making process. Whenever possible, decision-makers at the state level should reduce uncertainty. This will require a greater interaction between the decision-makers and scientists (Funtowicz & Ravetz, 1994).

Reducing the impacts of climate change is both a moral and economic imperative that needs to be clearly explained and broadly understood. To better prepare and plan for the impacts of climate change, policy-makers must sufficiently understand its effects as well as the resilience capacity of communities (Moser, Kasperson, Yohe, & Agyeman, 2008). However, this is proving to be very difficult. According to a 2009 Government Accountability Office (GAO) report, there are still no sufficient site-specific data on the expected changes. So, the key challenge is to determine how to prepare for action at the

local scale when so many uncertainties are present when applying global climate models at local scales[1] (U.S. Government Accountability Office, 2009).

Dealing with uncertainties at the local level is an important task since the majority of adaptation planning will be conducted at the local level. The decision-makers at this level usually lack the resources, information, or the experience to access the information that is available to help their work (National Research Council, 2010).

There is a special role for the federal government in climate adaptation planning. The federal government is positioned to develop and coordinate national strategies, and can provide resources for the development of a broadly accepted approach to conduct vulnerability assessments. The federal government can also support research on integrative approaches to responding to climate impacts and other stressors, as well as supporting the development of national standards for designing infrastructure that will withstand different climate change scenarios (National Research Council, 2011).

The role of state level decision-making is very important since state level decision makers are required to evaluate and discuss uncertainties with resource managers at the local level, who will then apply climate change adaptation strategies developed at the state level. States need to acquire more focused strategies to narrow the range of uncertainty associated with adaptation practices.

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[1] I.e., scales smaller than 10^4 km^2.

State of Maryland

Maryland is one of the smallest states in the country geographically. As of 2010 it was the fifth most densely populated state with 594.7 inhabitants per square mile (U.S. Census Bureau, Population Division, 2012).

Most of the state's waterways are part of the Chesapeake Bay water, which is a major economic force dominating the geography and culture of the state. Chesapeake Bay has been critical in defining the environmental ethics of Maryland citizens, thus making addressing environmental problems a policy priority.

The state of Maryland has a top national record in environmental policy innovation (Gerrit, 2012), mainly for initiatives such as leading the efforts to forge the regional Chesapeake Bay Agreement in 1983, passing the Water Quality Improvement Act in 1998 (just nine months after the August 1997 *Pfiesteria* problem), and developing Smart Growth policies over the last two decades.

Maryland's 4,360 miles of coastline are experiencing a naturally occurring land subsidence. As a result, the historic average rate of sea level rise along the coastline has been 3-4 mm/year, nearly twice the global average (1.8 mm/year) (Leatherman, Chalfont, Pendleton, McCandless, & Funderburk, 1995). According to climate models, thermal expansion, melting glaciers and ice caps, and the polar ice sheets will raise sea levels and expedite shoreline erosion, resulting in 2 -3 feet of sea level rise by the year 2100 and causing a serious impact on the state of Maryland (Leatherman et al., 1995).

Consequently, Maryland has recognized the need to act rapidly. It has expeditiously developed programs and directives related to the resources that are most likely to be impacted by climate change. It is expected that coastal infrastructure and

development will experience the biggest economic impact. The state's strategy to reduce its vulnerabilities focuses on protecting habitat and infrastructure from future risks associated with sea level rise and coastal storms, and on protecting human health, safety and welfare (Maryland Commission on Climate Change, 2008a).

Maryland Climate Adaptation Plan

The Maryland Commission on Climate Change (the Commission) was established by Executive Order (EO) 01.01.2007.07, signed by governor Martin O'Malley on April 20, 2007. The EO charges the Commission with the development of a Climate Action Plan (CAP) that would address greenhouse gas emission reductions and prepare the state for the impacts of climate change. The Commission is supported by three Working Groups: Scientific and Technical Working Group (STWG); Greenhouse Gas and Carbon Mitigation Working Group (MWG); and Adaptation and Response Working Group (ARWG). Each working group is supported by subgroups specializing in their respective areas of expertize.

The working groups developed separate chapters of the CAP, which was released in 2008. STWG developed the *Comprehensive Climate Change Impact Assessment (Maryland Commission on Climate Change, 2008b)*. MWG developed policy recommendations for the *Comprehensive Greenhouse Gas and Carbon Footprint Reduction Strategy* (Maryland Commission on Climate Change, 2008c). ARWG developed policy recommendations that were included in the *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase I: Sea Level Rise and Coastal Storms(Maryland Commission on Climate Change, 2008a).*

The CAP recommended that the Commission re-evaluate adaptation strategies appropriate for Maryland based on the impact assessment prepared by STWG. ARWG and STWG started work on Phase II of the Comprehensive Strategy to Reduce Maryland's Vulnerability to Climate Change in 2010 (Maryland Commission on Climate Change, 2011).

This dissertation focuses on the science-policy interface during the identification and the development of the climate adaptation policy recommendations and implementation strategies.

Objective

The objective of this research is to examine the science-policy interface during the development of Maryland's climate change adaptation strategies and the science-policy interface that took place during the subsequent integration of Phase I and Phase II into PlanMaryland, Maryland's State Development Plan.

Research Approach

This study will answer the following questions:

1. How did decision-makers obtain scientific information to develop climate change adaptation strategies?

2. How did scientists obtain relevant information on the policy priorities for the development of the climate change adaptation strategies?

3. What challenges were at the science-policy interface during the development of the climate change adaptation strategies, and how were they overcome?

These questions will be examined by following an exploratory case study method. Case study data were collected by using multiple relevant sources of evidence. Data collection included: (i) Primary document review; (ii) Scoping interviews; and (iii) Semi-structured interviews. Multiple sources of evidence ensure the triangulation of data, which is important to maximize the credibility of the data.

Organization

This thesis is organized into six chapters: Chapter One includes the introduction, objective, purpose, and methods. The second chapter presents an overview of the literature on the policy development process in the United States, adaptation policy development, and the science-policy interface. The third chapter discusses research methods, while the fourth and fifth chapters analyze two case studies. Chapter Six presents conclusions.

CHAPTER TWO: LITERATURE REVIEW ON THE SCIENCE-POLICY INTERFACE

Introduction

This chapter presents a review of the literature on the interface of science and policy in general, and in particular with respect to climate change policy development and climate adaptation policy development. The chapter starts with a review of the policy-making process in the United States, follows with the development of climate adaptation policies, and ends with a discussion of science-policy interface and approaches that ensure a more effective integration of science into policy.

The Policy-Making Process in the United States

The policy-making process in the United States is complex and requires expertise in legal aspects, scientific knowledge, and technical feasibility (Kingdon, 2010). These requirements call for open dialogue among many and varied stakeholders.

The literature on public policy formulation indicates several methods that share many of the same features. For example, public policy experts have identified four main steps that the US government takes to address a public concern (Kingdon, 2010). These are: agenda setting (or problem identification), policy formulation, policy implementation, and policy analysis and evaluation (Kingdon, 2010).

Kingdon (2010) notes that science needs to be relevant to the problem that is active in the policy agenda in order to influence it. To elevate an alternative in the policy

agenda, Kingdon (2010) uses a "garbage can model," or the three streams model, to describe a general process on the entry points of science into the policy process (Kingdon, 2010). The first stream of the model is the stream of problems. In the stream of problems, an issue must be defined and presented as a problem in order to be elevated to a prominent place in the agenda (Kingdon, 2010).

The second stream is the stream of policies wherein policy alternatives that are technically feasible are proposed. Some of these policy alternatives are not necessarily developed to solve that particular problem, but they can be identified as potential solutions (Kingdon, 2010)

The final stream is referred to as the stream of politics. In this part of the model, there is an important pending event such as an election that can make the issue/problem stay on or fall from the agenda (Kingdon, 2010).

The literature also emphasizes that the decision making process can be influenced by many actors outside of the government such as "interest groups, researchers, academics, consultants, media, parties and other elections-related actors and the mass public" (Kingdon, 2010).

Among the most important outside actors in the development of public policy are scientists including researchers, academics, and consultants (Kingdon, 2010). Scientists' influence is usually more prominent in the policy formulation stage rather than in agenda setting stage since policy-makers turn to scientists only after the problems have been identified (Kingdon, 2010).

Development of Climate Adaptation Policies

Historically, people have responded to their changing environment by adapting to it (Gupta et al., 2008). This can be done independently or collectively, and either in a pre-emptive or reactive way (McCarthy, Canziani, Leary, Dokken, & White, 2001). The development of climate adaptation policy-making includes a series of steps that follow Kingod's (2010) model. The first stage includes identifying the impacts of climate change and the vulnerabilities of the area. The second stage includes the assessment and identification of existing relevant policies and the development of new policy recommendations. The third and the fourth stages include implementation of the adaptation strategies and policy evaluation.

Since humans have historically adapted to their climate, institutions have developed adaptation policies as well (Gupta et al., 2008). Usually, these policies are not stand-alone climate adaptation policies, but can be found rolled into other policies, such as planning guidelines or other policies. For example, Maryland's existing climate adaptation policies on coastal zone management are included in broader coastal zone management policies (Maryland Commission on Climate Change, 2011).

Identification of these already existing policies and other adaptation initiatives and programs is usually the first step in the assessment of adaptation policies (Burton, Huq, Lim, Pilifosova, & Schipper, 2002). This can be done by assessing the most recent extreme climate event, the level and distribution of damages among socioeconomic groups, the level of environmental damages, and what measures have been used to reduce vulnerability and the success of these measures (Burton et al., 2002). Additionally, the

relationships among public policies, climate hazard, and sustainable development policies need to be assessed as well (Burton et al., 2002).

The development of new adaptation policies includes the design of a new policy, new initiatives, or new policy alternatives. This requires an assessment of regional climate projections, projected impacts, the costs of inaction, the vulnerabilities of habitats and infrastructure from future risks associated with sea level rise and coastal storms, human health, safety and welfare, and natural resources (Maryland Commission on Climate Change, 2008d).

Both types of assessments described require collaboration among scientists, decision-makers, and other stakeholders who would implement those strategies.

To streamline the adaptation policy-making process, an international team of experts developed an adaptation policy framework (Lim, Spanger-Siegfried, Burton, Malone, & Huq, 2005). The adaptation policy framework identifies five key components of adaptation policy-making (Lim et al., 2005). They are listed in Figure 1.

Figure 1 Adaptation Policy Framework Components (Lim et al., 2005)

Scoping and designing is the most important step in the development of adaptation strategies and its associated policies. Scoping and designing ensures that the adaptation strategy is well incorporated into the state policy planning process (Lim et al., 2005). In the next step, the project team assesses the current vulnerability and the existing vulnerability reduction policies in place. For assessing future climate risks, the project team needs to make projections of future climate, its impacts, vulnerabilities, and risks.

The development of an adaptation strategy to reduce current and future climate risks is the fourth step in the adaptation policy framework process. This step includes the identification and recommendation of policy options and the formulation of these options into a language that will fit into the state government process.

The final step in the adaptation process ensures that the recommended adaptation policy options are implemented, monitored, evaluated, and improved (Lim et al., 2005).

America's Climate Choices (National Research Council, 2011) presents slightly different steps in their *iterative risk management process* (Figure 2).

Identify the Problem and Objectives

↓

Establish Decision-Making Criteria

↓

Assess Risk

↓

Identiry Options

↓

Appraise Options

↓

Make Decisions

↓

Implement Decisions

↓

Monitor and Reassess

Figure 2 Illustration of the steps in an iterative risk management approach for addressing climate change (National Research Council, 2011).

Other similar approaches have been developed by the International Panel on Climate Change (IPCC), other national governments, and international organizations (Figure 4). Here in the United States, a good example of a climate change impact reduction strategy is PlaNYC, the New York City sustainability and growth management initiative (National Research Council, 2011). Activities involved are depicted in Figure 3.

These activities are set up in a way that the goals and strategies set forth are regularly

monitored, and correct them as new knowledge becomes available.
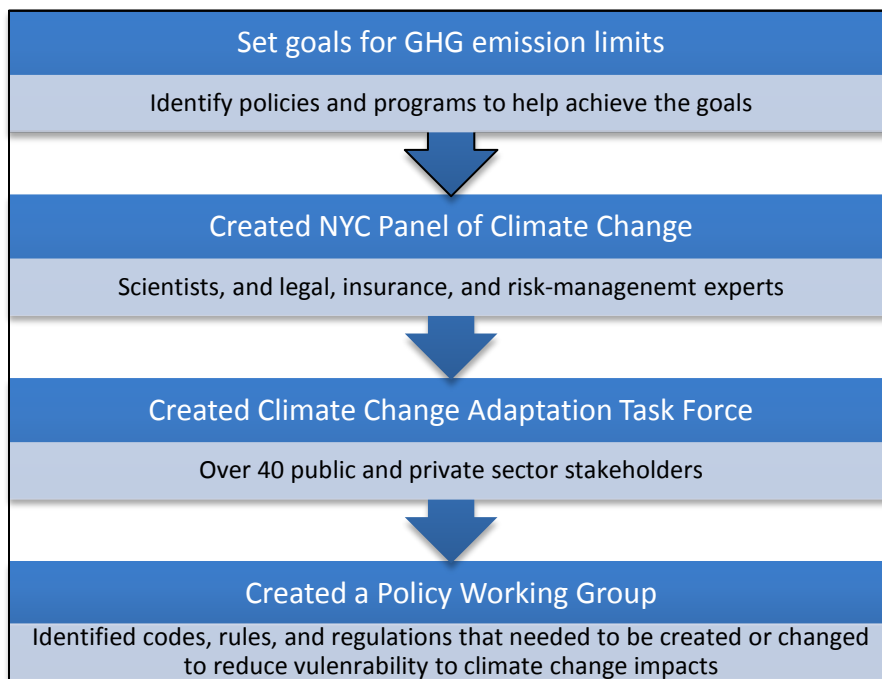
Figure 3 Adaptation and planning activities during the development of PlaNYC. Adapted from *Adapting to the Impacts and Informing Effective Decisions* **(NRC, 2010)**

Interaction between science and policy in the Intergovernmental Panel on Climate

Change (IPCC) adaptation assessments is described as a direct connection between

scientists and decision-makers (Kasperson & Berberian, 2011). The preparation of the

IPCC Assessment Reports of the state of the knowledge on climate change is based on

streamlined procedures agreed upon by the Panel. The IPCC process applicable to

preparing Assessment Reports is presented in Figure 5. All IPCC reports have to go

through the same procedure before they are published.

IPCC approves outline
Governments, organizations nominate experts
Bureaux select Authors
Authors prepare 1st - order DRAFT
Expert Review
Authors prepare 2nd - order DRAFT
Expert and Government Review
Authors prepare Final Draft
Final Distribution and Government Review of Summary for Policy-makers
Working Group/IPCC accepts/approves Report and Summary for Policy-Makers
Publication of report

Figure 4 IPCC Process Applicable to the Assessment Reports (Source: Adapted from IPCC Processes and Procedures (IPCC, n.d.)

In line with the processes above, the climate adaptation and planning process in

Maryland has followed the following guidelines depicted in Figure 6.

Figure 5 Adaptation and planning process in Maryland

This process is discussed in detail in Chapter Four.

Science in the Policy Development Process

The interface of science and policy has been the focus of research in many studies. These studies have covered topics from dissemination of knowledge, science utilization, policy oriented research, knowledge transfer and exchange, among others. Literature reviewed here focuses on the current state of the science-policy interface related to not only climate change, but also to other areas such as health and education.

Early literature on the interface of science and policy argues that there is a gap in communication between scientists and policy-makers and that this is caused by a cultural difference between the two (Caplan, 1979). This type of interface requires translation of science to policy-makers to ensure an optimal utilization of science, which assumes that

research moves spontaneously to policy-makers, and this is not usually the case (Holmes, Savgård, & Sverige. Naturvårdsverket, 2008).

Current literature argues that science does not move spontaneously from researchers to policy-makers and that science is co-produced by researchers and policy-makers (Lemos & Morehouse, 2005). A successful co-production of science is dependent on the receptivity of the decision-makers, their awareness of the need for and the benefits of the results, the relationship between scientists and decision-makers, and the acceptance of the science by decision-makers (Bressers, 2012).

However, to ensure to ensure that the dialogue between scientists and policy makers is effective several general criteria need to be met (Jones, Fischhoff, & Lach, 1999), (Mills & Clark, 2001). They include:

1. Relevance: Scientific research results must be relevant to the current policy questions in order to influence policy (Jones et al., 1999). Not all policy issues/problems are at the same time at the same stage in the policy agenda (Kingdon, 2010).

2. Compatibility: Research results must be presented in a form that is compatible with existing policy-making procedures and decision models. Research results must also be presented in terms that are understandable for the policy-maker (Jones et al., 1999).

3. Accessibility: The research results must be accessible to decision makers. Some organizations might have formal procedures in place for accessing relevant research results. Other organizations might have an ongoing informal

way of accessing relevant research results. In the public policy process, research results usually enter in the agenda setting and problem formulation stage, although it is not unusual for research results to enter the policy-process in any stage of the decision-making process (Jones et al., 1999).

4. Receptivity: Policy-makers and their organizations need to be open to the research results, and their decisions need to be consistent with these results. Decision-makers are usually more receptive to scientific information if they have been involved early on in the research project (Jones et al., 1999).

Several models of the science-policy interface that are common among various schools of thought (E. M. Glaser & Taylor, 1973; Havelock & Guskin, 1971; Weiss, 1979; R. K. Yin & Moore, 1988). These are: the knowledge driven model (a one-way/linear interaction), the problem solving model (also one way/linear), the interactive network model, enlightenment model, and the systems model (Best & Holmes, 2010; E. M. Glaser & Taylor, 1973; Havelock & Guskin, 1971; Weiss, 1979). These models are not mutually exclusive, but offer alternative approaches to research utilization.

The knowledge driven model, a highly regarded approach in the natural sciences, holds that research knowledge is a driving factor behind decision-making. The knowledge driven model is a one-way, or linear, process that assumes that basic research is conducted as a result of "curiosity" and will eventually be used in applied research (Weiss, 1979). This model of research utilization can be described as technology-push where research results eventually may be used for public policy (R. K. Yin & Moore,

1988). The knowledge driven model is driven by the need for a greater scientific understanding rather than the needs of decision-makers (Kasperson & Berberian, 2011).

The problem-solving model is another linear model that has a slightly different sequence of events (Lazarsfeld, Reitz, & Pasanella, 1975). This model assumes that a decision-maker (or an organization) has identified a problem that needs to be solved. The decision-maker communicates this need to the research team that will provide policy alternatives. This model assumes that the policy need was efficiently communicated and there was a consensus on the end goal (Weiss, 1979; R. K. Yin & Moore, 1988).

The interactive networks model assumes that policy-makers, researchers, administrators, practitioners, interest groups and other relevant stakeholders belong to the same network community where they interact regularly, discuss, and adjust their views based on new findings (Brooks, 1967). This model suggests that researchers, policy-makers, and other stakeholders don't discuss only the problem at hand, but they also discuss larger issues and ideas and understand each others' worlds (R. K. Yin & Moore, 1988). They rarely have clear evidence to solve the problem, but their discussions move them closer to a reasonable policy alternative (Weiss, 1979). This theory is supported by many sources (E. M. Glaser & Taylor, 1973; Knott & Wildavsky, 1980) as the "best way to transfer new technology is through the movement of knowledgeable people" (Brooks, 1967).

The enlightenment model assumes that scientific results influence decision-makers gradually over the years through indirect and informal channels of communication, and it is difficult for policy-makers to pinpoint which research result or

author influenced a certain policy change (Pope, Mays, & Popay, 2007; Stephenson & Hennink, 2002; Weiss, 1979).

The systems thinking model is a more recent approach to the science and policy relationship. It holds that the knowledge that is embedded in systems or organizations is important in guiding how the research is used. This knowledge is intertwined not only with relationships but also with the contexts, priorities, and the culture of systems (Best & Holmes, 2010).

Policy networks play an important role in the interactive networks, enlightenment and the systems thinking models. Policy networks are experts, individuals, organizations, or citizen groups linked together through a specific theme or a problem. Networks provide "communication channels for the exchange of ideas, data, and trust which identify gaps and opportunities within a policy domain" (Baker, Dickson, & Moon, 2008). The functions that characterize policy networks include connection, collaboration, and feedback (Baker et al., 2008).

In addition to the models described above, there are four key factors affecting the use of research (Nutley, Walter and Davies, 2007, Chapter 3). They are:

1. The nature of the research to be applied, such as the quality of findings, methods and timeliness;

2. The personal characteristics of both researchers and potential research users, such as the research users' educational background and attitudes towards policy change;

3. The links between research and its users, such as physical access, the existence of knowledge brokers and personal contacts between researchers and research users; and

4. The context for the use of research, such as interests and organizational culture.

The factors that affected the research and how they related to the science-policy interface in Maryland climate adaptation will be discussed in Chapter Four and Chapter Six.

Despite the development of models and approaches for bridging the communication divide between scientists and decision-makers, the growing scientific evidence to support decision-making about climate change has not reconciled conflicting beliefs about the need for action (Sarewitz, 2004).

Uncertainties associated with adaptation efforts are usually related to the inability to assess future impacts because of the limitations of climate impact models to consider all factors that have an influence on impacts (Dessai, Hulme, Lempert, & Pielke Jr, 2009).

This uncertainty makes it difficult to decide with confidence which types of adaptation measures are needed. In fact, many decision-makers' and scientists' call for more accuracy in future predictions has discouraged and delayed the development of many adaptation policies (Dessai et al., 2009). This makes adaptation to climate change contingent upon accurate climate predictions, although it is widely accepted that

"accuracy of climate predictions is limited by fundamental, irreducible uncertainties" (Dessai et al., 2009).

Given that some level of uncertainty will always be present in predictions, it is more justifiable to adapt to the changing climate than not (Webster, 2003). Other authors support this assertion as well, and further argue that if the political will exists, decisions can still be made despite the presence of uncertainties (Dessai et al., 2009).

America's Climate Choices describes three approaches that have been employed in more recent times to address scientific uncertainty: the precautionary principle, staying the course, and cost-benefit analysis.

The precautionary principle is an approach wherein decision-makers take all necessary measures to avoid serious potential hazards regardless of the level of scientific uncertainty.

Staying the course refers to the other extreme, wherein decision-makers take no action until the need for action is necessary and there are only minimal uncertainties.

Cost-benefit analysis compares the benefits of taking action with the costs using present value dollars (National Research Council, 2011).

All three approaches have their limitations. While the first and second approaches are both risk-averse, the third one, although very popular, has its own sets of drawbacks. First, it is very difficult to accurately determine the cost of future climate change impacts. Secondly, it is extremely difficult to quantify equity across age, social, and geographical groups (National Research Council, 2011).

Adaptive risk management or iterative risk management is a forth approach that has been employed recently to deal with scientific uncertainty (National Research Council, 2011). This approach consists of actions taken by decision-makers or a system (such as a government or organization) whenever there is a change exposure to risk. This approach requires a re-assessment of the previously chosen actions whenever new information becomes available (National Research Council, 2011; Scholz, Blumer, & Brand, 2012).

Literature review provides many examples of factors that influence the science-policy interface, as well as models that can improve that interface. Expanding our understanding of the ways that science-policy interface can improve the decision-making process, especially as it applies to a particular case study, would be a valuable contribution to that literature.

CHAPTER THREE: METHODS

As noted in previous chapters, this study aims to examine the science-policy interface during the development of Maryland's climate change adaptation strategies. Maryland's climate change adaptation strategies were developed as a part of Maryland Maryland's Climate Action Plan. The strategies were developed in two phases and were published in two reports:

1. *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change Phase I: Sea level rise and coastal storms* published in June 2008; and

2. *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change Phase II: Building societal, economic, and ecological resilience* published in January 2011.

This dissertation also examines the science-policy interface that took place during the subsequent integration of these reports into *PlanMaryland*, Maryland's State Development Plan, signed into law on December 2011.

This dissertation is guided by three principal research questions:

1. How did decision-makers obtain scientific information to develop climate change adaptation strategies?

2. How did scientists obtain relevant information on the policy priorities for the development of the climate change adaptation strategies?

3. What challenges were at the science-policy interface during the development of the climate change adaptation strategies, and how were they overcome?

   The sub-questions for the first two overarching questions are:

1. What (if any) established procedures are in place to ensure that research findings reach decision makers?

2. What (if any) established procedures bring policy agendas to the attention of the scientists?

   The dissertation propositions are:

1. Science-policy interface in Maryland is based on the problem-solving model.

2. Science did not adequately influence adaptation policy development in Maryland because of the lack of an effective dialogue at the interface between scientists and policy makers.

These propositions are based on a primary literature review which includes the Maryland Climate Action Plan (Maryland Commission on Climate Change, 2008a, 2011) and the findings of Hinkel (Hinkel, 2011) as well as numerous other articles on the need for improving the interface (Jones et al., 1999; National Research Council, 2010; Nutley, Walter, & Davies, 2007).

The above questions define this research as being exploratory in nature, and therefore favor a case study as a research strategy (R. Yin, 2009). The following sections discuss data collection including literature review, primary document review, interviews, and data analysis.

Data Collection

Case study data were collected by using multiple sources of evidence including literature review, primary document review, scoping interviews, and semi-structured interviews. Multiple sources of evidence were used to ensure triangulation of data, thus ensuring validity and increasing the overall quality of the study. Interviews were transcribed and coded using NVivo, qualitative data analysis software. Finally, the data was analyzed for emerging themes.

Primary Document Review

Primary document review provided important background information on the Maryland Climate Action Plan and other related reports issued by the Maryland Commission on Climate Change, as well as administrative documents such as agendas, minutes, monthly reports, grant proposals, and progress reports. Primary sources are particularly important as a source of unbiased information since they were not designed with my dissertation topic in mind. Additionally, they were a valuable source for triangulation of data. I collected primary documents directly from contributors to the two reports, and online whenever they were publicly available (Maryland Commission on Climate Change, 2008a, 2008b, 2008c, 2008d, 2011).

Interviews

This study's central approach to information collection was accomplished by interviews with experts working at the interface of science and policy-making and regulation related to climate adaptation in Maryland.

Interviews were conducted from February 1, 2012 to May 30, 2012 and again from October 1, 2012 to February 30, 2013.

The main criteria for choosing participants were (in the order of importance):

1. Participated in all sessions of the working group;

2. Was active in furthering adaptation strategies into PlanMaryland;

3. Active participant; and

4. Participated in the development of both Phase I and Phase II reports.

There were a total of thirty-five ARWG members that participated in the development of the Phase I report, sixty to seventy percent (twenty to twenty-five participants) of which participated in most sessions. About half of them were active participants (ten participants).

The Phase II report was developed by approximately one hundred ARWG and STWG members. About sixty percent of them participated in most sessions; of these only about thirty percent were active participants (eighteen participants).

Participants that engaged in further promoting adaptation strategies were identified in later phases of the study.

I sent out meeting requests to thirty participants and followed up by telephone. I received a response from fourteen of them (forty-six percent response rate). Six of the

fourteen fulfilled all the criteria for choosing participants. Table 1 presents the participant sample and the criteria that they fulfilled.

Participants were interviewed over eighteen sessions. Half of the participants were decision-makers (including scientists working as decision-makers) and half were scientists working either in academia or the private sector. About half of the respondents contributed to both the Phase I and Phase II reports and three were STWG members who contributed to the Phase II report. Others (too few to identify numerically) also contributed to the integration of adaptation strategies in PlanMaryland.

I interviewed three additional participants that did not attend all the meetings and where not active in brainstorming sessions that they had attended. The responses of this group of participants were very similar to those of active participants in terms of how science-policy interface works in Maryland. However, I did not include their responses in the analysis since they did not feel confident that their opinions depicted the right picture of the science-policy interface during the development of adaptation strategies. They were not active as they felt they were not the right fit for this effort. Table 1 presents the participant sample, but does not report on PlanMaryland as the sample size was too small to ensure anonymity.

Table 1 Participant Sample

#	Participant	Phase I	Phase II
1	ARWG (D)	☐	☐
2	ARWG (D)	☐	☐
3	ARWG (D)	☐	☐
4	ARWG (D)	☐	☐
5	ARWG (D)	☐	
6	ARWG (D)		☐
7	ARWG (D)		☐
8	ARWG (S)	☐	☐
9	ARWG (S)		☐
10	ARWG (S)		☐
11	ARWG (S)		☐
12	STWG (S)		☐
13	STWG (S)		☐
14	STWG (S)		☐

Legend: (D) – Decision-makers; (S) – Scientists

Five interviews were conducted face-to-face, and the rest were conducted over the phone. Although the number of respondents was not large, the overlapping content and data saturation provided validity and adequate descriptions of the science-policy interface.

Interview preparation included research on the participant and the organization (DiCicco-Bloom & Crabtree, 2006).

The first three interviews were scoping interviews with general questions about the projects, descriptions of respondents' involvement in the process, and their satisfaction with the dialogue between scientists and decision-makers. Based on these three interviews and primary document review, I developed a conversation guide for the rest of the semi-structured interviews. The conversation guide is presented in Text Box 1.

The conversation guide ensured that each interviewee was asked the same questions, and it allowed for comparison among respondents.

It should be noted that the conversation guide left room for topics and questions that emerged during the conversation. This allowed the respondents to express their opinions on the subject matter and also describe certain situations the way they experienced them. As participants described their impressions, I asked questions that would elicit more detail and reveal why the particular information was important. At the end of each interview, I invited participants to provide any other information that they thought was relevant.

Text Box 1 Sample Conversation Guide with Decision-Makers

1. What is your present position?
2. If not the same, what was your position when you became involved in the development of adaptation strategies for Maryland?
3. What is your educational and professional background?
4. How did you get involved? Why do you think you were invited?
5. How were other experts identified? Is there a formal process that lays out the steps in identifying experts? (If the person interviewed invited any other member.)
6. What was the charge?
7. Please tell me how were the strategies/policy options developed?
8. Who suggested the strategies/policy options?
9. How was scoping done?
10. Did everyone agree?
11. How was the problem identified? Where did the ideas come from?
12. How did you obtain information on climate change risks? Are there any procedures in place on how the scientific information is obtained?
13. How were projection scenarios selected? What other scenarios were considered?
14. How important is it to rely on science for climate adaptation policy development?
15. How would you describe your interaction with scientists (or decision-makers)?
16. What are your thoughts about this process?
17. Where there any challenges?
18. How were they overcome?
19. During this process, did you see any shifts in how scientists and policy-makers interact?
20. How would you improve that interaction in the future?

Each interview lasted one to two hours and was recorded with the respondents' permission. The records were then transcribed verbatim and entered in the database so that the raw data could be systematically analyzed. During this phase, data was verified and rechecked, and when needed, interview questions were adjusted to ensure better transparency.

To prevent any bias, some of the quality criteria I used included triangulation of not only document sources, but also of information received from different participants

through interviews. This was done to corroborate the same fact, or conclusion, and establish and maintain a chain of evidence.

Data Analysis

To analyze the interviews, I used grounded theory analysis. Grounded theory is an inductive method that is used to generate theories or hypotheses (B. G. Glaser & Strauss, 1967). During the analysis, qualitative data is coded based on the meaning, then categorized based on properties and the relationships among different categories. Grounded theory is characterized by the ongoing contrast and comparison of data throughout the process while simultaneously deciding which data should be collected next while the theory evolves.

In this dissertation, the theory had started to evolve before the data collection started. During literature research for the research proposal, and my previous work experience as a consultant for the U.S. EPA and other agencies, it had become evident to me that thematic networks of experts (e.g. decision-makers and scientists who worked on the protection of stratospheric ozone layer over decades) play a crucial role in ensuring the smooth transition of information between scientists and decision-makers.

Later during the data collection phase, the information found in the literature and primary document review, as well as interviews with participants, provided insights that augmented the above-mentioned theory. However, I kept an open mind for other emerging theories.

The dissertation followed the three main stages of grounded theory analysis (Miles, 1994; R. Yin, 2011): open coding, axial coding, and selective coding. The

description of the process of coding below also includes an example of how one of the three theories discussed in this dissertation developed during the analysis of data. Only a select number of paragraphs and codes are presented as examples. These paragraphs are not verbatim transcripts of interviews to protect the sources of information.

Open Coding: Open coding via free nodes was the first step of the data analysis. I coded interviews and primary documents line by line to ensure that the analysis was not influenced by my preconceived ideas or questions. Interviews were coded based on the content or meaning and not the phrases used. For example, the following paragraph is in response to a question on how the adaptation need was identified and was subsequently coded as "*long-standing effort.*"

> *"It is hard to pin point how we decided to do adaptation work. It was a culmination of a lot of work that had been going on for a while on sea level rise and coastal hazard. We had done a lot of research and policy analysis, and education and outreach around these issues."*

The above excerpt makes evident that the identification of the need for adaptation was not a one step process; rather, it was the result of gradual long-standing work on sea level rise and coastal hazards.

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Table 2 Excerpts that were coded *long-standing-efforts*

Initial Question	Excerpts of Interviews with Different Participants	Open Code
How was adaptation included in the Climate Action Plan?	*When Maryland decided to include adaptation into Climate Action Plan, other states were dealing more with greenhouse gas mitigation in their Climate Action Plans because that's where the political interest was. We, on the other hand, saw that as an opportunity to advance our planning into sea level rise and tie the two together. We had already done a lot of research on sea level rise and coastal hazard planning, and we were able to connect the two, which is hard to do in some states.*	Long-standing efforts
How did you obtain scientific information to contribute to your subgroup?	*We had a lot of information readily available because of our long history of research on the Bay. We had the scientific and technical formation ready for a lot of areas, and we didn't have climate impacts researched for other areas, but we had a lot done on sea level rise. So we had the expertise ready, we just needed to involve these experts in this effort.*	Long-standing efforts

Table 2 presents some of the paragraphs that went under this code. As further

illustration, Table 3 presents some of the paragraphs that were coded "*existing*

relationships."

Table 3 Excerpts that were coded *existing relationships*

Initial Question	Excerpts of Interviews with Different Participants	Open Code
Did you know other participants in your work group?	*Yes, even if I had not met them before, I knew who they were. With the decision-makers, we had an existing relationship that was set up around the long efforts to restoring the Chesapeake Bay, and other coastal research, so, we had existing relationships, I mean the scientists and the state agencies. That structure is set up with respect to certain issues that we dealt with, but with respect to some other issues it was not set-up yet.*	Existing relationships
What established structured processes bring policy agendas to the attention of the scientists?	*In this case, we had a structured process. We created work groups that would work in a structured way to formulate policy options that were published as Phase I and Phase II reports. However, in general, my experience is to work more informally since I have worked for a long time on adaptive management with scientists in the academia and in the federal agencies. I have developed relationships with people based on my professional activities.*	Existing relationships
How did the decision-makers in the workgroup help bring policy agendas to the technical people?	*It was a brainstorming process. This is how it works in Maryland. In the state of Maryland a lot of policy makers are pretty well informed, they might not be research scientists but they are pretty well informed on what the issues are and they are pretty conversant with what the scientists are doing. We've been working together for a long time. And the community of scientists that are involved in these issues, many of them know the policy makers reasonably well so it is not difficult to engage in that discussion. For a decision-maker and a scientist working on the same issues, chances are, they went to school together. Like in my case. So the interplay of scientists and policy makers is a close relationship.*	Existing relationships

After initial coding, I reviewed the coded interviews to compare and contrast them and see what else could be categorized using the same code, and to ensure I was being consistent in applying the code. Initially, there were over 100 codes, which were consolidated iteratively to 26 open codes.

Open coding and constant comparison of data eventually led to the saturation of that concept or an exhaustion of the open codes. All codes were defined so that the study is transparent and verifiable (Miles, M., 1994). A code book from this study can be found in Appendix Two while an example is presented in Text Box 2.

Text Box 2 Code book example

Code 1: Long standing effort

Description: Coded when respondents mention historical work.

While coding, comparing and contrasting data, I also took notes to write initial findings and ideas.

Axial Coding: Once all the interviews have been coded, the central ideas had already emerged. In this stage, open codes from the first stage were broadly grouped based on relationships. Relationships based on the common influences to the central theories, context and other factors eventually led to one of the central ideas or theories. If two different codes referred to the same phenomenon, I grouped them together in the next, axial level of coding. For example, codes identified in Table 2 and Table 3 were categorized together under "*trust and cooperation,*" as presented in Figure 7. I also further compared and contrasted data, looking for codes that were exceptions and did not quite fit in those categories.

Selective Coding: At this stage, after coding all the interviews and classifying the codes in categories, a core theory emerged: **The science-policy interface works well**

when there is an accumulated social capital between the stakeholders in the science-policy interface. The emergence of this theory from codes is presented in Figure 7.
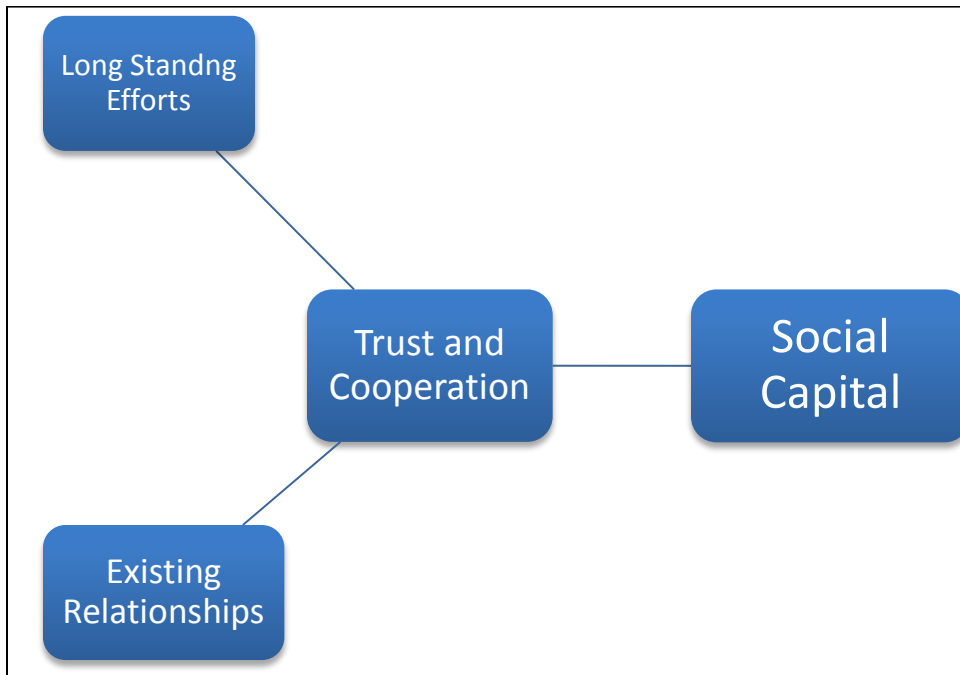
Figure 6 An example of three stages of coding

This chapter presented the methods, as well as the emergence of the central theory of this study. The next two chapters, Chapter Four and Chapter Five, discuss the two case studies. The central theory of this study, as well as other recommendations that emerge from the data analysis, are discussed in detail in Chapter Six. The emergence of two less central theories is presented in Appendix Two.

CHAPTER FOUR: AN ANALYSIS OF THE SCIENCE-POLICY INTERFACE DURING THE DEVELOPMENT OF THE MARYLAND CLIMATE ADAPTATION STRATEGY

This chapter presents data analysis and the themes that developed regarding the science-policy interface during the development of climate adaptation strategies in Maryland. The following sections present some background on the Maryland Climate Action Plan, and then discuss in more detail the development of the climate adaptation strategies. Finally, findings and how they related to the current literature are discussed.

Background

Maryland is among leading states of the United States in dealing with sea level rise and coastal storms. Additionally, Maryland is already implementing adaptive measures to reduce vulnerability to climate change. In fact, the State's work on climate change adaptation is an extension of the work on measures to reduce Maryland's vulnerability to coastal flooding which started several decades ago and which has increased the population's awareness of climate change impacts.

On April 20, 2007, Maryland formalized its response to climate change impacts. Governor Martin O'Malley signed the Executive Order (EO) 01.01.2007.07, which established the Maryland Commission on Climate Change ("the Commission").

The Executive Order charged the Commission with the development of a Climate Action Plan to address greenhouse gas emission reductions and prepare the State for the

likely impacts of climate change, and to establish goals and timetables for implementation. The Executive Order requests a progress report every November.

The Climate Action Plan is funded by the state government and legislature, while the work done by the Department of Natural Resources is also funded by the NOAA.

The Commission was supported by three Working Groups: Scientific and Technical Working Group (STWG); Greenhouse Gas and Carbon Mitigation Working Group (MWG); and Adaptation and Response Working Group (ARWG). Each working group was supported by subgroups specializing in their respective areas of expertise (Figure 7)
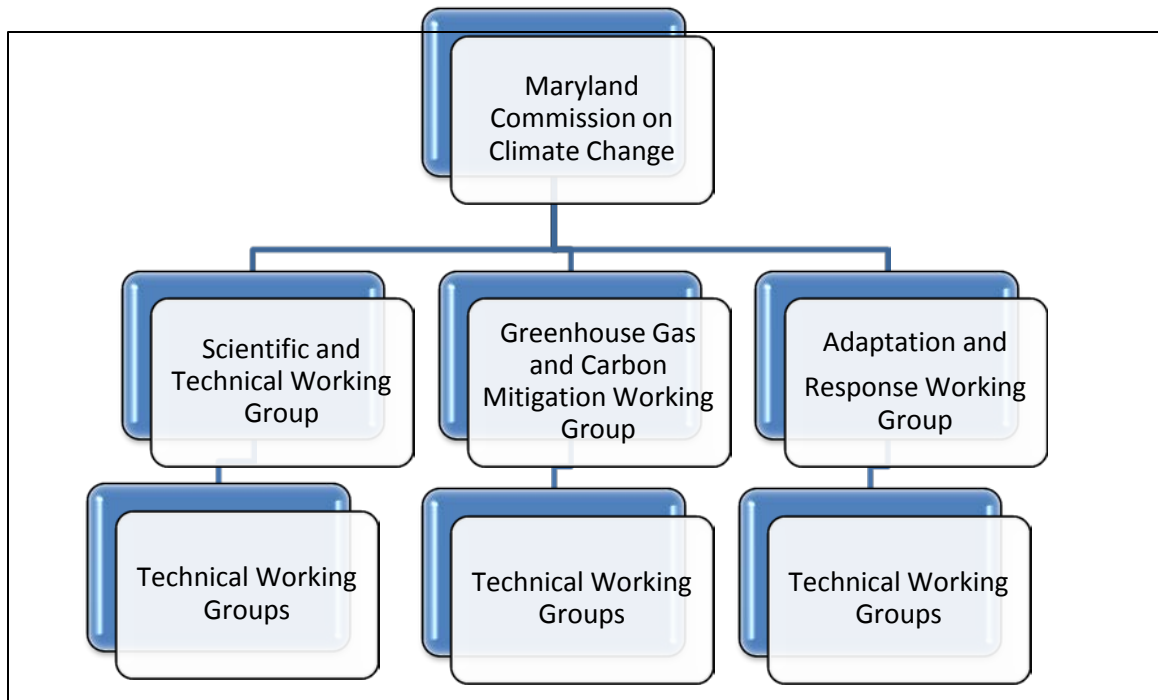
Figure 7 Maryland Commission on Climate Change Organizational Hierarchy (Personal Communication (February, 2012)

Figure 9 and Figure 10 presents areas of focus of technical working groups (or subgroups) that supported the development of Phase I and Phase II Reports. Members of the technical working groups were experts from academia, government, non-profit sector, and the private sector.

Members of ARWG and its subgroups were identified by their peers for their expertise and were approved by the Secretary of the DNR (Personal Communication, February 2011).

Governor O'Malley charged "the Commission" and the three working groups with the following questions (Maryland Commission on Climate Change, 2008c):

1. What can the State's best scientists tell us about how and when climate change will affect Maryland's citizens and natural resources?

2. What can Maryland do to adapt to the consequences of climate change?

3. What can Maryland do to reduce emissions of GHGs and the State's carbon footprint to begin reversing global warming trends?

The three working groups developed separate chapters of the Climate Action Plan, which was released in its entirety in 2008. They are:

- *Comprehensive Climate Change Impact Assessment (Maryland Commission on Climate Change, 2008b)*, by STWG;

- *Comprehensive Greenhouse Gas and Carbon Footprint Reduction Strategy* (Maryland Commission on Climate Change, 2008c), by MWG; and

- *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase I: Sea Level Rise and Coastal Storms* (Maryland Commission on Climate Change, 2008a), by ARWG.

Figure 8 lists the areas of focus of the ARWG subgroups in Phase I report.
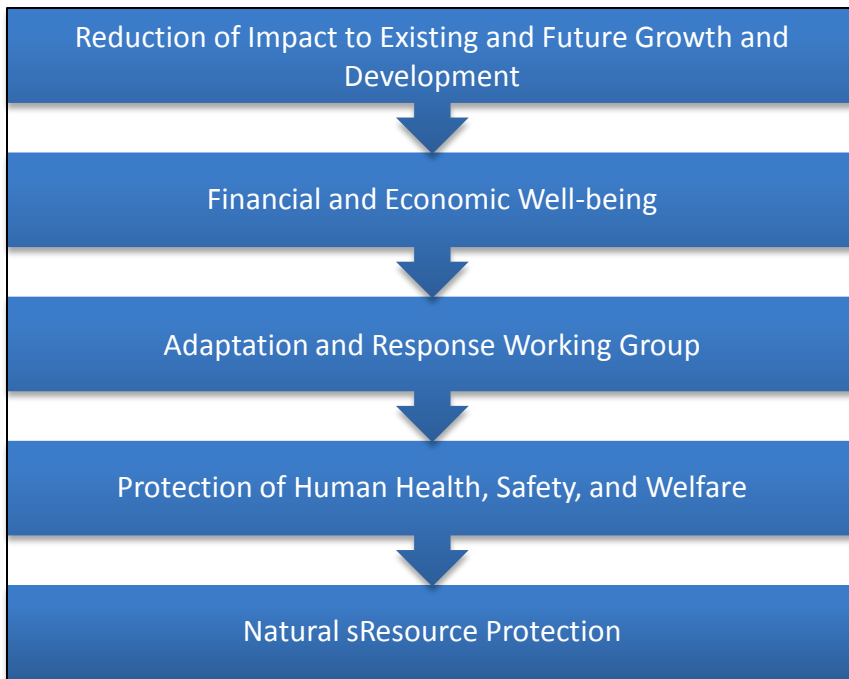
Figure 8 Phase I ARWG Subgroups

The key recommendations of the report are listed in Table 4. The Climate Action Plan also recommended that "the Commission" re-evaluate Phase I Report adaptation strategies appropriate for Maryland based on the *Comprehensive Climate Change Impact Assessment (Maryland Commission on Climate Change, 2008b)* prepared by the STWG, as well as the findings of ARWG in the Phase I Report.

The Impact Assessment projects a sea level rise of up to 1.3 feet by 2050 and 3.4 feet by 2100 (Maryland Commission on Climate Change, 2008b). This sea level rise indicates that current and future buildings and infrastructure could be impacted. This could not only create economic and social losses, but could also increase the rate of conversion of rural lands to development (Maryland Commission on Climate Change, 2008b).

Table 4 Key Recommendations of the Maryland Adaptation Strategies (Phase I)

| Recommendation	Requirement
Take action now to protect human habitat and infrastructure from future risks	Require the integration of coastal erosion, coastal storm, and sea level rise adaptation and response planning strategies into existing state and local policies and programs. Develop and implement state and local adaptation policies (i.e., protect, retreat, abandon) for vulnerable public and private sector infrastructure. Strengthen building codes and construction techniques for new infrastructure and buildings in vulnerable coastal areas.
Minimize risks and shift to sustainable economies and investments	Develop and implement long-range plans to minimize the economic impacts of sea level rise to natural resource-based industries. Establish an independent Blue Ribbon Advisory Committee to advise the state of the risks that climate change poses to the availability and affordability of insurance. Develop a Maryland Sea Level Rise Disclosure and Advisory Statement to inform prospective coastal property purchasers of the potential impacts that climate change and sea level rise may pose to a particular piece of property. Recruit, foster, and promote market opportunities related to climate change adaptation and response.
Guarantee the safety and well-being of Maryland's citizens in times of foreseen and unforeseen risk	Strengthen coordination and management across agencies responsible for human health and safety. Conduct health impact assessments to evaluate the public health consequences of climate change and projects and/or policies related to sea level rise. Develop a coordinated plan to assure adequacy of vector-borne surveillance and control programs.
Retain and expand forests, wetlands, and beaches to protect us from coastal flooding	Identify high priority protection areas and strategically and cost-effectively direct protection and restoration actions. Develop and implement a package of appropriate regulations, financial incentives, and educational, outreach, and enforcement approaches to retain and expand forests and wetlands in areas suitable for long-term survival. Promote and support sustainable shoreline and buffer area management practices.
Give state and local governments the right tools to anticipate and plan for sea level rise and climate change	Strengthen federal, state, local, and regional observation systems to improve the detection of biological, physical, and chemical responses to climate change and sea level rise. Update and maintain state-wide sea level rise mapping, modeling, and monitoring products. Utilize new and existing educational, outreach, training and capacity building programs to disseminate information and resources related to climate change and sea level rise.
State and local governments must commit resources and time to assure progress	Develop state-wide sea level rise planning guidance to advise adaptation and response planning at the local level. Develop and implement a system of performance measures to track Maryland's success at reducing its vulnerability to climate change and sea level rise. Pursue the development of adaptation strategies to reduce climate change vulnerability among affected sectors, including agriculture, forestry, water resources, aquatic and terrestrial ecosystems, and human health.

Source: Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase I: Sea Level Rise and Coastal Storms (Maryland Commission on Climate Change, 2008a)

As recommended by the Climate Action Plan, ARWG and STWG started work on Phase II of the Comprehensive Strategy to Reduce Maryland's Vulnerability to Climate Change in 2010 based on the findings of the Impacts Assessment Report (Maryland Commission on Climate Change, 2011). The resulting report, *Maryland's Climate Action Plan. Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change Phase II: Building societal, economic, and ecological resilience*, was released on January 2011. Figure 9 lists the ARWG and STWG subgroups and their areas of focus.
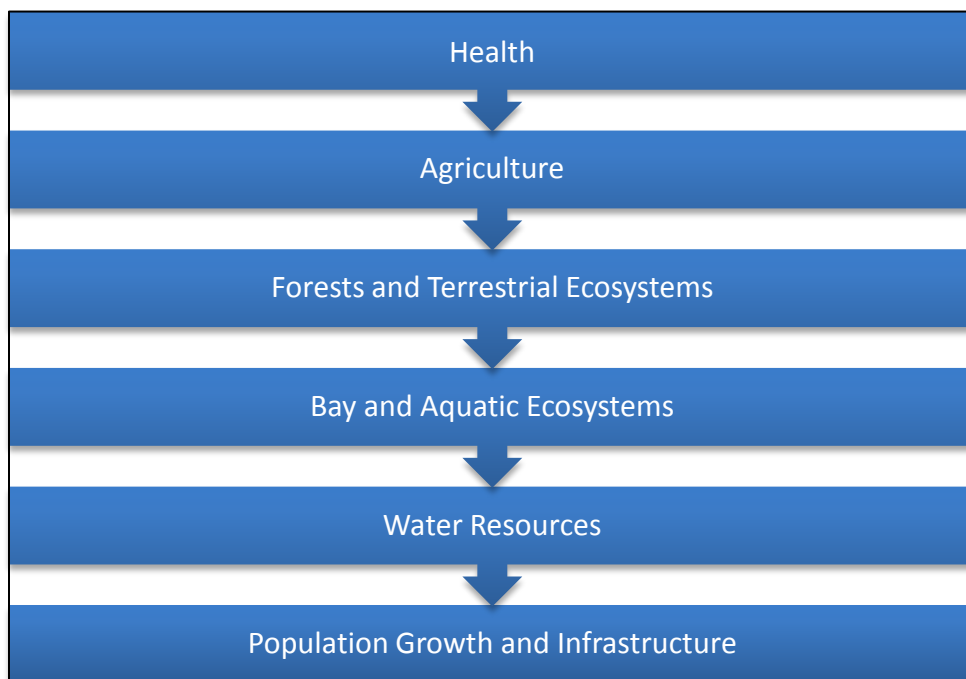
Figure 9 ARWG and STWG subgroups and their areas of focus

The STWG laid out an important foundation for the Climate Action Plan by assessing likely consequences of the changing global climate on the State's agriculture;

forestry; fisheries; freshwater, aquatic and terrestrial ecosystems; and human health

(Maryland Commission on Climate Change, 2008b). Their assessment was based on

extensive literature review and model projections (Maryland Commission on Climate

Change, 2008b). Additionally, local universities, federal agencies, and other groups

provided access to information relevant to climate change (Maryland Commission on

Climate Change, 2008a).

Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change

Maryland's development of an adaptation strategy was the culmination of years of

work on reducing vulnerabilities from sea level rise and coastal hazard issues. This work

was funded by the National Oceanic and Atmospheric Administration (NOAA) through

the Coastal Zone Management Act's (CZMA) Coastal Zone Enhancement Program

(Section 309).

The CZMA was adopted by the U.S. Congress in 1972 and provides a framework

for the management of national coastal lands. The framework provides policy guidance,

financial resources, and legal tools to increase states' capacity for coastal management

(Hershman et al., 1999). Maryland's Coastal Zone Management Program was approved

in 1978. Section 309 of the CZMA, as amended in 1990 and 1996, establishes a voluntary

coastal zone enhancement grants program. It also identifies climate change impacts as

one of the coastal hazards (Johnson, 2000).

Through this process, Maryland has conducted research and policy analysis while

also promoting education and outreach around the issues of vulnerabilities to climate

change impacts.

Maryland's Coastal Zone Management Program supports states' adaptation issues by providing information for or responding to specific requests by the Commission. Additionally, Maryland's Coastal Zone Management Program has also chaired and staffed ARWG.

As charged by the Executive Order in the Phase I Report, ARWG put forward nineteen priority policy recommendations focusing on the existing environment and infrastructure; future environment and infrastructure; human health, safety and welfare; and resources and resource-based industries (Maryland Commission on Climate Change, 2008a). For each policy option, ARWG also provided a detailed discussion of implementation mechanisms and identified new legislations or modifications to existing laws that would advance their implementation.

The Phase II Report outlines adaptation strategies to reduce impacts of climate change in the following sectors: human health, agriculture, forest and terrestrial ecosystems, bay and aquatic environments, water resources, and population growth and infrastructure.

Figure 9 and Figure 10 list the subgroups of Phase I and Phase II Reports, respectively. A full list of lead authors and subgroup members is presented in Appendix Three.

Findings

The Process

The development processes of both the Phase I and Phase II Reports were very similar. The working groups held a series of working meetings to identify and exchange

the most recent and relevant climate change literature, as well as evaluate adaptation options and recommend adaptation strategies to reduce Maryland's overall vulnerability to climate change.

In the development of Phase I Report, the facilitator handed out templates that needed to be filled out at the end of each brainstorming session or before the next meeting. The templates were used to draft the report. Participants of this study said that the use of templates made the process rigid as it what was difficult to fit the discussed topics in the templates. The templates had been created by the facilitator to develop strategies to reduce greenhouse gas emissions and had not been adjusted for developing climate adaptation policy options. All participants expressed frustration with this type of process, and preferred the more fluid process that was provided to them in the development of the Phase II Report.

In writing the Phase II Report, the new facilitator used storyboarding instead of the templates. A storyboard is a "series of cells (drawings, photographs, paintings, etc.,) physically arranged to tell a story in a specific sequence" (Sova & Sova, 2006). It was originally developed by Walt Disney Studios to help producers visualize the film and find and prevent potential problems. Storyboarding is increasingly being used in technical report writing as well, as it allows the writer to visualize the whole report before it is finalized (Greenly, 1985; Larkin, 1996).

Figure 11 presents the process that was developed and, based on interview responses, successfully used to write the Phase II Report.
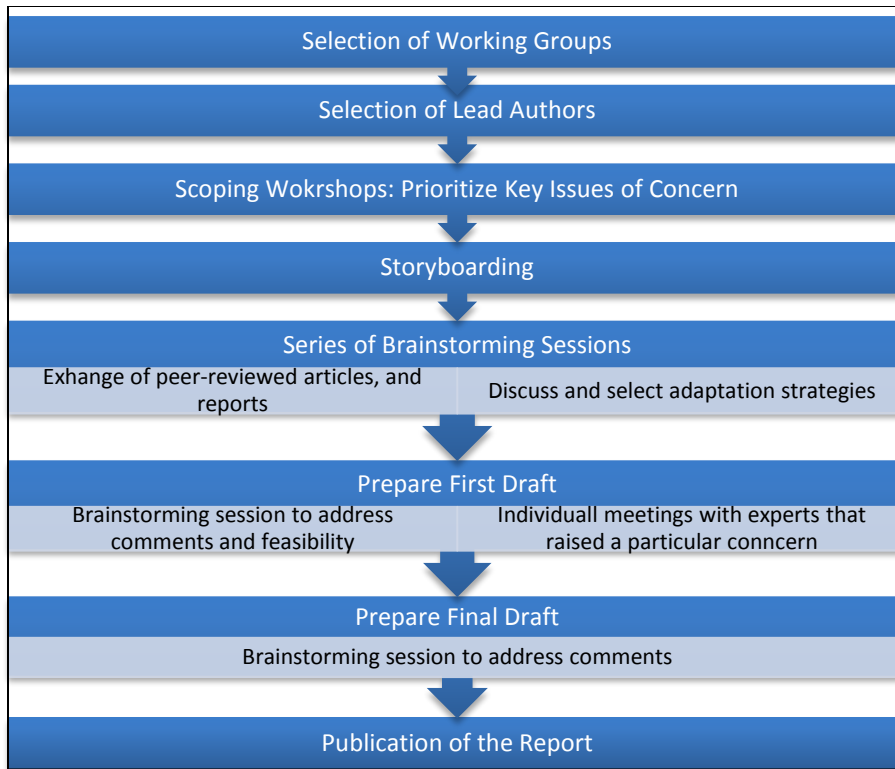
Figure 10 Adaptation and planning process in Maryland

The initial step in the process was to select experts/working group members who would cover all scientific areas that were discussed, as well as sectors such as real estate industry, insurance industry, marine trades, etc. The experts/working group members were selected by the coordinating agency, the Department of Natural Resources. All working group members were to be approved by the Governor.

The selection of the experts was done in several ways: Some experts were identified through their publications and work. Others were recommended by the already identified experts or staffers of the Maryland DNR. The majority of interviewed participants had volunteered to participate in the development of adaptation strategies and were approved.

The second step in the process was the scoping sessions: Each subgroup represented a sector and conducted a series of brainstorming meetings to identify key issues that needed to be included, existing policies that could address those issues, and new strategies to address those issues. The majority of respondents were satisfied with the process. For example,

> "*It was a pretty robust process. The first brainstorming session was about generating ideas on what the major issues are that we have to deal with (extreme events, vulnerability, etc.), and then what can we do about this.*" Excerpt from an interview held on March 21, 2012.

> "*[In] the second brainstorming session we identified what the institutional frameworks are, or structures that we have in terms of our society or management, regulatory framework that we can use to address these issues?*" Excerpt from an interview held on March 20, 2012.

> "*The third brainstorming session was about the strategies to address these key issues that we agreed on in the previous brainstorming session.*" Excerpt from an interview held on December 19, 2011.

The next step included the development of the first draft. Based on storyboards and notes from the brainstorming meetings, lead authors, with assistance from the facilitator, drafted the report.

The first draft of the report was reviewed and in the next session comments and concerns were addressed. If an expert or a select group of experts had particular strong concerns with an issue, the lead author and the facilitator and the coordinating group met with them to resolve the issue. All respondents felt that their concerns were addressed and their expertise was taken into account.

The final draft was completed and reviewed in the next step. All remaining comments were addressed.

The final step included the publication of the report.

Science-Policy Interface

Decision-makers interviewed for this research indicated that it is very important to rely on science when developing climate policies. All participants agreed that climate change is a complex issue and that science provides a basis for stating that there is a problem that needs to be addressed. The majority of participants also agreed that climate science provides one of the most important perspectives, but it is not the only factor to consider. Socio-economic factors are also important to agenda setting as well as policy alternative selection.

The following sections analyze this science-policy interface during the development of the Phase I and Phase II Reports.

Climate Change Impacts Information Use by Decision-Makers

Based on the scientist respondents of this study, Maryland decision-makers are very well informed about research findings related to climate change impacts in Maryland, as well as climate-related research in general. This is probably the result of

decision-makers that work on climate adaptation planning having both science and policy backgrounds. All decision-makers interviewed hold advanced degrees in science with additional policy training, and have years of experience in decision-making.

The primary climate change information source for the Adaptation and Response Working Group members during Phase I was the Scientific and Technical Working Group's projection of Maryland's sea level rise. The Scientific and Technical Working Group projection was based on the 2007 IPCC global sea level rise projections, along with regional land subsidence variables. This projection spanned from a conservative estimate of relative sea level rise of 2.7 feet (lower-emission scenario) to as much as 3.4 feet (higher-emission scenario) by 2100 (Maryland Commission on Climate Change, 2008a). For Phase II, the primary source of information for sea level rise was the research that was conducted for the CZMA. For other sectors, the primary source of information was the STWG report, *Comprehensive Assessment of Climate Change Impacts in Maryland (Maryland Commission on Climate Change, 2008b).*

Interviewed decision-makers, subgroup members and lead authors identified several ways of obtaining the climate science information they needed. These included peer-reviewed journals, IPCC Reports, conferences, forums and workshops, professional associations, and direct observation. The most dominant source of information on climate change for policy-makers was peer-reviewed journals. For instance:

"*For this work, I mostly relied on peer-reviewed articles. I've got three filing cabinets that are packed with research articles and a whole floor out there with*

research articles on monitoring etc., but we don't do a lot of looking at basic

relationships, e.g., the basic relationship between algae and fish. I mostly looked

at other peoples' research and tried to figure out what does this mean for the

decisions that I have to make." Excerpt from an interview conducted with a

decision-maker on March 20, 2012.

Other experts are informed about climate change impacts through the work that

they have done over the years. For example,

"We had a lot of information readily available because of our long history of

research on the Bay. We had the scientific and technical formation ready for a lot

of areas, and we didn't have climate impacts researched for other areas, but we

had a lot done on sea level rise. So we had the expertise ready, we just needed to

involve these experts in this effort." Excerpt from an interview conducted with a

decision-maker on February 20, 2012.

Another decision-maker had a similar response,

"There is a body of knowledge that we were all familiar with. We used that

knowledge when we developed this report. This is the body of research that we

had and we applied that in the development of strategies. In terms of conducting

research and monitoring for our subgroup, we were primarily scientists and

decision-makers. We do a lot of assessments; it is our job to evaluate the status

and condition of natural resources in Maryland. Because of that, we constantly

evaluate environmental change, and we have a collective eye on adaptive

management. Because we come from the adaptive management framework and

we understand change in stressors and how it affects the condition of our natural

resources, we constantly look at how the environment is changing. Climate

change is just one stressor." Excerpt from an interview with a decision-maker

conducted on March 20, 2012.

Other methods of obtaining climate change information included direct communication

with scientists, attending conferences and workshops, and casual (informal) information

exchange with networks of scientists:

"In my experience, I also obtain information informally since I have worked for a

long time with scientists in academia and in federal agencies. I have developed

networks of people based on professional activities. There is another group that I

run that is comprised of agencies that manage land. As a result I obtain a lot of

information relevant to my work through that network too." Excerpt from an

interview with a decision-maker conducted on March 9, 2012.

Conveying Policy Priorities to Scientists

Scientists who were involved in the development of the Phase I and Phase II

reports have a good knowledge of the relevant policy-making processes which, according

to their own accounts, they follow on daily basis.

All scientists interviewed agreed that there is no procedure in place that is followed by policy makers to convey policy priorities to scientists. Scientists obtain information on their state's policy priorities through networks, informal processes, workshops, and conferences.

For the Phase I and Phase II Reports, the policy priorities were conveyed during the scoping meetings, as well as subsequent brainstorming meetings. During Phase II, for example,

"Our starting point was the Phase I Report (the coordinators presented the Phase I Report) and an articulation that there is an acknowledgement that there are other categories, like human health, that had not been addressed in the Phase I Report and that the state was now ready and prepared to begin to examine. This is the way that it was presented to us.

What was also important […] was that a leading body was able to share with us some of the actions that have been taken, for example, by state legislature, or things that were in the works as a result of the Phase I plan. So, it gave us, again, a very real sense of what the opportunities were at that point in time for pulling together a plan that could lead to very practical initial steps to adapt to a changing climate.

We were given a free hand to think about any issues we wanted to relate to our sector, and I was really struck by how well informed people from state agencies were about the climate science. They were also very informed about what was

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feasible. That really gave us a sense for what was doable and what was not doable. And that helped us craft a plan that could have a real chance at implementation." Excerpt from an interview with a scientist conducted on March 16, 2012.

Other scientists' perspectives on how the policy priorities are conveyed were more general. For example,

"Conveying Maryland policy priorities on adaptation - there are no structured processes but […] everybody who was involved is pretty familiar with policy. They understood what the core issues were. This is because the scientists who were involved in this are also pretty used to the whole notion of applied sciences as well. Even if they are doing pure research they know what the applications are. But, in the first session, we had a very good presentation of what the big picture is, why we were doing this, so that everyone is on the same page. We did ask clarifying questions, but we were pretty much given a good overview of what is needed from us." Excerpt from an interview with a scientist conducted on April 3, 2012.

Another scientist emphasized the informal ways of obtaining policy information,

"It was a brainstorming process. This is how it works in Maryland: […]A lot of policy makers are pretty well informed. They might not be research scientists but they are pretty well informed on what the issues are and they are pretty conversant with what the scientists are doing. We've been working together for a long time. And the community of scientists that are involved in these issues, many of them know the policy makers reasonably well. So it is not difficult to engage in that discussion. For a decision-maker and a scientist working on the same issues, chances are, they went to school together, like in my case. So the interplay of scientists and policy makers is a close relationship." Excerpt from an interview with a scientist conducted on April 17, 2012.

Asked if there are structured processes that bring policy agendas the scientists, a scientists answers,

"[W]e had a structured process. We created work groups that would work in a structured way to formulate policy options that were published as Phase I and Phase II reports. However, in general, my experience is to work more informally, since I have worked for a long time with scientists in academia and in federal agencies. I have developed relationsips with people based on my professional activities." Excerpt from an interview with a scientist conducted on March 16, 2012

Challenges and Solutions

The main challenges that the respondents identified included those related to process and uncertainties.

Process

For the Phase I report, a consultant facilitated the process. The facilitator guided a process that was very structured, and somewhat rigid, and not open to adjustments. All respondents' opinions can be represented by the following two excerpts:

"They provided some templates on how to frame the problem for decision-making. We had a hard time in using that process. The facilitator had helped a lot of states with developing their mitigation plans, and Maryland was the first state they worked on adaptation. So, they were using those same mitigation templates for adaptation. I guess the templates were all right, but there was just a lot of discussion and brainstorming that did not necessarily fit into the templates. Also, the working group had to sit down and fill out templates, and not everyone was willing to do that." Excerpt from an interview with a decision-makers conducted on February 10, 2012.

This scientist's opinion was quite similar to that of a decision-maker,

"[T]he templates had already been established. The facilitator let us know that they already had templates in mind for all sections and we were asked to stick to the templates. So, although the discussions were not focused, we were asked to fit

into these templates what was being discussed." Excerpt from an interview with a

scientist conducted on March 6, 2012.

For the Phase II Report, the coordinating body used a different facilitator and

organized the process somewhat differently:

"[The] Phase II Report process seemed a little different. The process was not as

structured. In this phase, storyboarding was used instead of the templates. This

was important because in terms of the research, the process that is used to engage

the working groups or the stakeholders seems to have a big influence on decision-

making or the output." Excerpt from an interview with a decision-maker

conducted on March 7, 2012.

Scientists' views were the same, as captured by the following excerpt:

"[I]n Phase II, we did a lot of brainstorming. We discussed the science, the major

issues etc., and the coordinator did the writing for the working groups. In my

subgroup, we did a lot of interviews. After someone had introduced a concept in

the meeting, we would call them after the interview and ask them to elaborate on

the issue, and we helped them articulate their recommendations, or their portion

of the write-up. So we made sure that everybody's ideas, and their words got into

the report." Excerpt from an interview with a scientist conducted on April 12, 2012.

It should be noted that the facilitators for the production of the Phase I and Phase II reports did not facilitate the transfer of information between scientists and decision-makers, or the content of the meetings. The lead authors of subgroups conducted the facilitation of content. However, the facilitator facilitated the process of information collection and writing. Nevertheless, all respondents considered the role of the facilitator a very important one. In the Phase I Report where the facilitator provided a rigid process, the consensus among groups' members was reached with more difficulty, while in Phase II, where the facilitator provided a more fluid process; there was an improvement in consensus as well as in the writing process. This is in line with findings from literature which suggest that restrictive processes decrease the satisfaction of groups related to the consensus reaching (Miranda & Bostrom, 1997).

Scope

Not all respondents identified setting the scope as a challenge,

> *"I don't recall any major disagreements, related to the scope, but we had discussions on what should we prioritize. But, again, at least within Maryland's community of scientists and policy-makers, most of these issues are not that terribly controversial. We don't question if the sea level will rise. We don't know how fast it is going to happen, but we know that it is ongoing to happen. We don't know what the range is, because there is uncertainty. But, we still have to figure*

out a way to reduce the vulnerability. In Virginia, for example, the attorney general is questioning if this is even going to happen and if any of this research is even valid. But, in Maryland we don't have these types of disagreements because the state makes decisions based on sound technical advice." Excerpt from an interview with a decision-maker, March 9, 2012.

A scientist on the other hand had a different experience,

"Well, it was a little challenging because when we got together the team started to ask about budgetary, institutional issues, etc., how is monitoring going to be done, etc." Excerpt from an interview with a scientist, March 20, 2012.

They overcame this scoping challenge by re-focusing the meeting,

"[R]ight upfront, we had to stop [discussions about budget etc.,] and explain that we are not here to fix everything that is broken, but rather we're here to work on climate adaptation plans. It is important to know that given the existing structure of the state, what are the most effective things we can do now to begin to increase the resilience of the state? So we needed to tell them that that we are not here to fix other things." Excerpt from an interview with a scientist, March 11, 2012.

Yet, a different opinion came from another scientist,

"We were certainly made aware that because we were speaking to the legislature, we had to be careful of the language that we were going to use so that we were not recommending things that can not be funded or that can not go through. So we were making recommendations for things that we thought were feasible to accomplish. There were studies that were ongoing and that weren't adequately funded, and if the state would agree to continue to fund them it would allow them to collect additional information that was necessary for policy recommendations. So we had discussions about this sort of thing." Excerpt from an interview with a decision-maker May 10, 2012.

In the beginning of the brainstorming sessions, in Phase II, after a brief divergence in opinions on the scope, the participants agreed to take every opportunity to include climate change adaptation planning to existing laws or new legislations.

Uncertainty

Challenges related to uncertainties are associated with the degree of change that is expected to happen at the local level. As explained by one decision-maker,

"[The] uncertainty factor is always a challenge. In Maryland, when we work with resource managers, people on the ground that are trying to plan, it does get to be difficult in that the changes that are forecasted by science. It is difficult to break that down to a finer scale. In other words, we know it will become warmer, more flood events etc., however, resource managers would like to know more

specifically for this watershed, how much more water am I going to get through

this drainage system as a result of this extreme weather. We can't get to that level

of prediction and that is a challenge that we need to overcome. We need to start

thinking [about] what we need to do to create a more resilient ecosystem,

knowing that we have these more extreme temperature regimes." Excerpt from an

interview with a decision-maker, February 22, 2012.

Solutions that were suggested are in line with the literature that states that given

that some level of uncertainty will always be present, the adaptation decision will

still need to be made (Dessai et al., 2009). When the political will is present, the

decisions to increase resilience are not met with resistance. This is how a

decision-maker describes the solution,

"[W]e are aware that we don't need to know precisely how much it will change in

order to start increasing resilience. So this is a challenge for the scientist, and the

decision-maker, but the decisions still need to be made." Excerpt from an

interview with a decision-maker conducted on March 9, 2012.

Another excerpt comes from an interviewed scientist,

"It is easy for scientists to come up with a report that highlights what the issues

are, but [they] might waffle a bit on what the recommendations are because there

is always a lot of uncertainty. So we had to be clear that despite a certain amount of uncertainty, there were some pretty clear facts about the recommendations that needed to be made." Excerpt from an interview with a scientist conducted on March 20, 2012.

Despite the many uncertainties related to the prediction of climate change impacts participants were able to propose and adopt policy alternatives related to reducing vulnerabilities. Interviewees mentioned several uncertainties associated with adaptation issues, especially uncertainties related to impacts at the local scale, but were able to suggest meaningful action to begin to increase resilience to those potential impacts.

Other Findings

An important finding from the interviews with both decision-makers and scientists is that they are part of a network that was created as a result of a long engagement in the issues of sea level rise and coastal hazards.

This is how a decision-maker answered the question of how it was decided to work on adaptation issues,

"It is hard to pinpoint how we decided to do adaptation work. It was a culmination of a lot of work that had been going on for a while on sea level rise and coastal hazard. We had done a lot of research and policy analysis, and education and outreach around these issues." Excerpt from an interview with a decision-maker conducted on March 9, 2012.

To the question of how did the state include adaptation issues in the Climate Action Plan, another decision-maker answers in a similar way,

"When Maryland decided to include adaptation into the Climate Action Plan, other Sates were dealing more with greenhouse gas mitigation in their Climate Action Plans, because that's where the political interest was. We, on the other hand, saw that as an opportunity to advance our planning into sea level rise and tie the two together. We had already done a lot of research on sea level rise and coastal hazard planning, and we were able to connect the two, which is hard to do in some states." Excerpt from an interview with a decision-maker conducted on February 20, 2012.

When asked if they knew other participants in their groups and subgroups, all of participants answered that they did know almost all of them. Below is an excerpt that represents the majority of the responses,

"Yes, even if I had not met them before, I knew who they were. With the decision-makers, we had an existing relationship that was set up around the long efforts to restoring the Chesapeake Bay, and other coastal research. So, we had existing relationships. I mean, the scientists and the state agencies. That structure is set up with respect to certain issues that we dealt with, but with respect to some other

issues it was not set-up yet." Excerpt from an interview with a decision-maker conducted on February 22, 2012.

Conclusion

Data analysis revealed several key themes regarding the interface between scientists and policy-makers in the context of Maryland adaptation planning strategies.

The work on Chesapeake and Coastal Zone Management Program over the past several decades has resulted in an evolution of the interface between scientists and policy makers in the traditional sense, to that of special networks consisting of scientists, policy-makers, local governments and communities, industry and others interacting with each other.

Also, because of the nature of the work of the Department of Natural Resources, all of the decision-makers interviewed stated that there is a culture of research in their organization, and as a result they are influenced by the research results in their field that are published in peer-reviewed articles.

Another important conclusion is the role of the facilitator. All interviewed respondents found that the change of the facilitator in the Phase II Report increased the satisfaction of the participants with regard to consensus reaching and report writing.

CHAPTER FIVE: SCIENCE-POLICY INTERFACE IN THE DEVELOPMENT OF THE CLIMATE CHANGE COMPONENT OF PLANMARYLAND

Background

Following the recommendations of the Phase I and Phase II Reports, Maryland passed two key pieces of legislation (Maryland Department of the Environment, 2011):

1. The Living Shoreline Protection Act of 2008 that requires the use of nonstructural shoreline stabilization measures, unless proven unfeasible;

2. Amendments to the Chesapeake Bay Critical Area Protection Act that requires:

    a. Increased vegetative buffers,

    b. Updated jurisdictional boundaries to account for sea level rise, and

    c. Consideration of coastal impacts during growth allocation decisions.

Additionally, Maryland made several modifications to existing laws and programs to include climate change adaptation policy recommendations (in line with Executive Order 01.01.2007.07).

Since reducing vulnerability from sea level rise is a complex task, the Phase I Report recommends integration of adaptation strategies into various relevant existing or new State and local government management regulatory programs. Table 5 lists state programs identified by ARWG in Phase I Report.

Table 5 State government programs where sea level rise planning can be integrated

Programs	Description
Designation of areas of critical state concern	State Finance and Procurement Article, Title 5, Subtitle 6 establishes the authority for the Maryland Department of Planning (MDP) to define areas of critical state concern. State and local governments should work together to define the geographic limits of areas potentially impacted by sea level rise, coastal erosion, and storm surge. Once defined, these areas should be formally designated as areas of critical state concern.
Planning and policy integration	See Table 6 for targeted activities.
State capital planning projects	Establish a directive and means to review all state-funded projects to determine the cost-effectiveness of minor alterations in the setback and/or design standards based on life expectancy of proposed structures in relation to projected levels of sea level rise.

Source: Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase I: Sea Level Rise and Coastal Storms (Maryland Commission on Climate Change, 2008a)

Additionally, the State of Maryland is integrating sea level rise policies developed by ARWG into different state agency policies (Maryland Commission on Climate Change, 2008a). Table 6 lists these planning and policy integration targeted activities.

Table 6 Targeted Activities for integrating sea level rise issues into Planning and Policy Integration

Activities
Utilize Geographic Information Systems (GIS) technology to analyze areas vulnerable to sea level rise in combination with jurisdictional and regulatory mandates of existing management programs, including but not limited to Green Infrastructure, Smart Growth, and Resource Conservation Areas.
Align State Smart Growth strategies, including Priority Funding Area requirements, to reflect population growth and development patterns in relation to areas vulnerable to sea level rise and coastal hazards.
Integrate planning for climate change and sea level rise into the Maryland State Development Plan, currently under development.
Direct existing land conservation programs, such as Green Infrastructure, Rural Legacy, Program Open Space, the Conservation Reserve Enhancement Program, and the Coastal and Estuarine Land Conservation Program, to consider the use of conservation easements and other land conservation initiatives as a means to protect key coastal areas vulnerable to sea level rise and to provide sufficient lands for wetland migration.
Evaluate state natural resource management practices and advocate the means for enhanced protection through such efforts as the promotion of 'living shorelines', tidal marsh restoration, increased vegetative buffers, bay island restoration, and land conservation.

Source: Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase I: Sea Level Rise and Coastal Storms (Maryland Commission on Climate Change, 2008a).

Findings

The Process

This section describes the process of incorporating the first key policy

recommendation of the Phase I report into PlanMaryland, which resulted in a new state

law. The Summary of the policy recommendation reads as follows:

"Take action now to protect human habitat and infrastructure from future risks.

Require the integration of coastal erosion, coastal storm, and sea level rise adaptation and

response planning strategies into existing state and local policies and programs. Develop

and implement state and local adaptation policies (i.e., protect, retreat, abandon) for

vulnerable public and private sector infrastructure. Strengthen building codes and construction techniques for new infrastructure and buildings in vulnerable coastal areas." (Maryland Commission on Climate Change, 2008a).

This is identified in the Phase I Report as *Policy Option FBEI-1: Integrated Planning for Coastal Erosion, Coastal Storms, and Sea Level Rise*. The goal of the policy is to enhance the State's and local governments' capacity to adapt and prepare for climate change impacts. This policy also aims to increase coordination and consistency between state agencies and local governments and create a framework for the integration of other adaptation proposals.

Further, policy option FBEI-1 calls for the Maryland Department of Planning (MDP), Department of Natural Resources (DNR), and Maryland Department of the Environment (MDE), in consultation with local governments, to investigate appropriate planning mechanisms to implement this policy option. PlanMaryland, the state development plan, was identified as the most appropriate mechanism to implement this policy. Implementing agencies are MDP, the Smart Growth subcabinet, and all other Maryland agencies. DNR coordinated the integration of adaptation components into PlanMaryland. DNR will also implement adaptation components of PlanMaryland.

PlanMaryland

PlanMaryland is a framework for collaborative work between State agencies and local governments to achieve smart growth goals (Maryland Department of Planning, 2011). Governor Martin O'Malley signed the PlanMaryland Bill into law in December 2011.

The same month, Governor O'Malley also signed an Executive Order (EO 01.01.2011.22) outlining the steps for the plan's implementation. The Smart Growth Subcabinet (established by Executive Order 01.01.1998.04) coordinates the implementation of the plan among State agencies and reports on the progress of its implementation. The Subcabinet provides a forum for exchange of information among different state agencies, as well as citizens and different stakeholders, and recommends to the Governor changes in State law, regulations, and procedures needed to support the Smart Growth Policy that incudes reducing vulnerabilities to climate change impact.

PlanMaryland establishes five preservation/conservation areas, shown in Table 7, including climate change impact areas recommended by the Maryland Commission of Climate Change.

Table 7 PlanMaryland Preservation/Conservation Areas

Preservation/Conservation Areas
1. Priority Preservation Areas for Agriculture
2. Natural Resource Areas
3. Water Resource Areas
4. Historic and Cultural Areas
6. Climate Change Impact Areas

Source: (Maryland Department of Planning, 2011)

The purpose of designating climate change impact areas is to "identify, map, preserve, and protect" critical natural and built environments from climate change impacts and natural hazards (Maryland Department of Planning, 2011).

The Maryland Commission on Climate Change considers climate change impact areas lands that are projected to experience relative sea level rise of at least 2.7 feet

(lower-emission scenario), and as much as 3.4 feet (higher-emission scenario), by 2100 (Maryland Commission on Climate Change, 2008a).

Climate change impact areas were designated by the ARWG during the development of the Phase I Report. During that process, DNR had provided the mapped-out climate change impact areas that were designated with the help of its Coastal Atlas. Coastal Atlas is an online mapping and planning tool that supports decision-making related to the Maryland coast (Department of Natural Resources, 2012a). Climate change impact areas are presented in Table 8.

Table 8 Maryland's Climate Change Impact Areas

Climate Change Impact Areas
Storm Surge Risk
Wetlands Adaptation
Sea level Rise Vulnerability
Erosion Vulnerability
100-year and 500-year floodplans
Wildfire Priority Areas
Drought Hazard Risk
High Quality Cold Water Resources

Source: Maryland Department of Natural Resources, 2012

In accordance with PlanMaryland, DNR reached out and encouraged local governments to designate climate change impact areas then develop local strategies to avoid or reduce impacts. *Climate Change Impact Areas: Planning for Climate Change*, a DNR outreach brochure, provides climate adaptation planning guidelines for local governments (Department of Natural Resources, 2012b).

Science-Policy Interface in Integrating Climate Adaptation in PlanMaryland

Interviewed decision-makers at MDP and DNR identified the Phase I and Phase II Reports as the only source of information and strategic guidance for the climate change adaptation component of PlanMaryland. Therefore, the science-policy interface findings discussed in Chapter Four apply to the science-policy interface during the incorporation of climate adaptation component into PlanMaryland.

Climate change impact areas were designated by DNR. This data was then offered to ARWG and STWG for use in the development of adaptation strategies. Hereafter, the implementation phase of PlanMaryland will include additional sources of information that will be identified at that time.

Conclusion

Based on the findings in this section, it can be concluded that the climate adaptation science-policy interface has not continued actively once the Phase I and Phase II Reports were finalized.

Upon completion of the reports, the coordinators were responsible for integrating the policy options from the Phase I and Phase II Reports into PlanMaryland. Therefore, conclusions below (Chapter Six) focus on discussing the science-policy interface in both case studies.

CHAPTER SIX: CONCLUSIONS

Introduction

This dissertation has examined the science-policy interface during the development of Maryland's climate change adaptation strategies. Special emphasis was placed on the climate change adaptation strategies published in the following two reports:

1. *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change Phase I: Sea level rise and coastal storms* published in June 2008 (Phase I Report); and

2. *Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change Phase II: Building societal, economic, and ecological resilience* published in January 2011 (Phase II Report).

This dissertation also examined the science-policy interface that took place during the integration of climate adaptation components into *PlanMaryland*, Maryland State Development Plan.

Research Questions

Based on findings in Chapter Four and Chapter Five, this section responds to three principal research questions:

Question 1. How did decision-makers obtain scientific information to develop

Maryland's climate change adaptation strategies?

For Phase I, the primary source of scientific information was the STWG's

projection of Maryland's sea level rise as well as the research that was conducted for the

CZMA. For Phase II, the primary source of information for sea level rise was the

research that was conducted for the CZMA. For other sectors, the primary source of

information was the STWG report, *Comprehensive Assessment of Climate Change*

Impacts in Maryland (Maryland Commission on Climate Change, 2008b). STWG

members that developed the report also participated in the development of adaptation

strategies. In the brainstorming sessions, they also presented those findings, as well as

other scientists that conducted research for the CZMA. Generally, based on interview

responses, there are no established procedures in place to ensure that research findings

reach decision-makers. The decision-makers' primary sources of scientific information

about climate adaptation strategies were written materials and formal communications

with scientists at conferences, workshops, and other professional forums. Written

materials – including journal articles, IPCC reports, conference proceedings, books,

newsletters, and professional journals – were the most important sources of information

in the first phase of the model. Formal events (such as conferences and other professional

meetings) and informal contacts with scientists (such as alumni reunions, social media,

lunch breaks during conferences and workshops) were important as well.

Although the literature argues that policy-makers do not use academic, peer-

reviewed articles (Kasperson & Berberian, 2011; Percy-Smith et al., 2002), interviewed

decision-makers emphasized that they rely greatly on peer-reviewed articles for their work. This probably reflects the fact that all decision-makers interviewed for this research have dual policy and science degrees, and live in a culture of research, where research is valued and used on their daily work. Decision-makers who have scientific backgrounds or are familiar with research have a more accepting position towards science and its importance for their work (Nutley et al., 2007).

Question 2. How did scientists obtain relevant information on the policy priorities for the development of Maryland's climate change adaptation strategies?

For the Phase I and Phase II Reports, the decision-makers from the DNR presented the policy priorities and the need for the development of adaptation strategies in the initial meeting, the scoping meetings, as well as subsequent brainstorming meetings. Generally, based on interview responses, there were no established procedures that bring policy agendas to the attention of the scientists. Interviewed scientists who were involved in the development of the Phase I and Phase II reports followed policy priorities of their state on a daily basis by reading the policy memorandums, publications of the Maryland General Assembly, regulations, and other relevant sources. Informal networking and exchange of information was mentioned as a significant source of policy information. Participation in various formal professional forums, task oriented meeting, workshops, seminars, and conferences was considered important as well.

Question 3. What challenges were at the science-policy interface during the

   development of the climate change adaptation strategies, and how were

   they overcome?

Ninety percent of respondents indicated that the main challenge at the science-policy interface was the process. As described in Chapter Four, during the development of the Phase I Report, the writing process included brainstorming and then, based on the notes from brainstorming, participants would fill out templates that were provided by the facilitator. The majority of participants found the templates too stringent, and the brainstorming proceedings could not fit into the templates. During the development of the Phase II Report, the process was improved by using a different writing procedure. The facilitator used a storyboarding approach, discussed in Chapter Four, to generate the final report. This adjustment allowed for all the ideas discussed in the brainstorming sessions to be included in the report. The storyboarding resulted in improvement of the science-policy interface by encouraging more exchange of ideas in the following brainstorming sessions.

Research Propositions

1. *The science-policy interface in Maryland is based on the problem-solving model.*

In contrast to the proposition, the exchange of knowledge in Maryland can be best described by the interactive model (Brooks, 1967; Weiss, 1979) of science-policy interface, and has elements of the systems model as well (Best & Holmes, 2010). The long-term engagement around Chesapeake Bay and CZM program has created a community of policy-makers and researchers as well as other and other relevant

stakeholders who interact regularly to discuss, and adjust their views based on new findings. Maryland has also developed into a "system" where knowledge that is embedded in it guides research use. As in the systems model, knowledge is intertwined not only with relationships but also with the contexts, priorities, and the culture of systems.

Also, given the long-term research that has taken place on sea level rise, the Weiss' enlightenment model is relevant to this case as well (Weiss, 1979). In the enlightenment model, scientific results influence decision-makers gradually over the years, through indirect and informal channels of communication, and it is difficult for policy-makers to pinpoint which research result or author influenced a certain policy change (Pope et al., 2007; Stephenson & Hennink, 2002; Weiss, 1979).

These models explain the communication between scientists and decision-makers that concludes with dissemination of research results. The models described above helped understand the beginnings of the development of the social capital. However, they were not sufficient for understanding the complete process of production of adaptation policy options in Maryland, thus creating the need for an alternative model of the science-policy interface that includes all observed steps in the process.

2. *Science did not adequately influence adaptation policy development in Maryland because of the lack of an effective dialogue at the interface between scientists and policy makers.*

The grounded theory that emerged from findings here challenges this proposition. As it is depicted in Figure 11 and then discussed in following section, science not only influenced policy development, but scientists are an integral part of the policy development process for climate adaptation in Maryland.

Proposed Science-Policy Model

Based on the findings from the Maryland case study, I recommend a new science-policy interface model founded on the concept of social capital. The most frequent definition of social capital is the "features of social life—networks, norms and trust—that enable participants to act together more effectively to pursue shared objectives" (Putnam, 1995). In this case study, social capital refers to the community of scientists, decision-makers, citizen groups and other stakeholders that have been working together on a variety of issues related to sea-level rise and coastal hazards, as well as other environmental problems. The proposed three-component model guides a decision-making model that culminates with the production of policy alternatives. The model suggests that Maryland's rich social capital among scientists and decision-makers increased access to knowledge via the ongoing exchange of ideas over time, thus ensured an efficient interface in the development of climate adaptation strategies.

Relationship building is the first step in the proposed model for describing how an optimal science-policy interface is achieved, as depicted in Figure 11, below.
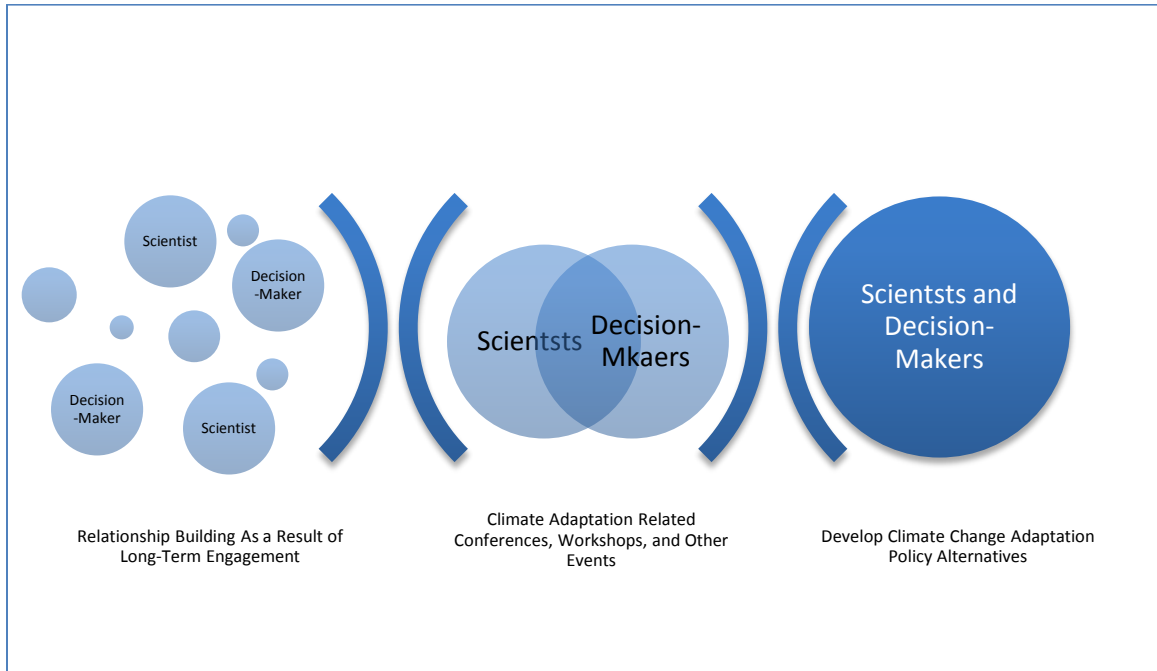
Figure 11 Recommended Science-Policy Interface Model for Developing Adaptation Policy Alternatives

In the first component, scientists produce the science while decision-makers convey the challenges that they are currently facing and/or anticipating. As described in Chapters Four and Chapter Five, Maryland's work around adaptation planning started decades before the adaptation strategies were formalized in 2007. Vulnerability to sea level rise and coastal hazards has been a concern among citizen groups, non-governmental organizations, researchers and State and local governments. They discussed this vulnerability with each other over time (Interview sources, 2012). These problems and the latest best solutions to them have also been debated regularly by the leading experts and the decision makers inside and outside the government (Interview sources, 2012).

In this first component, science and policy connect through policy networks that include policy communities, epistemic communities, and issue networks.

Maryland policy communities working on adaptation issues know each other's work and know each other personally as well. Policy communities include actors with a stake in a certain issue (Badie & Morlino, 2011),.

Haas' (1992) concept of epistemic communities is pertinent here: They are knowledge-based communities that can include state, national and international experts who are leading authorities in their field. Maryland decision-makers often ask science-related epistemic communities for their input.

The science-policy interface in the first component of this model, like the science-policy interface related to adaptation in Maryland, is also pushed forward with the help of issue networks. Issue networks consist of stakeholders who are interested in a particular policy issue. Adaptation strategies in Maryland were developed in part by various experts who are interested in the issue and have volunteered their time to develop the adaptation strategies. This also supports Weiss' (1995) theory that issue networks are channels for communicating research, where "expert networks maintain contact over extended periods of time and the currency of exchange is information."

In Maryland, research had a cumulative influence on understanding not only the problem, but the questions as well. As a recent UNESCO paper notes, "the research for policy is not so much about providing answers as about changing the way questions are understood." In this manner, researchers and decision-makers, as well as other stakeholders, can begin to build a different response to those problems (Papanagnou,

2011). Thus, the Maryland research community, through work in CZMA has gradually influenced decision-makers as well as other stakeholders by framing the problems as well as the solutions to the problems. Decision-makers have also influenced the scientific agendas by communicating policy priorities at different periods of time, thus creating a two-way dialogue.

The next component of the proposed model includes information exchange in an organized manner through the attendance at conferences, workshops, and other joint science-policy events. This component presents opportunities for mutual influence and the discussion of uncertainties and decisions about the next steps. In Maryland adaptation planning, this component played a crucial role in information exchange between scientists and decision-makers. It prepared both scientists and decision-makers for the third component, adaptation strategy development.

The final component of the model is a deliberate, organized activity with a very specific goal. In the case of Maryland, the goal was the development of adaptation strategies with the aim of reducing vulnerabilities from the impacts of climate change. In this component, scientists and decision-makers work as one entity, with a shared goal of developing policy alternatives with the help from the best available science. In Maryland, the social capital building component, the first component, has helped with consensus building that was very important, especially with so many uncertainties related to climate impacts.

In the final component, despite the many uncertainties related to the prediction of climate change impacts, AWRG participants were able to propose and adopt policy

alternatives for reducing vulnerabilities. Interviewees mentioned several uncertainties associated with adaptation issues, especially uncertainties related to impacts at the local scale, but were able to suggest meaningful action to begin to increase resilience to those potential impacts.

It should be noted that this model is a live model and not static or sequential. The first component is always in the making, and second and third components happen or "live" in the first component.

Additionally, a very important feature of this model is the backgrounds of the scientists and decision-makers. Interviewed decision-makers had dual, science and policy backgrounds, e.g., masters' degrees in science with PhDs in policy, or some other science and policy combination. However, they are not researchers. Their job is policy-making. Interviewed scientists, on the other hand, know how to design and conduct research that is directly relevant to policy-problems and concerns, and know how to communicate their results to policy makers. But, they are not policy-makers; they are researchers.

The role of the facilitator was also mentioned as an important one, especially with respect to summarizing the conclusions of the brainstorming sessions. In Phase I, the facilitator asked the participants to summarize the conclusions of the brainstorming sessions in templates that were prepared for a mitigation project. In the Phase II Report, the facilitator provided a storyboard of the sections of the report and summarized the conclusions of the brainstorming sessions, consistent with best practices (Todd & Hayter, 2003).

Policy Recommendations for an Efficient Science-Policy Interface

The following factors lead to a productive dialogue between scientists and decision-makers prior to and during the development of Maryland's climate change adaptation strategies:

An effective science-policy interface gets created when the science and policy communities work jointly over long periods of time. This results in a culture of mutual trust and understanding, effective information sharing, and the shared ownership of problems and solutions. The main feature of the proposed science-policy interface model is the development of strong links and collaboration between the science and policy communities over the years that lead to the accumulation of social capital.

Participants in the study asserted that the main factors that led to an efficient science-policy interface were those that characterize social capital such as trust and mutual respect that were built through the work that was conducted over multiple decades. In this type of interface, scientists and decision-makers are partners in the production of both science and policy alternatives. Decision-makers are trained in science and keep up with the latest scientific information related to their field through peer-reviewed articles. They make good co-producers of science as they join the conversation prepared, and are not just passive listeners. Scientists are also informed about the applications of their research and the priorities of the policy-makers.

The science-policy interface model introduced here requires scientists that are experts in their technical fields and familiar with the policy context of their research (locally, nationally and internationally), or at a minimum are open to becoming familiar

with the policy context and implications of their research. These experts also need to know how to advance their technical results into the decision-making world.

The decision-makers who are directly involved with climate adaptation issues should either have dual science and policy degrees, or have science backgrounds with a minor in public policy, or be willing to become familiar with the science.

Established trust and cooperation, as well as familiarity with the work that is conducted within the policy network, lead to decision-making that is open to influence from the scientific community. This social capital leads to a dynamic interface between the two communities, which in turn leads to more accumulation of social capital.

Another important lesson from this case study is that when policy alternatives are developed in an organized forum with both decision-makers and scientists, it is imperative to use a good facilitator. This research has shown that a good facilitator, with good leadership skills, who is active and dynamic, is central for fostering a supportive learning environment for the group. The facilitator's use of appropriate process-support tools helped engage participants in generating ideas. Based on the case study, good facilitators do not structure the process unilaterally. Instead they ask for the input of the participants on how they would like to structure it. Sometimes, the facilitator offers a wide variety of choices such as brainstorming, calling caucuses, opening statement, among others. The main characteristics of good facilitators include the ability to create a safe environment for sharing ideas and building trust within the group. Good facilitators also listen actively, lead the process, and summarize the conclusions of the brainstorming process (Todd & Hayter, 2003).

Contributions to the Literature and Implications for Future Research

From 1970 to 2005, there were over 3000 peer-reviewed articles on decision support in general, but only 75 of them have addressed decision support and climate change (Pyke et al., 2007). This study contributes to the increasing literature on that topic. Much of this literature emphasizes the lack of communication and the weak linkages between science and policy. By contrast, this study demonstrates an example of strong linkages and exemplary communication between scientists and policy makers as a result of rich reserves of social capital.

Findings here could inform or contribute to future research on producing "best practices" for the science policy interface in general, and climate change in particular. The model that this dissertation presents is based on social capital that took decades to create. Although Putnam (1995) suggests that social capital in America is in decline, Maryland scientists and decision-makers have created strong social networks that helped improve the science-policy interface. However, I did not investigate the state of community among other stakeholders, like citizen groups. A better understanding of characteristics of institutions, or states like Maryland, that are more successful at building rich reserves of social capital would help create boundary organizations whose primary responsibility would be to build social capital. Boundary organizations are intermediary organizations that create linkages between science producers and users (Guston, 2001).

It is important to note that majority of interviewed participants in the development of Maryland's adaptation strategies had not been invited to participate, but volunteered to do so. Although this study does not investigate if any stakeholder who volunteered was

not approved by the governor, based on responses from those interviewed, it seems like whoever wished to participate could do so. If this is true, this could be viewed as a best practice for democracy at work, sending a strong message that open decision-making produces better results.

Also, although this case study is focused on Maryland as a "specific, unique, bounded system," its conclusions can be generalized to theory. This study reveals broader theoretical issues in science-policy interface, such as the development of social capital to improve science-policy interface, recruitment of decision-makers with both science and policy backgrounds, and use of dynamic facilitators with outstanding leadership skills.

Lastly, this study sheds light on the science-policy interface during the incorporation of the adaptation strategies into Maryland law. This study is a good gateway to further explore the science-policy interface during the implementation of Maryland's adaptation strategies by local governments, and similar initiatives elsewhere.

APPENDICES

MASON UNIVERSITY

TO: Dann Sklarew, College of Sciences

FROM: Keith R. Bushey   *Q1 V\p*
:   Chief of Staff, Office of Research

PROTOCOL NO.: 7500

TITLE: An Assessment of the Science and Policy Interface as Applied to Climate
            Adaptation Planning in Maryland

DATE: July 26, 2011

Cc: Iliriana Mushkolaj

Under George Mason University (GMU) procedures, this project was determined to be exempt by the GMU Human Subjects Review Board (HSRB) since it falls under DHHS Exempt Category 2, research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior.

You may proceed with data collection. **Please note that all modifications in your protocol must be submitted to the Office of Research Subject Protections for review and approval prior to implementation.** Any unanticipated problems involving risks to participants or others, including problems regarding data confidentiality must be reported to the GMU Office of Research Subject Protections.

GMU is bound by the ethical principles and guidelines for the protection of human subjects in research contained in The Belmont Report. Even though your data collection procedures are exempt from review by the GMU HSRB, GMU expects you to conduct your research according to the professional standards in your discipline and the ethical guidelines mandated by federal regulations.

Thank you for cooperating with the University by submitting this protocol for review. Please call me at 703/993-3088 if you have any questions.

INFORMED CONSENT FORM

Title: An Assessment of the Science and Policy Interface as Applied to Climate Adaptation Planning in Maryland

Researcher: Iliriana Mushkolaj, PhD Candidate, Environmental Science and Public Policy, George Mason University

This consent form, a copy of which will be left with you for your records and reference, is part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

Dear Participant:

The purpose of my research is to assess science and policy interface during the development of the climate change adaptation planning in the state of Maryland.

In this research I would like you to participate in a one-hour conversation to discuss your role in the process of the development of climate adaptation planning and your impressions of the science and policy interface during the development of the climate adaptation planning. With your permission, an audio recording will be made of the conversation. You can ask me at any time during the conversation to pause or stop. Your responses will be held in strict confidence to ensure your anonymity. All interviews will be coded to protect the confidentiality of the participant and entered in the database. The database as well as all electronic files will be password protected. The audiotapes and handwritten notes will be destroyed as soon as the conclusions are drawn. The data presented in the final report will not contain any references to individuals interviewed. The results and raw data may be shared with my Advisor, Dr. Dann Sklarew, Environmental Science and Policy Department, George Mason University and the results of this study will be reported with no reference to participants' names. Your mailing address will only be requested if you wish to receive the summary of research findings.

Your participation is voluntary, and you may withdraw from the study at any time and for any reason, and/or refrain from answering any questions you prefer to omit, without prejudice or consequence. There are no costs to you or any other party. Your continued participation should be informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

Please let the researcher know whether or not you agree to have your interview audio-taped.

Thank you for your time and consideration.

Iliriana Mushkolaj
PhD Candidate, Environmental Science and Public Policy

George Mason University
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4400 University Drive, MS 5C3
Fairfax, VA 22030

Dr. Dann Sklarew,
Professor
Environmental Science and Policy Department
4400 University Drive, 5F2
Fairfax, VA 22030

You may contact the George Mason University Office of Research Subject Protections at 703-993-4121 if you have questions or comments regarding your rights as a participant in the research.

This research has been reviewed according to George Mason University procedures governing your participation in this research.

If you wish to receive a copy of the research findings please provide your mailing address or email address.

Mailing Address: _____
Email Address: _____

APPROVED
t"X.)o
George Mason University

Dear Madam or Sir:

I was given your name by X.Y. who said that you could contribute tremendously to my research. My name is Iliriana Mushkolaj and I am a PhD Candidate in Environmental Science and Public Policy at the George Mason University. The purpose of my research is to assess science and policy interface during the development of the climate change adaptation planning in the state of Maryland. The title of my thesis is "An Assessment of the Science and Policy Interface as Applied to Climate Adaptation Planning in Maryland."

In this research I would like you to participate in a one-hour conversation.to discuss your role in the process of the development of climate adaptation planning and impressions of the science and policy interface. I would greatly appreciate if you could find the time to discuss this important issue with me. Attached to this e-mail, please find the consent forin.

Best regards,
Iliriana
Mushkolaj

APPROVED
t'SCJI)
George Mason University

Emergence of Other Themes

The main theme of this dissertation is social networks. However, there are a few other themes that could be followed besides social networks. These are policy networks and factors that lead to an improved science-policy interface.

Policy Networks

Within social capital there are networks of scientists and decision-makers that work on various issues related to climate change adaptation. These policy networks include policy community, epistemic community and issue networks. The emergence of this theory from codes is presented in Figure 12.

The responses that lead to open codes were omitted as they are sector specific and anonymity could not be ensured.
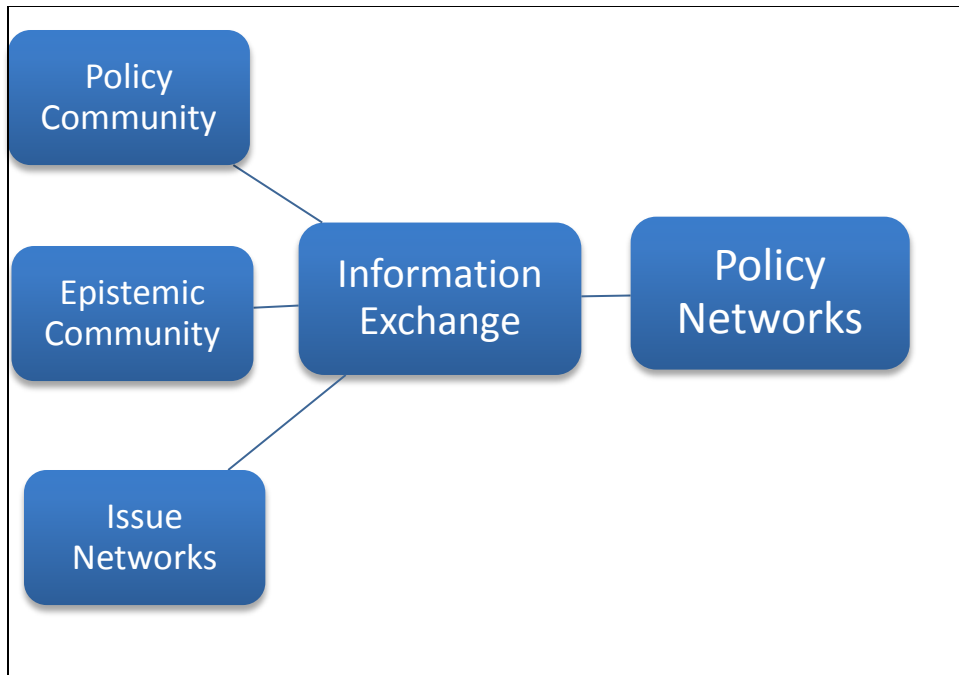
Figure 12 Three stages coding for Policy Networks

Factors that Improve the Science-Policy Interface

Within social capital there are networks of scientists and decision-makers that work on various issues related to climate change adaptation. An interesting characteristic of the participants of this study is that the decision-makers were trained in science with additional policy training. Also, scientists were also very well informed about the applications of their research, and with the priorities of the policy-makers. Collaboration amongst them leads to an efficient science-policy interface. The emergence of this theory from codes is presented in Figure 13.

The responses that lead to open codes were omitted as they are sector specific and anonymity could not be ensured.
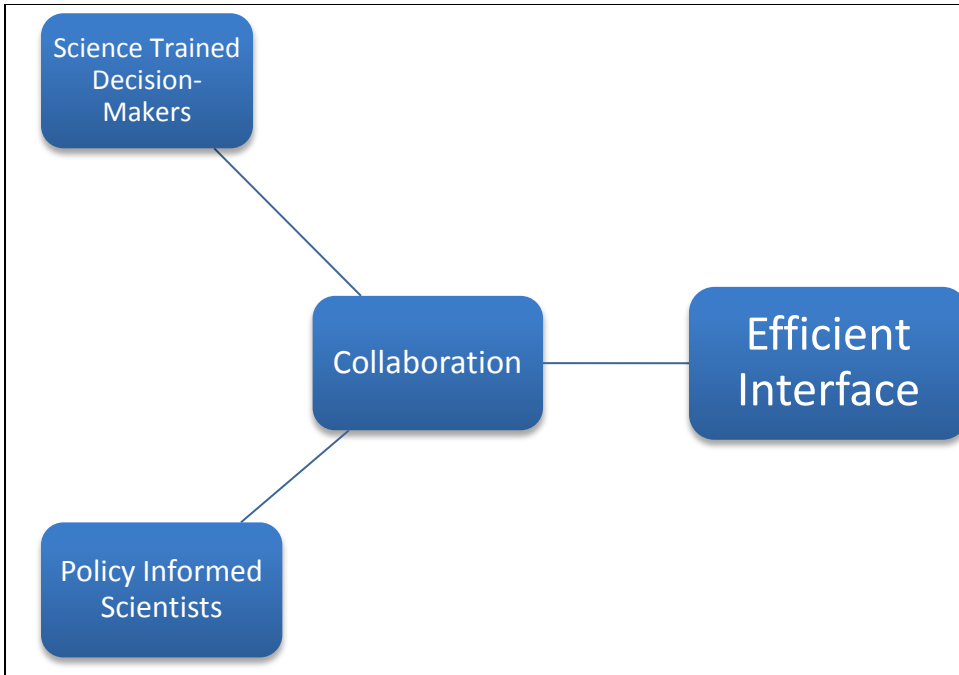
Figure 13 Factors that lead to improvement of science-policy interface

CODE BOOK

Text Box 3 Code Book

Code 1: Long standing effort **Description:** Coded when respondents mentioned historical work.
Code 2: Existing Relationships **Description:** Coded when respondents mentioned relationships that were formed before this effort.
Code 3: Issue Networks **Description:** Coded when respondents mentioned involvements of groups of experts interested in the same issue.
Code 4: Policy Community **Description:** Coded when respondents mentioned involvements of actors with a stake at a certain policy outcome.
Code 5: Epistemic Community **Description:** Coded when respondents mentioned involvement of knowledge based communities.
Code 6: Formal Communications **Description:** Coded when respondents mentioned conferences, forums, or other professional meetings.
Code 7: Informal Communications **Description:** Coded when respondents mentioned meeting with their peers for lunch during lunch breaks at conferences, dinner, and other similar informal ways.
Code 8: Writen Materials **Description:** Coded when respondents mentioned reading peer-reviewed articles, reports and other writen materials containing science information.
Code 9: Experience **Description:** Coded when respondents mentioned knowledge gained based on

experience.

Code 10: Factors **Description:** Coded when respondents mentioned factors influencing science-policy dialogue.
Code 11: Funding **Description:** Coded when respondents mentioned funding of projects related to climate adaptation planning.
Code 12: Policy Communication **Description:** Coded when respondents mentioned how policy priorities were communicated.
Code 13: Process **Description:** Coded when respondents mentioned anything related to the process of development of adaptation strategies.
Code 14: Facilitator **Description:** Coded when respondents mentioned the involvement of the facilitator.
Code 15: Drafting **Description**: Coded when respondents mentioned summarizing or writing the report.
Code 16: Improvement **Description:** Coded when respondents mentioned any imrovement to the science-policy interface.
Code 17: Uncertainty **Description:** Coded when respondents mentioned challenges related to uncertainties.
Code 18: Rigid process **Description:** Coded when respondents mentioned challenges related to rigid process during development of adaptation planning strategies.
Code 19: Challenges **Description:** Coded when respondents mentioned any challenges.
Code 20: Solutions **Description:** Coded when respondents mentioned solutions to challenges.

Code 21: Opportunity driven policy making **Description:** Coded when respondents mentioned acting whenever windows of opportunity opened.
Code 22: Agenda setting **Description:** Coded when respondents explained how the problems where identified.
Code 23: Advisors **Description:** Coded when respondents mentioned science advisors to the decision-making process.
Code 24: Brainstorming **Description:** Coded when respondents mentioned brainstorming.
Code 25: Technocrats **Description:** Coded when respondents identified themselves as scientists involved in decision-making.
Code 26: Science Communication **Description:** Coded when respondents mentioned how science is communicated to decision-making.
Code 25: Networks evolution **Description:** Coded when respondents mentioned the history of knowing each other and working with each other on adaptation adaptation issues.
Code 26: Culture of Research **Description:** Coded when decision-makers mentioned how much they value and use research in their daily work.
Code 27: Collaboration **Description:** Coded when respondents mentioned teamwork between scientists and decision-makers or between various networks.
Code 28: Science trained decision-makers **Description:** Coded when decision-makers said they have science training.
Code 29: Policy Informed Scientists **Description:** Coded when scientists mentioned that they tailor their results to the decision-making audience.

Code 30: Information Exhange

Description: Coded when responents mentione information exhange.

Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change. Phase I: Sea Level Rise and Coastal Storms

<u>Adaptation and Response Working Group</u>

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Co-Chair: Don Halligan, Asstistant Secretary, Maryland Department of Planning

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Comprehensive Strategy For Reducing Maryland'sVulnerability to Climate Change. Phase II: Building Societal, Economic, and Ecological Resilience

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