Perceptions of Watershed Management in the Erhai Lake Basin

Determining the feasibility of participatory-based simulation game development and use in the Upper Mekong Basin, Yunnan Province, China

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Heath Baumann
Robb Chapman
Chris Cook
Celine Debrosses
Caitlin Dufraine
Bruno Gabrielli
Yang Hu
Jill Knoll
Bill Lavinder
Jarrod Lichty
Darin Liston
Kelly Mattingly
Brian Milchak
Georgette Msambo
Mireya Pasa
Monica Pearce
Jay Pinsky
Yasmina Raya
Eric Ruffer
Michael Somerville
Aaron Weddle

Editors

Courtney Kimmel
Michael J. Mortimer
Maggie Striz Calnin

Executive Summary

Natural resource shortages are regularly at the forefront of environmental debates. Increasing population, increased resource use, changes in traditional practices and a multitude of other reasons have compounded these resource sustainability challenges. Identifying the most effective strategies for integrating conservation and development in particular ecological regions is critical and may include approaches that are highly technical. According to the Food and Agriculture Organization of the United Nations (FAO), "integrating activities for conservation and development through people's participation and collaboration among different institutional and social actors is being increasingly recognized as the most promising approach to sustainable natural resource management," (Warren 1998). A number of such methods have been developed in western, industrialized nations, and transferring them across geographies and cultures requires consideration of numerous factors, which is the premise of this report.

One method to reduce negative human impacts particularly on water resources is integrated watershed management (IWM),, a planning and decision making process that brings together stakeholder groups to coordinate resource use so that the long-term sustainable benefits are optimized and conflicts among users are minimized. IWM sets a specific geographic boundary of a watershed area in which planning and decision-making activities take place, with an effort recognize and manage for the various uses and demands on the resource in a holistic way.

Communicating the situation and engaging the full range of stakeholders in decision-making for IWM can be challenge as people are often spread across a wide geographic area, bring different cultural and political perspectives to the situation, and have different levels of background knowledge on the elements of watershed dynamics that must be managed. One method that has proven to make these scenarios and choices more accessible to a broader audience is to embed them in a gaming situation. *The Bay Game*, developed by the University of Virginia, is one such game that relies on computer modeling scenarios to illustrate the impacts stakeholders have on their environment and the ways their resource usage decisions relate to other decisions and ultimately water quality impacts. The Bay Game was built using participatory modeling methods and has been deployed to engage a broad range of stakeholders across the watershed of the Chesapeake Bay in dialogue about development choices across the watershed.

Like other large watersheds around the world, rapid growth and development on land is having increasingly compounded effects on water quality and quantity. The Bay Game allows players to assume the role of influential stakeholders within the watershed, make decisions about resource use based on motivations such as their livelihoods or regulatory authority, and learn how their decisions create economic and environmental impacts. The goal of the game is to help real-world stakeholders in the Chesapeake Bay better understand their impacts on the Bay and their relationships with other stakeholders, while at the same time leading to more informed policy-making and resource use decisions.

The question we explored through this study was whether such a tool as The Bay Game could be implemented in a non-western setting, namely in Yunnan Province, China which serves as the

headwaters region of the Mekong River Basin. This feasibility assessment was undertaken by the Virginia Tech Executive Master of Natural Resources (XMNR) 2013 cohort ("The Cohort") in consultation with the Stimson Center and The University of Virginia Global Water Games program (see "The Audience", below). This working paper describes the feasibility assessment in the context of the Erhai Lake Basin in Yunnan Province, including local perceptions of natural resource issues and technological capacity among the local population. In addition to the feasibility assessment, recommendations for implementing a participatory simulation model in the Erhai Lake Basin are offered.

Content

This working paper provides:

- Background information about the Erhai Basin, including the geographic area of interest, aspects of the natural environment, the social and cultural context in the Basin, current resource management activities and projected future management challenges.
- Discussion of the stakeholder groups The Cohort chose to engage and why
- Perceptions of environmental issues gathered from discussions with various stakeholder groups.
- A discussion regarding the current feasibility of developing a Bay Game type decision support and simulation tool to engage stakeholders in dialogue about sustainable forms of development in the Erhai Basin.

Findings

This feasibility assessment concludes that a participatory simulation game like The Bay Game, as it currently exists, would be difficult to implement as a means of building capacity for watershed management in Erhai Basin. Barriers to employing this approach in the Erhai Lake Basin include:

- Data limitations and uncertain data integrity. In many cases, available data is only in Mandarin, necessitating translation. This can be addressed by building stronger partnerships with Chinese organizations and institutions to develop the game.
- Stakeholders' limited access to technology, including computers. However, there might be alternative methods or technologies to deploy the game.
- Public perceptions that water and natural resource issues in the Erhai Basin are not as severe as in other locations in Yunnan. This could present a challenge for motivating participation, or as a point of pride for local communities and leaders, depending on how it's framed.
- Uncertainty whether government leaders would be supportive of development of such a participatory tool that builds capacity among civil society

Recommendations and Challenges

While developing and deploying a Bay Game type simulation tool in the Erhai Basin would be likely met with the barriers identified above, The Cohort has provided a number of recommendations that, if implemented over time, create capacity and structure to introduce a participatory model based simulation tool and game in the region. Near-term (0-3 years), mid-term (3-5 years), and

long-term (5-8 years) recommendations provide a phased approach that, through additional data collection and iterative development of simpler games, can provide the necessary data and engagement to build a more complex participatory model. Potential challenges associated with these recommendations are also discussed.

Audience

This feasibility assessment was initiated by Virginia Tech's XMNR Program and Center for Leadership in Global Sustainability (CLiGS), the University of Virginia's Global Water Games, and the Stimson Center ("The Partners") and undertaken by The Cohort. Findings and recommendations are primarily intended for The Partners to inform their goal and plan for building capacity among civil society to participate in IWM decision-making in the Erhai Lake Basin.

Table of Contents

Table of Figures

Table of Tables

Table of Appendices

1. Introduction

1.1 Background

In late 2012, Virginia Tech's (VT) Center for Leadership in Global Sustainability (CLiGS), the University of Virginia's Global Waters Initiative, and the Stimson Center (collectively, "The Partners") engaged the 2013 Cohort of the VT Executive Masters in Natural Resources Program (XMNR) (from here out referred to as "The Cohort") to assist The Partners in assessing the feasibility of applying high-tech, multi-agent simulation tools toward watershed health decision-making in rural China. The Erhai Lake Basin in China was chosen as the watershed study site due to its ecological and cultural significance, its location in the headwaters of the Mekong, its rapid development and rural to urban transition trends, and existing academic relationships between The Partners and other entities in the Basin, including private enterprises and faculty at the local Dali University.

Of particular interest as a model for a simulation tool was The University of Virginia's *Bay Game*™. The Bay Game is one type of participatory watershed management modeling and simulation tool currently being deployed as a game in the US engage a broad audience in dialogue about the decisions different key stakeholder groups in the Chesapeake Bay watershed have to make and illustrating the interactions and effects of those decisions on water quality and economic prosperity. Given the success of the game in the US, The Partners were interested in how a similar game might be developed effectively for other watersheds, particularly in Yunnan Province, China.

Similar to the Chesapeake Bay, the Erhai Lake Basin is experiencing its own complexities with watershed management, specifically degradation of water quality and decreasing water quantity. Like the Chesapeake Bay, Erhai Lake is in the headwaters region of the Greater Mekong River Basin, which presents transboundary management challenges. The Partners are well aware of The Bay Games' success in its intended use the United States, and are interested in how this multi-agent simulation tool could be translated to a different cultural and political context, with the idea that if successful, it could be scaled up to simulating the full Mekong Basin. Factors identified as initial points of inquiry for facilitating the transfer of the gaming model to a rural Chinese setting included cultural, local, social, technological, and political complexities would need to be taken into consideration in game development and deployment.

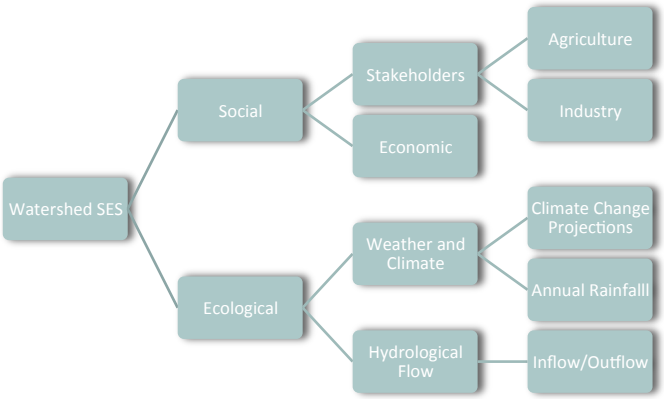

Figure 1. Example of Watershed subsystems

Watersheds are representative of complex socio-ecological systems (SES), which can be defined as intricate layers of subsystems that interact and impact one another in often subtle ways. Watersheds, in particular, consist of a number of subsystems with intricate dependencies upon one another. Figure 1 presents a conceptual model of a watershed SES and the

types of subsystems that interact on a variety of levels to impact the ecological health or state of a watershed. This chart could continue to expand as more becomes known about a particular watershed, which further increases the complexity and interactions that occur at each sublevel.

Because of these complexities, scientists, policy makers and planners have come to the realization that centralized, top-down approaches to watershed management may not be the only strategy used to improve watershed conditions. As a result, the use of IRM and IWM, as discussed in the Executive Summary of this paper, has become more widespread. IWM is unique compared to other land management practices because it considers that a watershed is made up of many land-use practices (e.g. agriculture, forestry, livestock production) that may vary in scale but all have an impact on overall environmental health within the watershed. Because of the incorporation of these various land use practices in the management of the watershed, IWM requires a participatory management framework that engages stakeholders in policy development, policy implementation, and creative solutions to natural resource challenges. The Bay Game is one tool to achieve this engagement.

1.2 Purpose of the Paper

This was undertaken to support The Partners' current and future work in the Erhai Basin. The primary objective of this feasibility assessment and report are to provide insights and recommendations for developing and implementing a multi-agent simulation tool based on The Bay Game in Erhai Basin, Yunnan Province, China. This exercise is a component of The Partners' overarching initiative to build capacity among civil society to advance more sustainable forms of development in the Province.

2 Erhai Basin Overview

2.1 Geographic Area of Interest

The Erhai Basin is located in west-central Yunnan Province (approximately 26° North, 100° East), 260km to the west of Yunnan's largest city, Kunming (Figure 1). The research and analysis detailed in this report is focused on the Erhai Lake Catchment Basin area, as defined in studies by Shang et al (2012), Mao et al (2012), and Yan et al (2008). Yunnan Province borders Myanmar, Laos, and Vietnam to the south and west, and shares a domestic border with the provinces of Guangxi, Guizhou, Sichuan, and Tibet. Erhai Lake is an alpine fault lake, and one of nine large (greater than 30km^2 in area) lakes in the Yunnan Plateau. Erhai Lake is located at

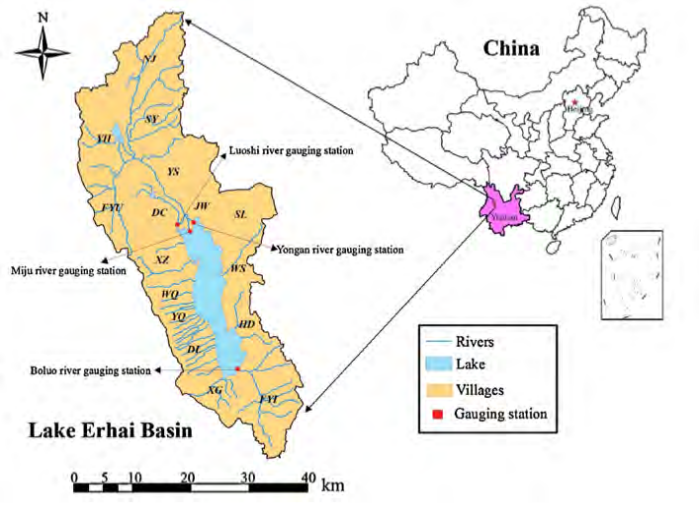

Figure 1: Geographic Overview of Erhai Lake Basin (Source: Shang 2012)

approximately 1,970m above sea level, and is oriented northwest to southeast. It measures approximately 42 km in length and 8.5 km at the widest point. The total surface area of the lake is estimated to be between 250 and 257km^2. The Erhai Basin covers nearly 2,656 km^2. Although the total volume of water in the lake fluctuates seasonally, the average volume is estimated to be close to 2.88×10^9 m^3 and the average depth is 10.8 m (Huang et. al. 1999, Wan et. al. 1988). The lake is fed by rainfall, snowfall, and several rivers and tributaries.

The monsoonal climate and dynamic hydrologic system in Yunnan Province makes water management particularly important. In the Erhai Basin, most of the annual rainfall (1,000-1,100 mm/yr) occurs between June and August. During the rest of the year there is minimal rainfall within the region. However, snowfall is common in the Cangshan Mountains, west of the lake, in the winter (according to locals we spoke with, snowfall has been diminishing in recent years).

There are 117 freshwater rivers and streams that flow into Erhai Lake. The Miju and Luoshi rivers, which enter at the northern end of the lake, provide approximately 70 percent of the lake's inflow; a number of smaller streams bring water from melting snow in the Cangshan Mountains to the western side of the lake, several other small rivers and streams, such as the Bolou River, enter the lake from the east (Crook et. al. 2008). The Xi'er River, located in the southwestern corner of the lake, is the lake's only river outlet. The Xi'er River runs through Xiaguan, the newest, most heavily populated area of Dali (Huang et. al. 1999). The Erhai Basin, and the water that flows through the Xi'er, is considered an important part of the headwaters of the Mekong River system, which flows from southwestern China all the way through Southeast Asia to the South China Sea (Mekong River Commission 2012).

2.2 Land use change

The importance of Yunnan and the Erhai Basin to China's future economic strategy is largely based in the natural resources and biological and cultural diversity of the area. Much of the local economy is based on region's natural capital, including tourism development and primary sector industries (e.g. timber, stone, metals). In order to begin understanding the relationships between stakeholder groups in the region, it is important to first consider land use and cover.

Within the Basin, land cover has been changing rapidly over the last several decades. **Error! Reference source not found.** and Figure 3 (Wang et. al. 2004) indicate land cover as it existed in the early 2000s, but given recent development trends observed many our informants, we question how the current validity of these percentages (The Cohort was unable to attain more recent land cover data).

Observations of state of land cover can only be substantiated anecdotally through The Cohort's

Observations of state of land cover can only be substantiated anecdotally through The Cohort's observations and information gathered during interviews, though we recognize the need to corroborate these observations with recent data sets before moving to the next phase of research. While outdated, the published data from 2000 still provides meaningful insights into land use activities in the Erhai Basin and provides context for development and economic development trends in the region. The prevalence of new development and construction observed, substantiated by reports from informants in our research suggests a rapid pace of development in the region.

Land Cover	%
Forest	45.1
Barren	26.3
Paddy Farmland	18.9
Dryland Farming	8.6
Water	0.7
Urban	0.2
Industry	0.1

Table 1 Land Cover within Erhai Basin

Figure 2: Land Use in Erhai Lake Basin (Wang 2004). The locations focused on by The Cohort are also highlighted.

2.2.1 Forestry

Forests have historically played an important role in the Erhai Basin. Anthropogenic pollen studies indicate that large-scale human activity resulting in changes in forest cover and type dates back to approximately 2160 BP (Before Present), a period that archaeological evidence suggests was marked with population growth associated with immigration as well as expanding agricultural activities (Yang et. al. 2005). Deforestation and changes in the forest have continued over time and increased at a greater rate in the last sixty years during China's Great Leap Forward (1958 – 1961).

During the Great Leap Forward forested land was cleared throughout China to create more arable land for agriculture and to provide firewood and kindling for heating, cooking and backyard smelting operations, among other activities. This led to extensive destabilization of soils and erosion. Over time, previously deforested lands either naturally regenerated or were replanted,

resulting in a significantly different distribution of species than had been in the region historically (Crook et. al. 2008). Forest management, as it exists today within the Erhai Basin, is fairly informal. Strict laws limit timber production, but illegal timber harvesting continues to be a problem.

2.2.2 Fishing and Fish Farming

Fish harvested from Erhai Lake has provided a primary protein source for local people and has served as a important part of the local economy. A number of fish species are native to the lake. Several of them, primarily carp and ice fish (*Neosalanx taihuensis)* are economically viable (Li 1999). The introduction of new species of carp into the lake starting in the 1950s increased total fish yields, but led to declines in native fish populations. It also created other environmental challenges for the lake (Yan et al. 2001). It widely believed by local people that the introduction of non-native fish is related to severe algal blooms that occurred in 1996, though the direct correlation is questionable. According to a fisherman interviewed by The Cohort, cage-net fish farming was drastically reduced within the lake shortly after the algal bloom. Fishermen began using more retention ponds located near the lakeshore. Though this form of aquaculture is removed from the lake, overflows of nutrient rich water often runs directly into the lake.

In the late 1990s, efforts to improve the health of the lake included changing the legal structure regulating fishing in Erhai Lake. Fishing in the lake is currently limited to two months of the year. Nonetheless, overfishing still occurs during these two months due to economic pressures including the demand for fish and the number of fishermen competing to meet demand. Enforcement of fishing outside of the restricted season appears be lacking, given that number of people fishing members of The Cohort observed while visiting outside of the legal season.

2.2.3 Agriculture

According to 2000 data, agriculture within the Erhai Basin made up nearly a quarter of the land use and based on observation continues to be a predominant land use. Agriculture also presents a significant water demand. Agricultural land uses in the area include paddy and dry farmland as well as pasture and rangeland for animal husbandry and dairies. The climate of the region allows for two growing cycles per year, one during the dry season and one during the wet season. The primary crops grown during the wet season are rice, corn, and tobacco. During the dry season, a variety of crops including fava beans, garlic, onions, sorghum, rapeseed, and wheat are grown. In higher elevations, tea and coffee are also produced.

Throughout Erhai Basin, shifts in agricultural practices and agricultural management decisions present trade-offs that must be reconciled by the farmer, their family, and the broader community. For example, choices about the type of crop and fertilization to use present tradeoffs between yield vs. environmental impacts; modernization vs. traditions; local vs. regional/ global demand; investment vs. return; etc. Each decision impacts the family's quality of life and the lake.

The transition from a rice-fava bean dominant agricultural system to a rice-garlic dominated agricultural system is an example of the tradeoffs that farmers in the region face. This transition has yielded a nearly 135% increase in economic benefit for farmers. Garlic, however, requires more nitrogen than fava beans resulting in additional nitrogen being used and in turn running off into the soil and eventually into Erhai Lake. Though admittedly dated, data show that the rice/garlic crop

rotation results in nitrogen concentration in the soil that is 2-3 magnitudes higher than the rice/fava bean rotation (Qui-xiang et. al. 2012). Changing crop rotations also lead to changes in the amount of water used for farming: most agricultural activity on the western shore of the lake uses irrigation systems that draw water from streams running from the Cangshan mountains. With added water demand resulting from changing crops, farmers have to rely on other sources including groundwater or Erhai Lake.

Dairy operations are also a growing agricultural industry within the region, primarily located at the northern end of the lake. These dairies are a large source of the pollutants, namely phosphorous and nitrogen, in the Luoshi River and Erhai Lake. Pig farming and beef cattle are also a non-point source of pollutants in Erhai Basin, however, they only represent about 1/5th of the total pollutant load associated with animal husbandry (Huang et. al. 2010).

2.2.4 Industry

Industrial and urban land make up a relatively small portion of the Erhai Basin, however it is these areas where the greatest amount of population growth is occurring.. Historically, the main industrial sectors in the region included textiles, chemical fiber, pulp/paper, food processing, cement, leather, and tobacco. Lake management initiatives and policies implemented following the algal bloom in 1996 pushed much of this industry either out of the area entirely or away from the lake, downstream, along the Xi'er River, south of Xiaguan. There is still some evidence of the tobacco industry present along the western shore, as well as a large cement factory on the southeastern end of the lake, which supports the development that is occurring in the area. The Dali Beer Factory replaced an old chemical manufacturing plant that was in the Dali City area. Erhai Basin also supports the hydropower industry with facilities including the Xi'er Power Station and several other small power generating facilities scattered along various rivers within the basin.

2.2.5 Population

The estimated permanent population within the Basin is around 850,000 people, with an estimated population growth of approximately 2% per year occurring over the past twenty years. The majority of the population (approximately 500,000 people) is located in the Dali Plain on the southern and western side of the lake, with the second largest proportion being located on the Eryuan Plain in the northern portion of the catchment basin (Crook et. al. 2008). These estimates do not take into account transient populations (i.e. tourists or migrant workers who are not permanently settled in the area). In addition to permanent residents, Dali Tourism Bureau estimates between 50,000 and 150,000 tourists are visiting the area at any given time. This population increase puts significant pressures on existing water infrastructure systems (i.e. sewer systems and wastewater treatment plants; water supplies).

2.3 Social and Cultural Context

Population dynamics that impact the health of a watershed include the social and cultural context of the people who live in the region. A thorough understanding of the cultural and social complexity of the area is a necessary component in designing and implementing a participatory watershed model within the Erhai Basin. Yunnan Province contains measurable populations of a vast majority of the

56 defined ethnic minority groups found in China. While many of these ethnicities are present in the Erhai Basin, the most prominent minority ethnic group is Bai, with smaller numbers of Yi and Hui (predominantly Muslim ethnic minority groups). Han Chinese (the predominant ethnic group throughout China) makes up a large percentage of the total population in the area as well (Notar 2006).

The total Bai population in China is just under 2 million people (2010 Census), with approximately 80 percent of the population living in the Dali Bai Autonomous Prefecture (the prefecture in which the Erhai Basin is located). Although there is extensive debate over what ethnic group(s) the Bai is descended from, it is believed that their ancestors have continually inhabited the Erhai Basin for at least the last 1,300 – 1,500 years (Mackerras 1988). The Bai refer to themselves as "speakers of Bair," which has been classified as a Sino-Tibetan language, one that has no written variant (Notar 2006). Bai religion is a mixture of Buddhism, Taoism, and ancestor worship, and many Bai incorporate aspects of each of these religions into their belief system (Mackerras 1988). The large Bai population in the region has long been in close contact with the Han and, although much cross-cultural assimilation has taken place, the Bai have remained a distinct and unique ethnic group with their own language, dress, and cultural mores.

2.4 Current Management & Projected Challenges in the Erhai Basin

In the 1990s, China launched a "Go West" campaign to spur economic development in the less heavily populated and less urbanized western regions of the country. The goal of this strategy was to boost the economies of western China that had not yet experienced the benefits of China being open to the outside world. When Deng Xiaoping first opened China's doors to the world economy in 1978, the majority of overseas investments were dedicated to the eastern provinces. This created a regional disparity in economic investment, quality of life, and development activity. There was and continues to be considerable concern about how the Go West strategy is affecting environmental management; Erhai Basin is certainly not exempt from this concern. To understand the challenges that Erhai Basin faces, it is important to look at where environmental management currently stands.

Authority over environmental protection within Erhai Basin primarily occurs at the Dali Prefecture level; however, ongoing efforts associated with land and water management in Erhai Basin are difficult to capture. Like in the US, there are a number of different government agencies at various levels, NGOs, stakeholder groups, and other groups involved in the management system. Unfortunately, much of the information that is available about environmental management is anecdotal or at odds with other sources, as solid data is in many cases carefully protected and controlled by government agencies. This is of great concern considering the role that data will play in developing a participatory model similar to The Bay Game. Much of the information detailed below was provided through interviews with various stakeholders around Erhai Basin.

The bulk of environmental regulation dates back to 1988, though a major revision of local environmental policy in Dali Bai Autonomous Prefecture took place in 2004, providing more stringent guidelines for environmental management in the Erhai Basin. These regulations include clearly defining the boundaries of the watershed, establishing both minimum and maximum water

levels in Erhai Lake (to provide a steady water supply, as well as to limit the concentration of pollution during times of low water levels), and establishing agricultural buffer zones around the lake. This buffer zone precludes any farming activity from the shore up to 5 meters into the lake, and from the shore up to 15 meters onto land. Prior to this regulation being implemented there was agricultural activity taking place within this zone, which created issues of resettlement and dissent between farmers and the government. Ultimately, the regulation took precedence and all agricultural activity in the buffer zone was ended or moved elsewhere.

As confirmed by Mr. Zhang, a former chief engineer for the Dali Prefecture Environmental Protection Bureau (EPB), there are six management priorities within the Basin that are currently being pursued. These include:

- Improved water treatment ability
- Restoration of upstream water sources
- Promoting more environmentally friendly agriculture practices
- Wetland restoration
- Soil protection and erosion control
- Capacity building to improve research and monitoring

To achieve these various priorities, a number of different activities are either taking place or are planned for implementation in the near future. The prefecture implemented a 3-year management plan in 2012, with the following goals (as described by Mr. Zhang):

- Build an additional 200 water treatment facilities (from single home septic systems to larger facilities). There are currently approximately 70 different treatment facilities within the Basin of various sizes, ranging from simple single home septic systems to larger facilities capable of handling significant quantities of waste from both Dali Old Town and Xiaguan. The current facilities are not enough to keep up with projected population growth, and in many cases the infrastructure doesn't exist to transport wastewater to the treatment facilities that already exist. These 200 additional plants would help to limit the amount of wastewater that goes directly into the lake.

- Restore 2,000 hectares of wetland. There were multiple examples given during interviews of wetland restoration activity already around the Basin, and in some locations the creation of artificial wetlands is taking place. These wetland projects are primarily located in Eryaun County to the north of the lake, and are being used to not only improve water quality upstream from the lake, but also to provide improved habitat for migratory birds.

- Tree planting initiatives in various locations around the Basin. It is hoped that an increased number of trees will help to stabilize soil in areas that were previously logged to minimize the erosion that is currently taking place.

- Improve water quality of the two main inflow rivers (the Miju and Luoshi). Both rivers are currently class V quality, which is the lowest quality. It is believed that if the upstream quality can be improved, the quality of water in the lake (which is currently class III) will also improve. ¥3 billion is being invested by both the central and provincial level governments to address this issue.

- Publicize results of monthly water quality monitoring in the media. There are water quality monitoring points at several different inflow sites around the lake, as well as at the outflow into the Xi'er River. The EPB is currently collecting this information monthly. By publishing the data, the EPB would increase transparency and help the public understand trends in water issues in the lake.

These efforts will undoubtedly help limit the amount of water quality degradation that takes place within the Erhai Basin, but cannot prevent all future environmental challenges associated with watershed management. Throughout Erhai Basin there is rapid development, changing land-use patterns, and increasing pressure from the tourism industry. In addition to human activity within Erhai Basin, changes in natural factors such as climate are also impacting the basin. All of these changes create existing and potential challenges that will require consistent attention and continual improvement to watershed management approaches.

One of the biggest existing challenges we heard through speaking with our informants is that while there are frequently sufficient resources for initial capital investment in projects like new wastewater treatment facilities and wetlands rehabilitation, there rarely is sufficient funding to cover the operating costs and maintenance, which ultimately limits the effectiveness of these projects. Likewise many of the workers hired to run these facilities and maintain, and manage improvements are rarely properly trained, which can prevent the objective which the initial investment sought to achieve from being efficiently or effectively achieved. In the specific case of water treatment facilities, water use fees in the area only cover about 40% of the cost of running the facility, leading to funding shortfalls for essential operations costs such as electricity and an inability to maintain and operate the facility properly.

This background and contextual content is intended to highlight several existing and future challenges within the Erhai Lake Basin watershed. Effective IWM and participatory engagement methods can help to address current and future challenges that may arise as the economic, social, and environmental context of Erhai Basin continues to change.

3 Research Methods

Qualitative research methods were used for this feasibility assessment. The Cohort decided the best approach to determining the feasibility of utilizing a multi-agent simulation game in Erhai Basin was to investigate and understand the environmental, cultural, political and social complexities present in the region. In particular, The Cohort's efforts were focused on understanding perceptions about water quality issues. Literature review, consultation with subject

matter experts, on-site interviews, observational research and additional research following the interviews were used begin to understand these aspects of watershed health.

3.1 Literature Review and Initial Research

In March of 2013, The Cohort traveled to the Erhai Basin to interview strategic stakeholder groups, gauge local perceptions, and determine the feasibility of developing a participatory simulation model in order to increase environmental awareness and community collaboration to improve the health and sustainability of the Erhai watershed. To prepare for fieldwork prior to our visit to the Erhai Lake Basin, we spent three months organizing and defining an approach to exploring the feasibility of developing a multi-agent simulation model for use in the Erhai Basin. During this initial phase, members of The Cohort conducted preliminary research consisting of a literature review (both primary and secondary) as well as consultation with subject matter experts.

Beyond the literature review and engagement of experts, The Cohort played The Bay Game in July 2012 to gain an understanding of IWM, stakeholder engagement strategies/protocol, and multi-simulation participatory modeling. This exposure to The Bay Game provided the foundation for The Cohort to assess the feasibility of The Bay Game model for use in the Erhai Lake Basin. The Bay Game is described by the University of Virginia's Global Water Games as "a large-scale participatory simulation based on the Chesapeake Bay watershed" and is considered a tool that can be used to engage stakeholders, enhance collaboration, and correlate stakeholder action with social, economic, and ecological impacts within the watershed. As discussed earlier, The Bay Game promotes participatory watershed management by allowing gamers (e.g. stakeholders, students.) to negotiate the interests of stakeholders, set priorities, and evaluate opportunities.

To complete the literature review, The Cohort divided into four teams, each researching one of four key questions. The information gathered and initial perceptions resulting from this effort were used to inform the project as it moved forward. The questions researched and addressed during this phase of the project are as follows:

- What are the most pressing challenges for Erhai Lake?
- What are the challenges to engaging stakeholders in the Erhai Basin?
- What inputs/data are needed to develop a participatory watershed model?
- What do we know/need to know about the management of Erhai Lake?

Investigation of these four research questions enabled The Cohort to develop a database of literature and documents as well as scientific and cultural data pertinent to Erhai Basin and participatory watershed models. Scientific data that was gathered focused on Erhai Basin water quality and quantity issues. Quantitative data, such as hydrologic flows, water quality measurements, water quantity measurements, and nutrient loading information was collected and catalogued for partners and future cohorts (see Appendix A).

Other information collected during this preliminary research was qualitative data, such as information about regional population and social dynamics. This initial research helped identify information about stakeholders, which guided the focus of on-the-ground research in Erhai Basin,

including developing interview questions to effectively collect additional information that would help achieve the feasibility assessment objectives.

Also during this phase, The Cohort attended briefings and participated in question and answer sessions with subject matter experts with first-hand knowledge about China, Yunnan, and specifically Erhai Basin.

- Dr. Beth Notar, an associate professor of anthropology at Trinity College, has conducted extensive research in Yunnan Province and particularly in Dali and was provided The Cohort with information about the social and cultural intricacies in the region. Dr. Notar's briefings helped The Cohort contemplate the broader complexities of the project beyond assessing the technical aspects. Following these briefings, we concluded that the project objective should focus on identifying how to gather social, environmental, and cultural perceptions that would inform the feasibility assessment of developing a participatory model, rather than focusing on gathering the data necessary to develop a multi-agent simulation model.
- Michael Keefrider, CLiGS' Yunnan liaison and an employee at the Linden Centre, an American-owned boutique hotel located in Xizhou Village that is also a partner with CLiGS, was The Cohort's on the ground contact in Erhai Basin. He provided insight about what to expect upon arriving in the region. He also coordinated and facilitated interviews The Cohort conducted in Erhai Basin.
- Dr. Marc Stern, an associate professor for the Forestry and Environmental Conservation Program at Virginia Tech, assisted The Cohort in better understanding human-ecosystem relationships, which, in turn, helped determine which stakeholder groups should be the focus of The Cohort's study. In doing so, he helped The Cohort better define the scope of the project and keep it an appropriate scale given the amount of time and resources that were available.

3.2 Stakeholder Identification and Analysis

Initial research efforts in the form of literature review and subject matter expert interviews led to the identification of stakeholders in Erhai Basin appropriate for inclusion in a multi-agent participatory tool for watershed management. During this identification and research process, certain stakeholders were deemed crucial to engage during The Cohort's time in China. These included stakeholders with the most significant impact on water quantity and quality in Erhai Basin or those with potential to leverage change. The Cohort also was interested in stakeholders who would be willing and able to provide pertinent information. The following questions were used in this stakeholder prioritization process for local interviews:

- What areas of Erhai Basin/which stakeholders would provide the greatest insight into cultural and social understandings?
- Of the stakeholders identified, which perform actions that impact the water quality and quantity of Erhai Lake the most?
- Which stakeholders are important to the future growth of the region?
- Which stakeholders may be accessible once on the ground in the Erhai Basin?

After creating a comprehensive stakeholder list and gathering a basic understanding of their economic, social, and environmental role and impacts in the region, an importance/ impact matrix was developed in order to narrow the targeted list of stakeholders even further. Table 2 identifies the list of stakeholders that were the focus of the interview portion of the feasibility assessment. Given the uncertainty about which stakeholders would be available for interviews while The Cohort was in Erhai Basin, some of these stakeholder categories were designed to be broad.

Table 2: Importance/Impact of Erhai Lake Watershed Stakeholders

Stakeholder	Catalyst for Change	Impact on Erhai
Academics	✔	
Agriculture		✔
Industry (Beverage)		✔
Environmental	✔	✔
Tourism & Development		✔ (Future)

As evident from Table 2, academic and environmental stakeholder groups were identified as potential partners/ catalysts for change within the region. The Cohort hoped to also be able to gather from them information pertaining to: historical context, laws, regulations, current research initiatives, etc. Other stakeholder groups engaged in agriculture, industry, and tourism & development were identified because of their current and projected environmental impact on the Erhai Lake.

Geographically, The Cohort chose to focus interview efforts on three specific locations within the Erhai Basin: Old Town Dali, Xizhou Village, and Shuanglang (all shown in Figure 3). These sites were selected based on their locations within the Basin, the types of stakeholders present, and the ability to arrange in-person meetings with stakeholders in those areas. Xizhou, on the wetter, more level western shore of the lake, is a smaller village whose primary economic driver is agriculture, specifically crop-based farming. Old Town Dali, also on the western shore further south and at a slightly higher elevation than Xizhou, is the hub of tourist activity in the Basin and is highly urbanized compared to most other areas around the lake. Shuanglang, on the eastern shore of Erhai, is smaller than both Old Town Dali and Xizhou, significantly drier and has more terrain relief than the other two sites. It also has not seen as much development as many locations on the western shore. Shuanglang is fairly representative of other villages along the eastern side of the lake.

3.3 Onsite Interviews and Observational Research

After identifying these five stakeholder groups as the primary focus, The Cohort reorganized from four teams to five, each responsible for a stakeholder group. While in China, each team was responsible for conducting interviews and observational research pertaining to their respective stakeholder group. The onsite interviews were critical to this project and to future initiatives within Erhai Basin for the knowledge gained, but also for developing relationships and identifying new opportunities for potential future collaboration with The Partners. The following sections discuss the approach each of the stakeholder teams used, as well as the context and outcomes of their discussions with stakeholders in Erhai Basin.

4 Findings

4.1 Academic

Universities and other academic institutions can be important stakeholders in watershed management efforts. Academic institutions reach a wide demographic, are able to obtain funding for research and engagement projects and carry creditability through name recognition. A particularly critical way in which academic institutions contribute to improved watershed management is their ability to inform and influence watershed management and sustainability.

In the context of the Erhai Lake Basin, academic institutions including Dali University, high schools and middle schools emerged as potential key players to engage because of their current projects, their curriculum, community engagement activities and their contingent of students, faculty, and staff with capacity for influencing and shaping matters that affect the community. The Cohort's academic stakeholder team spoke with multiple students and faculty at Dali University, students and administrators at Wutai High School in Xizhou and students from Xizhou Middle School. By meeting with students ranging from primary school up to postgraduate, as well as faculty at each school, The Cohort's academic team was able to gain a better understanding of what kinds of environmental education youth in the Basin are receiving, as well as how research from the academic community is received and used by policy makers and other stakeholders.

Primary school students reported that they receive some formal education on the environment and water issues from an early age, with topics of study including: pollution, biodiversity, invasive species, food chains among other topics. These students also stated that they study lakes as part of their science curriculum, but the focus is on lakes in general, not necessarily Erhai or the other Plateau Lakes, specifically. Interestingly, students say that they have a close cultural bond with the lake (many told stories of having nicknames for the lake and treating it as a trusted friend or family member, telling the waters their secrets) and that they want to help protect it. These cultural ties are present not only among youth, but their parents as well, and could prove to be a very strong leveraging tool for near-term engagement efforts initiated by the partnership.

At the university level, faculty and students are engaged in education and research covering a wide variety of environmental topics affecting various stakeholders, many of which are present in the Erhai Basin. Research outcomes are reported to various levels of government for consideration, but the tone is non-persuasive, as persuasive recommendations to the government are not well received in Chinese culture. Students at the primary and secondary levels have some of the best access to computer technology and the Internet as compared to other stakeholder groups researched. However, access is still quite limited, although staff at both the university and primary schools believe the availability of computers and regular Internet access will increase over time.

4.2 Agriculture

With agriculture being one of the primary industries in the region as well as one of the primary sources of damaging nutrient runoff into the lake, The Cohort devoted a team of five students to engage stakeholders in the agricultural industry. The Cohort's agriculture team wanted to ensure that a broad cross-section of the agriculture industry was represented and, similar to The Cohort's

academic team, utilized The Cohort's contacts in Dali to help arrange meetings with several individuals. Interviewees included faculty members and students Dali University who study the effects of agriculture on the lake, as well as a local farmer, in order to gain some insight into the daily operations and perceptions of typical farmers. The team also spoke to a fisherman, not only because he represents stakeholders affected by agricultural activity, but also because fishermen impact the water quality of Erhai Lake, and have similar socio-economic status as many farmers in the region.

The Cohort's agricultural team's perception is that agricultural stakeholders are certainly concerned with environmental management, motivated primarily by its connection to their livelihoods. Farmers are acutely aware that their activities have a major impact on lake water quality and express concern about environmental management, since it plays a major role in their livelihoods. Data concerning how much nutrient runoff is occurring is limited, and although farmers understand that runoff from their fields is occurring and effecting water quality, there is a more limited understanding of the science behind it. Researchers at the university claim that farmers are willing to do what they can to help, given the right tools and guidance. Mr. Zhang (the farmer the team spoke with) reiterated this statement. University faculty suggested that the best way to engage farmers in a participatory model might be to meet with them one-on-one. There are also agricultural management organizations for each county that could act as organizers and facilitators for meeting with farmers. These organizations could help future engagement teams connect in a more functional and meaningful forum.

From the fisherman's perspective, nutrient runoff from farming or animal husbandry is negatively affecting the number and health of fish in the lake. The fisherman also mentioned that there used to be a very large cage-net fishing industry based all around the lake, which was a major reason for previous algal blooms. Government regulations enacted cleanup efforts of the lake in the late 90's resulted in a ban on cage-net fish farming, and fish farming now occurs in retention ponds near the lakeshore. The general attitude of fishermen is that if further actions are not taken to address the pollution entering Erhai Lake from agricultural sources, there is a high probability that the small fishing industry that remains will collapse.

4.3 Environment

The Cohort's environmental team's goal while in the Basin was to try and speak with researchers, government officials and other parties that are either interested or involved in environmental research or environmental policy development and implementation. The team was unable to identify any local governmental or non-governmental organizations during the initial research phase prior to arriving in country; a number of conversations with CLiGS contacts in Dali helped to identify and reach out to several current and former government officials (including from the Dali Bai Autonomous Prefecture Environmental Protection Bureau), faculty and staff involved in environmental research at Dali University, as well as grassroots organizers from the region.

The team chose to structure their research on environmental stakeholders from a comparative perspective, comparing them to similar stakeholders that can be found in the Chesapeake Bay watershed, groups which are modeled presently in The Bay Game. This perspective was useful for

this particular stakeholder group, as the majority of individuals interviewed were well educated, environmentally active and very much aware of Erhai Lake's current situation. This allowed for a more intensive discussion process because participants were able to "talk shop," allowing room for scientific jargon and more in depth questions regarding policies, perceptions and management actions both current and planned.

All of the interviewees mentioned that a broad cross-section of society assisted with the cleanup and improvement efforts of Lake Erhai in the late 1990s, primarily in cooperation with government initiatives. One such initiative that was repeatedly mentioned was wetland restoration and artificial wetland creation at a number of sites around the Erhai Basin. These very tangible, visual cues are similar to other visual cues that were mentioned by a number of stakeholder groups throughout conversations by all of the stakeholder teams, and could prove a valuable avenue to engage a wide variety of participants in future efforts by the partnership.

The officials from the Environmental Protection Bureau have also mentioned that despite the potential negative impacts from rapid development currently taking place in the Erhai Basin the government is taking a "wait and see" approach to implementing policies to respond to or address development and its impacts. The provincial government has switched their focus from policies directed at short-term fixes, and is more interested in long-term planning and policy development that will lead to long-term solutions for environmental challenges in the region.

4.4 Industry (Beverage Focused)

China has been the world's largest consumer of beer since 2002. Beer brewing and bottling has become a major industry sector, as well as producing and bottling other types of beverages. Since the beverage industry in general tends to have a large water footprint both in terms of water consumption and wastewater, a Cohort team was formed to examine the beverage industry in the Basin and whether or not it would be an important stakeholder group to engage in the future.

The beverage team focused their research and interviews on Dali Beer, a local brewer in Yunnan Province that is owned by Carlsberg. Dali Beer's facility in Old Town Dali is the largest of its kind in the Erhai Basin. There are also several other smaller breweries, bottled water facilities and other bottling plants in the area. The team toured the Dali Beer facility and spoke with the head engineer. Other meetings with beverage companies were not possible, including attempts to meet with a bottled water company (Wahaha) and a small local brewery (the Bad Monkey), but team members were able to sit in on a number of other interviews with different stakeholder groups to gauge how they viewed the beverage industry and their role in water issues affecting Erhai Basin.

During the tour and interview at Dali Beer, the team learned that the brewery, as well as a number of other beverage production facilities in the area, receives their water primarily from mountain streams originating in the Cangshan Mountains to the west of Dali. Brewery staff mentioned that their wastewater footprint is quite small, as most of the water used goes into their beer. However, the team saw a bottle washing station at the brewery that appeared to use both water and some kind of cleaning agent, and it was not made clear where that water goes or whether or not it is treated before release. In response to a number of questions about water quality and quantity concerns, the head engineer stated that if either water quality or quantity were to reach a critical

negative level, the brewery would relocate somewhere else, as that would probably be less expensive than treating water or transporting water in from another source.

The team believes that, although the beverage industry uses a good deal of water, several different factors make the industry a less important stakeholder to engage early watershed management efforts. These factors include: the utilization of a singular water source, willingness to relocate, and self-described limited wastewater impact. Given the information gathered, it appears that the beverage industry is a much smaller part of the water management challenge than initially believed. Engagement in the long-term will most likely still provide value, but efforts could be focused on engaging other stakeholders with a greater impact in the near-term.

4.5 Tourism

Much of the initial research that was conducted by The Cohort hinted at a rapidly developing tourism industry being a major part of both the economy and environment in Erhai Basin. Based on this information, a team of six cohort members examined what role tourism may be playing in environmental management in Erhai Basin. Tourism in Erhai Basin involves an extensive number of actors (policy makers, hotels and guesthouses, restaurants, tour operators, etc.). It was important for the group to try to gain as wide of a perspective as possible. Through research and communication with CLiGS contacts in Dali, meetings were arranged with Dali University students and faculty, guesthouse and shop owners in Old Town Dali, the Dali Bai Autonomous Prefecture Tourism Board, and a tour operator in the village of Shuanglang. In addition, the larger size of the tourism team allowed for team members to sit in on various meetings conducted by other stakeholder groups.

On arrival in Dali, initial assumptions were proven quickly: development is happening throughout Erhai Basin, and appears to be occurring at a rapid pace. Tourism drives a large amount of environmental management activity in the region. One of the major draws of the region for tourists is the perceived natural beauty of the area, and according to the Tourism Bureau, natural beauty and the environment are their highest priorities to maintain and leverage for the purpose of attracting visitors. The Tourism Board also mentioned that water quality and quantity in the lake is a major piece of the area's environmental beauty. The tour operator in Shuanglang Village also mentioned his concern that other stakeholder groups in the region, particularly agricultural stakeholders, that are damaging the resources, including water quality, may be affecting his businesses bottom line by reducing the scenic beauty of the region.

Many within the tourism industry believe that the industry as a whole should play a role in addressing environmental issues within the watershed, but that other actors, particularly government, should spearhead efforts. If given the proper tools to improve their own environmental practices with limited financial impact, those within the tourism industry appear to be very interested in playing a role in sound environmental management within Erhai Basin.

4.6 Interview Conclusions

It is apparent that stakeholders nearly across the board are aware of the environmental challenges facing the Erhai Lake Basin. Many interviewees are also very interested in better understanding what they can do to maintain and improve environmental quality in the region. This knowledge,

willingness and interest will be key in developing a participatory model in the future, and may ultimately help shape what the model looks like and the format in which it is presented. The information and insight obtained through these interviews is the foundation of the feasibility analysis (section 5) and recommendations (section 6) in the following sections.

5 Bay Game Background & Feasibility for International Use

As discussed in earlier sections of this report, The Bay Game is a participatory simulation game focused around the interactions of stakeholders in the Chesapeake Bay Watershed. It was designed to educate stakeholders about the ways their actions along with the actions of other stakeholders impact the health of the Chesapeake Bay. To accomplish this objective, the game was designed to capture the large-scale (spanning the six states within the Chesapeake Bay Watershed) and dynamic complexities of the watershed. Each time the game is played, it engages multiple players who assume the roles of stakeholders in the region, specifically: farmers, developers, watermen, policy makers and others. While playing the game, players learn how certain actions, individually and collectively, impact water quality in the Bay. This is achieved throughout the simulation as participants are encouraged to communicate and cooperate with one another, to negotiate their interests, set priorities, and evaluate opportunities; this can create valuable conversations and learning opportunities that are intended to help build stakeholder capacity and better outcomes for Chesapeake Bay Watershed health.

The Bay Game tool was initially designed for students, with the hope that in the future the general public and policymakers could use it as well. In reaching these various audiences the game has achieved its objective of contributing to:

- Watershed Education and Stewardship
- Multi-sector Capacity Building
- Watershed Policy Innovation

By accomplishing these three objectives the game has been successful in the United States, in part because there are venues where players have been able to access and play the game such as conferences, universities and schools, local governments, NGOs and companies, who have sponsored game play events. The willingness of organizations and individuals to host and participate in The Bay Game can be partially attributed to the level of stakeholders' awareness and concern for the health of the Bay, and other social, economic, and environmental interests related to the management of the watershed. This basic awareness and understanding stems from years of work towards understanding and improving the health of the Bay.

The Bay Game is considered an exemplary tool for encouraging widespread education and engagement of watershed stakeholders. It utilizes a computer-based, video game interface that calls upon a series of algorithms derived from social, economic, and environmental data. The concept for the game was conceived, designed, developed and tested at UVA within a six-month

period* prior to being publically released on Earth Day 2009. The ability to work with fellow faculty and students on a project centered on a watershed that many of the researchers had previous familiarity with provided the developers of The Bay Game a number of advantages and efficiencies.

The Bay Game prototype is being used to inform the development of similar games in the Guadalupe-San Antonio River Basin in Texas as well as the Murray-Darling Basin in Australia. However, the question remains whether The Bay Game, or fundamental elements of the game's design, can be successfully used in additional international and cultural settings, in particular the headwaters of the Mekong River. The Erhai Basin simulator development team is fortunate to have the experience and platform developed by The Bay Game designers; however the Erhai Basin context presents unique challenges to transferal of The Bay Game model. Understanding The Bay Game's applicability to other regions of the world requires an even greater comprehension of the differences that are specific to the localized area of study. There are several ways to help frame what exactly the game is being used to accomplish, and how best to do so within a geographic area.

An example that is applicable to The Partner's initiative is Rare's Theory of Change, defined as a "specific and measurable description of a social change initiative that forms the basis for strategic planning, ongoing decision-making and evaluation" (Rare 2013). Rare's Theory of Change serves as a basic roadmap for social change with measurable milestones that help achieve overall conservation results (see Figure 4). Rare uses its Theory of Change strategy in its international work as a means of creating social change involving perceptions of natural resource use.

Figure 4: Theory of Change© Rare

Graduate students in the Department of Systems and Information Engineering worked on the game's interface and an undergraduate student advisory group also influenced the development process. Faculty members from 10 departments in seven schools contributed the expertise and data for the back end of the simulation, including real statistics on variables such as crab population and pollution. Some 144 students tested the game shortly before its release. Student participation was critical to test the principles of the simulation and provide feedback to further refine the model. Although The Bay Game was completed in this short time frame, The Cohort believes that developing a game for the Erhai Basin would take significantly longer. From http://oscar.virginia.edu/researchnews/x15497.xml.

Rare's Theory of Change concept parallels the objectives of the Chesapeake Bay Game participatory model. Examining these concepts in the context in which the Chesapeake Bay Game model was developed, as well as the context in which the Erhai Basin model might be developed, illustrates several of the challenges unique to implementing such a project in Erhai Basin (or other international settings).

Several key considerations for the applicability and feasibility of an international participatory model in Erhai Basin were identified through The Cohort's examination of Rare's Theory of Change, consultation with subject matter experts, interviews and field observations (Table 3). For example, in the Chesapeake Bay, stakeholder knowledge, community attitudes and interpersonal communications (the first three steps in Rare's Theory of Change approach) were present to some extent due to growing awareness around the problem and the implementation of administrative policies that encouraged citizens to be aware of actions that might impact the Bay. In the Erhai Basin, there is a need to focus on these initial three Theory of Change milestones. Prior to the implementation of a participatory game, targeted outreach activities must occur to increase the awareness and concern for water management issues. Once these Theory of Change milestones are met, then a participatory model may be an appropriate means of beginning to remove social barriers.

Table 3: Key Components of The Bay Game and Their Attributes in the United States Versus Erhai Lake Basin

Chesapeake Bay Watershed, United States	**Erhai Basin, China**
Access to Technology	
• Most stakeholders have access to computers and internet and/or are computer/internet literate	• Some stakeholders have access to computers and internet and/or are computer/internet literate
Availability/Quality of Data	
• Geographic, environmental, social, and economic data tends to be publically available and fairly transparent/reliable/valid	• Geographic, environmental, social and economic data is not readily available, if it is the transparency/reliability/validity is more often in question • Most data requires translation for English speaking model developers
Language/Literacy	
• Written and spoken English is understood by most stakeholders • High literacy rate	• For some stakeholders, their language does not have a written component, and they may not speak Mandarin • Unknown Mandarin literacy rate
Baseline Public Knowledge About Issues	
• Public opinion of Bay health is informed only in part visual cues • The Bay water quality is poor compared to its historic state • Improvement in recent years is good, but more *should* be done • Many stakeholders understand the need to treat waste water • There is an awareness about water quality and policy "upstream"	• Public opinion of lake health is commonly determined by visual cues • The lake water quality is good compared to other lakes in the province • Improvement in recent years made the lake better • The need to treat waste water is not widely understood by stakeholders • There was awareness of poor water quality upstream, but little awareness about water policy upstream
Government Acceptance of Public Involvement/Participation	
• NGOs are common and involved in community outreach and engagement • Coalitions and alliances are encouraged	• NGOs are difficult to establish and therefore few in number • Coalitions and alliances are discouraged and dis-banned • There is money to make capital investment in projects,

Chesapeake Bay Watershed, United States	Erhai Basin, China
	but the projects/facilities are not monitored or maintained
Cultural Value	
• "To do culture" emphasis on individuals define themselves based on their work and achievements • Solves problems in a linear fashion and uses scientific studies and logical persuasion to move a discussion forward.	• "To be culture" emphasis on relationships and geographic identity. • Solves problems in a circular fashion. • Uses the assets and organization of the community (elders, political and religious leaders etc.) to solve problems and create effective change • May (or may not) acknowledge the creditability of scientific information and logical persuasion, which may result in continuing to do what they are doing in light of well documented problems or concerns
Stakeholders: Accessibility and Willingness/Interest in Participating	
• Conferences, universities and schools, local governments, NGOs, and companies host game play events • Public and private sector organizations recognize the applications of the game technology • Game developed by UVA	• Schools and universities are potential hosts for game play events • NGOs, conferences, and companies are not likely hosts of game play events • Public and private sector organizations may not understand the applications of the game technology • Game to be developed by international partnerships including multiple organizations

Potential partners and data availability are two other elements that must be taken into consideration in weighing the feasibility of developing and deploying a simulation game in the Erhai Basin. For example, Dali University may prove to be an important partner in the development of a model that fits Erhai Basin. The university has significant capacity to collaborate, offer data, and provides information and awareness about the management and economic impacts of watershed management. However, whether or not the university has the necessary resources to help develop a model for Erhai Basin is not yet clear. Regardless of how much data and information they are able to bring to the project, they will be working in conjunction with The Partner's development team. Depending on what information the university does not have available, the partnership may also need to involve local government agencies in Erhai Basin. With each additional entity that is required to develop the model, there are greater opportunities for capturing the complexity of the system and reaching more stakeholders. However, this demands more capacity to facilitate coordination and communication. To address the additional layers of partnership and necessary coordination, the project will likely require additional stakeholder engagement and relationship building efforts that were not required while creating The Bay Game.

One advantage to using a game-based simulator that may be especially useful in the Erhai Basin is its ability to illustrate environmental challenges that may not otherwise be easily visualized, such as non-point source pollution, environmental health concerns, and economic implications. This also holds true for illustrating relationships that may be hard to define, but are more easily represented visually.

6 Challenges and Recommendations

As discussed in Section 5, The Cohort believes that given the context of the Erhai Basin, a Bay Game type model in its current form would not likely be successful in the near future. This does not mean that participatory modeling of some form would be impractical in the area, nor does it suggest that a data-focused participatory model could not be effective in the future. The Cohort concludes that there are near-term actions that would help engage stakeholders and develop environmental and social capacity that should be implemented first. Upon reaching this conclusion, The Cohort analyzed the information and data collected over the past several months and identified a set of alternative recommendations for building capacity (social, ecological, and economic) in Erhai Basin. Many of these recommendations align with the concepts associated with Rare's Theory of Change.

Rather than providing a single recommendation as an alternative to participatory modeling, The Cohort proposes a multi-faceted approach to leveraging and engaging stakeholders as well as partners. Several facets of this approach, such as outreach, can be initiated in the near-term (0-3 years), while mid-term (3-5 years) and long-term (5-8 years) efforts will build upon the data, relationships and capacity developed in the near-term. Ultimately, these efforts should provide the building blocks for a full-scale participatory model.

The Cohort's alternative strategies focus on entities operating within Erhai Basin for which The Partners have relationships or are working toward establishing relationships (see Appendix D). The Cohort's research and experience during this feasibility assessment has highlighted a number of cultural norms and contextual considerations that are unique to Erhai Basin and of which The Partners were previously unaware. Some of the recommendations presented in this section aim to further the understanding of the local context, while also achieving community engagement through means that may not have been previously been considered by project partners.

These recommendations focus on the goal of developing a toolset (not just a multi-agent simulation tool) for building capacity among local stakeholders for integrated watershed management. The envisioned toolset includes a simulation tool, but may also include other options such as scenario-based learning (calling upon success stories from other geographic locations), info graphics, board games, and other collaboration-oriented activities or games that engage and educate stakeholders about their environmental impacts.

6.1 Engaging Stakeholders in the Erhai Basin

The Bay Game was developed with known parameters to maximize awareness of issues related to the Chesapeake Bay watershed. In doing so, the "game" builds capacity by providing players an array of potential actions that impact the water quality and health of the bay. It is in that context that we frame our recommendations. The near-term suggestions described in this document align with Rare's Theory of Change through outreach strategies that focus on building knowledge, awareness and interpersonal communications within the Erhai Lake Basin. These initial efforts are intended to lay the foundational work for participatory game development and implementation in the mid-term and long-term time periods. However, rather than provide a long-term recommendation that leads to a solution specifically for Erhai Basin, a robust model that keeps scalability as the core focus is suggested. This will allow for the development of a much more

robust model of participatory engagement strategies that allow development and delivery of simple, efficacious tools at multiple scales

6.1.1 Elements of the Game

The Cohort analyzed the components associated with development and implementation of The Bay Game (see Table 3) to determine which components that were essential parts of The Bay Game were not present in Erhai Basin. The Cohort found that three components associated with developing a model like The Bay Game present the greatest challenges and opportunities in Erhai Basin: cultural and language disparities between researchers and the identified stakeholders and the game's current reliance on both technology and quantitative data-heavy algorithms.

Each of these components represents a fundamental aspect of participatory modeling: connecting players, understanding inter-relatedness of the geographic area as well as cultural, social and literal mores of stakeholders within the project area. These three factors must be further understood before a basic concept for an effective game design and implementation plan can be successfully developed. Beyond increased understanding on the part of game developers, the proposed strategies also focus on building awareness among the target population. The Cohort has created these strategies to achieve an increased level of understanding about environmental issues in the target area, specifically, water quality, water quantity and impacts of socio-economic systems, within Erhai Basin.

6.2 Raising Awareness and Gathering Information: Near-Term Strategies

To set goals for raising awareness, it is important to understand current awareness levels in order to set a baseline. The Bay Game was developed within the context of several decades of awareness building and advocacy by special interest groups and non-profits. In developing regions, Erhai Basin specifically, awareness baselines are not currently known. The Cohort's observations provide insight into the stakeholders' attitudes, habits, and beliefs that pertain to Erhai Lake but these need to be substantiated further. Rather than spend time and resources trying to ascertain in great detail the current level of awareness, actions that make basic information widely available in Erhai Basin appears to be an appropriate approach. Tracking those reached in such outreach activities would help establish a baseline for awareness that can be measured and tracked going forward as an indication of progress.

An annual month-long celebration of Erhai Lake, held in multiple locations within the Basin, presents an ideal opportunity for an initial campaign for increasing awareness about key environmental, social, and economic issues through education. Students we spoke with at Dali University suggested that setting up booths at local street fairs and festivals combined with an outreach through various media would be an effective potential strategy. These efforts would lead to an increased public awareness of resource challenges in Erhai Basin, and may be the first step in reframing the stakeholders' perception of water quality and quantity in the region, as well as providing valuable information to The Partners for continuing work. In addition to awareness of

key issues, messaging that introduces the "brand" of the partnership working on this project should also be disseminated as a means of gaining trust and buy-in.

Social media outlets, such as Weibo (the Chinese version of Twitter), are among the tools that may help increase awareness. Internet and smartphone based tools may be a powerful way to reach a segment of stakeholders. Individuals who have access to these types of technology often live in more urban areas (such as Xiaguan) or are younger and have access technology at school. An interactive media campaign through Weibo could work hand-in-hand with a broader public awareness campaign to help bring environmental issues to the attention of users. Weibo also serves as a platform for online-based games such as Farmville or Wei-City, a concept that could be used to set the stage for developing a similar game, which, like The Bay Game, would reflect the resource challenges present in Erhai Basin and encourages participatory modeling. Additional information about Weibo and the potential role it could play in this effort can be found in Appendix E.

6.2.1.1 Leveraging Partner Relationships and Strengths

These outreach and awareness efforts will benefit from increasing the involvement of the multiple partners engaged in exploring the option to develop a simulation game for the Erhai Basin. Each of these partners provides expertise and capacity that can support awareness and outreach efforts in a variety of ways. Several partners may play a particularly important role in the initial information-gathering stages.

In March 2013, Dali University signed a Memorandum of Understanding (MoU) establishing a formal partnership with CLiGS. This partnership will increase access to networks and resources, facilitate data sharing, and create opportunities for collaborating on research projects. Being able to access data will be essential for developing a participatory model as well as early education and awareness initiatives. The university's natural resources research program includes individuals with subject matter expertise who can assist with data gathering, translation, and can both serve as primary sources of and ground truth observations gathered from other sources.

The Sidwell Friends School (SFS) is organization that may, in the future, be a partner involved in this initiative. SFS currently works in Yunnan province and has capabilities that would complement this effort. The SFS China Fieldwork Semester for 11th and 12th grade students takes place from January through May. Students spend nearly all four months in Xizhou and their curriculum includes a strong environmental science component. Should a formal partnership be established with SFS in the future, SFS students could assist with survey design and distribution, document stakeholder awareness, and catalogue other early outreach efforts aimed at collecting information and building awareness?

Another key capability of the SFS China Fieldwork Semester program is its development of a digital database for archiving information. SFS faculty and students could assist The Partners with developing a database that would serve as a digital repository for information collected during throughout the Erhai Basin initiative. This would help this project by providing a means of organizing and accessing various types of information, while also providing SFS students the opportunity to apply their skills to a "real world" environmental project that seeks to improve the sustainability of the community in which they community they are living and studying.

Attached in Appendix D, a partnership table describes current and potential future partners, as well as the role that they may play in future efforts.

6.3 Developing the Participatory Format: Moving into Mid-Term

In regions where cloud-based computing is available, it is a means of connecting people. Computer games that are cloud-based allow for visually rich experiences and are able to support several players. However, developing regions may not have widespread access to such technology, as is the case with the Erhai region. We have also not yet been able to identify reliable sources of necessary data to build realistic watershed model. In light of data and technology availability limitations The Cohort focused on alternative means of accomplishing The Partner's ultimate goal - increasing awareness of issues, empowering a population, and encouraging participation, as a means of building capacity for achieving sustainability. The Cohort believes the recommended strategies can achieve those results in a simple, cost effective manner that does not rely on technological approaches driven by quantitative data.

These strategies focus on efforts that embrace the benefits of real time, in-person, human interactions and communication. The alternatives to cloud-based models that are suggested as more feasible in the current context of rural China rely on participants engaging in face-to-face interactions in a game administered in a roundtable setting. These games may be driven less by data and algorithms, however, will still be based on information and data that represents relationships between stakeholders and interactions between variables within Erhai Basin. Roundtable session can serve two purposes: 1. They can promote participant education and engagement and 2. They can provide The Partners with information that can inform future engagement and watershed model development

For example, following initial awareness-building and information gathering, teams might begin working with stakeholders willing to participate in roundtable sessions. During these sessions, participants would engage in "participatory mapping" exercises. Using a map, players can represent themselves and their interests Erhai Basin. Facilitators would lead the roundtable sessions using a series of prompts and discussion points. The resulting interactions (body language, discussion and exchanges) between participants involved in the mapping process would be noted by observers and serve as a central tenet of data collection. In turn, this information would inform the design of roundtable games that can be used in subsequent sessions. The early versions of the game would likely involve a small number of individuals, perhaps just a representative or two from each of the stakeholder groups identified in this project. Each of these roundtable sessions would be part of an iterative process for the partnership to engage in (Figure 5).

Figure 5: Iterative Roundtable Session Process

Through several iterations of this process, the partnership should be able to amass enough knowledge and information about the region, people, social, cultural, and physical systems in order to begin mapping the socio-ecological system within Erhai Basin. By starting with small groups of stakeholders and a seemingly simple tool for participatory mapping, the partnership would gain valuable insights into the relationships between stakeholder groups very quickly. As the map of the socio-ecological system evolves and becomes more refined it would not only help shape future roundtable sessions, it would also enable to the partnership to identify and pursue additional strategies for building capacity and engagement.

6.4 Scalability: Long-Term Approaches

Strategies for building capacity through empowerment and awareness must vary depending on the scale and location of an initiative. The variability of issues by region makes identifying a pilot project that can be scaled and adapted to meet the needs of other locations a challenge. For participatory games this is especially true, because there are thresholds at which the game's variables must shift from focusing on a micro-scale to a more encompassing macro-scale or vice-versa. In Erhai Basin for example the project's focus is water quality and quantity issues associated with Erhai Lake; however, these issues can in no way be uncoupled from issues associated with development or land use upstream, for example. Likewise, the lake should not be considered without recognizing the downstream implications. In this case, synergy of each of the micro-scale issues compounds creating macro-scale externalities that resonate throughout the Mekong River Basin.

The Cohort kept the ultimate goal of creating a process for designing and implementing a participatory model that could be applied the Erhai Basin, with the possibility of scaling up, in mind throughout this project. Recognizing that producing a custom game or simulation for any one location could require several years' worth of research, field-testing, and adaption, The Cohort attempted to identify strategies for this project that would be applicable for projects involving different scales and levels of complexity.

The participatory and iterative nature of the recommended roundtable strategy, in essence, allows the target region's population to lead to the conclusions (the information needed to map the system) all while building capacity through engagement with various stakeholders. This process allows the partnership to experience the "otherness" of a location. The "otherness" presents both unique challenges and opportunities, in that it comprises much of the intangible social guidelines and knowledge, which can be extremely hard to detect, interpret and incorporate into a project. By anticipating and embracing as many of the potential roadblocks and challenges to developing a participatory model as possible, the roundtable strategy is inherently designed to be scaled up or down as necessary.

6.4.1 Limitations of Scalability

Like any system, there are limiting factors that impact the ability to successfully design and implement a scalable model. Those limiting dynamics often become evident only when the scale at which a strategy is being implemented changes. Changes in scale can occur vertically, which is when every additional increase in scale adds another layer of complexity. Scaling vertically increases the volume of information associated with each part of the model (i.e. data, land area). For the Erhai Basin there are aspirations for vertical scaling, which would expand the model for participatory engagement to encompass a larger region. Scale can also change horizontally, which causes a shift in the initial understanding of the system, making the system increasingly complex. The new system map may include additional factors, processes, entities or locations, which present an unknown "otherness".

Problems with scaling up typically occur when the originator of an idea, process or product has deemed it worth growing larger or others seek to adopt the idea. These challenges often occur because the project originator overestimates their internal capabilities and may become overwhelmed by the "unknowns" associated with the new scale (Cooley 2006). Within the context of the Erhai Basin and the larger context of the Upper Mekong, there are both discrete and overlapping challenges that must be addressed. Fortunately, these represent operational challenges and as such strong leadership that fosters a collaborative environment can lead to success in responding accordingly and managing to adjust the strategy to the new scale effectively.

6.4.2 Scaling Strategy

Many newly developed products live or die by scaling. Successful products trigger market signals, which stimulate access to capital that allows the originator to scale vertically. In turn, those signals can alert other, more established originators who are looking to scale horizontally by adapting the product as their own. Scaling vertically and horizontally requires increased capacity for data gathering and storage, technology, mobility, expertise, human resources and capital. When the originating organization cannot meet new capacity demand, intermediary partnering with an organization is a solution to meeting the necessary capability to meet those demands (Cooley 2006). Understanding our stated limits, CLiGS has worked to solidify partnerships with organizations whose core competencies create a comprehensive battery of those required for implementation of the model to basic scale.

7 Conclusion

When comparing Erhai Basin to the Chesapeake Bay watershed, there are many differences that exist between the two. The Bay Game was developed in the Chesapeake Bay watershed, a region of relatively homogenous political culture, literacy and environmental awareness, development pressures, infrastructure, and access to technology. Erhai Basin contains an incredible number of distinctly different cultures and possesses a vast array of levels literacy, education, environmental awareness, development, infrastructure, and access to technology. Within each of these facets of society there are multiple differences that present challenges to not only determining the feasibility of a participatory model similar to The Bay Game, but also to merely achieving a basic understanding of the environmental perceptions within Erhai Basin.

Through its experiences with The Bay Game and Erhai Basin, The Cohort believes that participatory gaming models for capacity building can be successful in watersheds globally. However, for participatory gaming to be effective, it may take multifaceted engagement strategies, multiple iterations of streamlined participatory engagement tools, and persistent effort in order to reach a point when participatory modeling based simulation games can be used to remove barriers and lead to behavioral change. The suggestions stemming from this project identify next steps for the partnership, future XMNR Cohorts, researchers, and sustainability professionals who seek to engage stakeholders, identify issues, challenges and opportunities, and gather the necessary data to develop a participatory game. It is The Cohort's hope that, with the lessons learned from this project and implementation of the recommendations presented in this paper, Erhai Basin will gain capacity for sustainably managing its watershed and shaping its social, economic, and environmental future.

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Appendix A: Preliminary Research Documentation

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Appendix B: Key Players for The Partners in Yunnan Province, China

Professor Hongyan Su, Dali University

Professor Hongyan Su is a lead scholar at Dali University. Her research and teaching interests is primarily microbiology. She also serves as the Party Secretary of the Agriculture and Biological Sciences College (Institute).

Shi Linhong, Environmental Journalist

Shi Lihong is an environmental journalist and activist who filmed an anti-dam documentary (*Waking the Green Tiger*) that was used to gain awareness and engagement about the implications of dam projects on local residents in China.

Waking the Green Tiger, a documentary about the Nu River dam project, helped ethnic minority communities participate in dialogue about the impact of hydropower on their communities. This is a significant accomplishment because in a poor province many residents have no formal education and limited awareness of the experiences and circumstances that other villages face.

She recognizes and embraces the power of images in increasing awareness and engagement of individuals on environmental issues. Through her work in China has developed a keen sense of how to navigate issues pertaining to Chinese environmentalism and politics. Her skill in this regard has allowed her be an advocate and leader for social and civic change, and do so without raising too many official's eyebrows.

Ms. Shi and her husband founded Wild China Film, which is based in Dali and works with grass roots environmental organizations. She and her husband also are hoping to establish a NGO in Dali with an environmental stewardship and cultural preservation focus. With their strong relationships within the community, especially with local government officials she is hopeful they will be able to go through the appropriate challenges to register and establish their NGO.

Dr. Dequn Zhou, Kunming University

Dr. Dequn Zhou is a professor at Kunming University of Science and Technology. He in his capacity at the University, he is responsible for fundraising and international cooperation. His interests include mycology and conservation biology. He has published a number of paper in Chinese and international journals and received numerous awards from the Chinese government for his research on these topics.

Brian and Jeanee Linden, Linden Centre

Brian and Jeanee Linden have developed a successful model for cultural and placed based tourism in China. They have established a strong relationship with the Chinese Government. The government supports the Lindens' efforts to connect tourists with local individuals in order to create and experiential learning experience and exchange of information. The Linden's model for tourism relies on a strong network of relationships and connections surrounding each of their facilities. As the Linden's continue to open new facilities throughout China their network will only continue to grow in number and encompass even more resources the can support a diverse range of subject matter interests.

The Linden Centre in Xizhou, and the contacts the Lindens have in the Erhai Lake basin were tremendously helpful during the March 2013 XMNR trip to Dali, and will likely presents an number of opportunities for subsequent phases of this effort. The Linden Centre served as the primary conduit to scale The Cohort's feasibility efforts around the Basin, and will likely provide a similar role during future implementation efforts.

Ed Grumbine

Ed Grumbine is a professor of Environmental Studies at Prescott College in Arizona. He has also served as a senior international scientist at Kunming Institute of Botany, Chinese Academy of Sciences, Yunnan Province. His current interests understanding and defining environment security in western China, including hydropower and dam development in the Mekong River.

He is the author of *Where the Dragon Meets the Angry River* that chronicles his experiences, observations, and understanding of the environmental perceptions and challenges in China.

Beth Notar

Beth Notar is an Associate Professor at Trinity College in Hartford, Connecticut. Beth's research has focused on the interaction between popular culture and tourism and how it has shaped southwest China. She is an expert on ethnographic research and spent years in Dali learning about the culture, sense of place, and tension over what it will become as development and economic growth continues.

Appendix C: Description of The Partners

Stimson Center

The Stimson Center is a nonprofit institution that is focused on international peace and security. One of the major branches of focus for the Stimson Center is regarding transnational environmental security. Specific research includes how increases in stress on ecosystems can lead to social and/or political unrest in different areas of the world. The Stimson Center recently has begun to focus on water security, specifically the transnational issues that are arising from hydropower dams along the Mekong River.

UVA Global Water Games

UVA's Global Water Games has extensive experience with data management and model development. With the Chesapeake Bay Game the individuals involved with Global Water Games have created a successful prototype for how a participatory model can be designed and used by a broad range of stakeholders. The Bay Game prototype is being used to inform the development of similar games in the Guadalupe-San Antonio River Basin, Texas as well as the Murray-Darling Basin, Australia.

Sidwell Friends School (potential partner)

Sidwell Friends School is offering an experiential, semester study abroad program each spring (January-June) located in Xizhou, China for its students. The students will be studying how people interact with place and how those interactions change over time. The focus of the program is on:

- **History/social science research** on changes in space/place and livelihood
- **Environmental Science research** on applied geology, conservation biology, diverse landscapes, ecosystems, biodiversity, and sustainable development
- **Chinese literature** focused on encounter with place in rural China
- **Intensive Chinese language**

The students will also be contributing to an ethnographic database, with an emphasis on collecting and archiving information using multi-media and digital methods.

There is an opportunity for Virginia Tech CLIGS and the other partners on the Erhai Lake project to work with John Flower at the Sidwell Friends School to help inform the design for the database. This presents an opportunity for creating a database that captures and stores of wide range of information in an organized and accessible format. Having a tool to manage and share information and data about Erhai Basin that is collected by a number of different entities will be immensely valuable to this effort.

There may be additional opportunities for partnerships with the Sidwell Friends School semester program. For example students participating in the program may be on-the-ground resources that could help collect information on Erhai Lake management or help advance subsequent stages of this project.

Appendix D: Potential Roles for Key Partners

Key Partners	Status	Future Role
Stimson Center	**Existing Partnership**	TBD
UVA/Global Water Games	**Existing Partnership**	TBD
Dali University	**Existing Partnership**: MOU signed March 2013.	SME/Data exchange and collection
Linden Centre	**Existing Relationship:** CLIGS and XMNR cohorts have visited the Linden Centre in Xizhou multiple times over the past several years.	Environmental awareness advocate, building trust and buy-in with local populations
Sidwell Friends School	**Ongoing discussions with John Flower about opportunities for partnership.**	Data Collection/Outreach
Shi Linhong	**Potential Relationship:** Expressed interest in exploring how Bay Game like tool might be applicable in Erhai Basin	TBD
Ed Grumbine	**Existing Relationship.** Ed spoke with XMNR 2013 Cohort prior to the IR and while in China	TBD
Beth Notar	**Existing Relationship.** Beth spoke with the XMNR 2013 Cohort prior to the IR	TBD
Future XMNR Cohorts	**Existing Relationship.** Exchanging of information has occurred between current cohort and 2013-2014 cohort	Data Collection/Planning/ Outreach
Himalayan Institute	**Existing Relationship**. MOU signed March 2013	Data Collection/Planning/SME

Appendix E: Simplified Gaming Model For School Use or Through Social Media

Working relationships have been established with local schools and the Linden Centre. These institutions will be key for implementing strategies to build capacity and engage stakeholders. Schools have the resources and capacity necessary to implement a computer-based game and students learning about Erhai Basin can serve as vectors for sharing the information they learn with their family, friends and community. Schools have some computers, and incorporating an environmental game into their curriculum could help emphasize their learning about the Erhai Basin and watershed management. The general public in the region does not have as much computer literacy or access as the individuals affiliated with schools, although this is expected to improve in coming years.

The Sina Corporation's Weibo, which means "microblog," in English, is China's most popular social media website with over 500 million registered users, representing 30% of those with internet access nationally (Rapoza, 2011). It is often compared to Twitter and Facebook in the United States as it provides similar social networking services. Among these services, Weibo provides a platform for online games, including popular games based on farming and city development (i.e., Farmville and WeiCity) (Rapoza, 2011). Part of Sina Corp.'s success may be attributed to the fact that they closely monitor and censor Weibo, which secures government acceptance (Zhu et al., 2009). Despite this censorship, the platform has been used in the past to bring awareness to social issues (Guoxiu, 2013). Data on Sina Weibo's market penetration in the Erhai Basin was not available. However, social media is commonly accessed on mobile devices in China, which could improve the potential to reach stakeholders in areas where computers and bandwidth are sparse (Fong, 2012).

Many young people in the Erhai Basin area go to university or work in the tourism industry following completion of primary school, which often means they spend time in urban areas where computers and the Internet are more accessible. It could be feasible for the partnership to develop an interface (probably simpler than The Bay Game and compatible with mobile devices) on Sina Weibo that allows users to log in as representatives of stakeholders and provide information on common practices that impact Erhai Lake that would feed into a database. Dali University may have the capacity to help develop this interface, as they currently collect data on environmental issues in the area. While this method does not directly engage stakeholders, it might provide some impetus to build the project into a larger, more comprehensive participatory model.

Appendix F: Surveys as a Participatory Engagement and Capacity Building Tool

Surveys may be an effective means of collecting information from members of Erhai Basin communities about their perceptions, values and interests. Surveys provide an interactive way for participants to provide information that will shape strategies that are designed to improve education, awareness and build capacity within the community. In and of themselves, surveys may also serve as an education and awareness tool, because they may cause participants to consider questions, relationships, and their own personal perceptions and values in ways that they have not previously considered or articulated.

Surveys are a suitable means of collecting information and engaging stakeholders in Erhai Basin because they can be administered:

1) On paper in written form (translated into any written language)

> **Benefit:** enables engaging those who are literate, but may not be computer literate, or have access to a computer; they can be widely distributed, and administered anywhere.

2) On a computer (translated into any written language) and either saved to the administrator's hard drive, emailed to the administrator, or via a web based interface

> **Benefit:** enables use of personal computers, survey administrator's computers, or publically available computers; this method could also be used to assess how many and which stakeholders have access to computers, informing future computer based modeling strategies.

3) Verbally in the form of a scripted interview

> **Benefit:** enables engaging those who are illiterate or speak a non-written language; personal engagement may provide additional insights not gained through other indirect interactions.

Surveys, unlike The Bay Game, do not provide real time feedback about the responses provided by participants, nor do they allow for collaborative discussions about individuals' responses to the questions presented and their rationale. However, there is an opportunity to tabulate the survey responses and create visual displays that can be shared (via the internet, brochures, multi-media presentations and displays). Therefore, surveys may present a low-tech opportunity to create a tool that is participatory, visual, engages stakeholders and builds capacity.

There are a number of ways surveys can be designed depending on the type of information that one seeks to collect and the informants who will be queried. Carefully designing and selecting a survey format, medium, and wording of the prompts and responses provided for participants to select, as well as prudently identifying and implementing methods for administering the survey that suits the target audience are all important. These facets of a survey can shape the answers provided by respondents, and therefore the results.

If using a survey as a means of collecting information and engaging stakeholders in the Erhai Basin, consideration of how the information will be used and what the respondents can expect for an

outcome following their participation in the survey should be considered because these questions will likely arise. As The Cohort has noted, building trust and goodwill and being culturally sensitive and aware is an important component of the Erhai Basin participatory watershed management effort, and therefore these considerations are of the utmost importance when undertaking a survey-based information collection effort (on both a small or large scale).

Several of the CLiGS partners have experience designing and implementing survey-based data collection efforts, while others have a high level of local political, social and cultural knowledge. These individuals should be consulted and engaged when designing a survey and when training those administering and analyzing the results of a survey.

A notional example of a survey (which has not been vetted through any survey design subject matter experts) is as follows:

Erhai Lake Watershed Management Survey

Please fill out this survey to reflect your opinion about the following:

Local Economy					
	Extremly Important	Important	Neither Important Nor Unimportant	Unimportant	Extremely Unimportant
Tourism is _____ to the local economy	○	○	○	○	○
Agriculture is _____ to the local economy	○	○	○	○	○
Industry is _____ to the local economy	○	○	○	○	○
	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree
Erhai Lake is important to local tourism	○	○	○	○	○
Erhai Lake is important to the local economy	○	○	○	○	○
Erhai Lake is important to my livelihood	○	○	○	○	○
Erhai Lake impacts my health	○	○	○	○	○
Water					
	Very Concerned	Concerned	Neither Concerned Nor Not Concerned	Not Concerned	Very Much Not Concerned
The quality of the water in the local rivers, streams, and lake is something I am _____about	○	○	○	○	○

I am _____ that as the population grows water quality may decline	○	○	○	○	○
The availability of water is something I am _____about	○	○	○	○	○
I am _____ that as the population grows water availability may decline	○	○	○	○	○
	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree
Local agricultural activities impact the quality of the water in the rivers, streams, and lake	○	○	○	○	○
Municipal waste water (sewage) impacts the quality of the water in the rivers, streams, and lake	○	○	○	○	○
Industrial activities impact the quality of the water in the rivers, streams, and lake	○	○	○	○	○