Statement of Purpose – Jeff Walters

In the developing world, over 783 million people are without access to clean drinking water. However, despite well-intended efforts, intervention attempts to lower these statistics have proven highly unsuccessful. Studies have shown that more than 30% of rural water projects (water systems, wells) fail between 3 and 5 years following construction. Currently, approaches to plan and evaluate the sustainability of rural water projects in developing countries are reductionist, and thus, do not consider, interpret and adapt to the dynamic interactions of technical, social, financial, institutional, and environmental factors that often influence project success or failure. In order to create sustainable solutions to water poverty, the systemic and dynamic complexities must be considered. Thus, this research will create a system dynamics based methodology to better understand the dynamic factors that affect sustainability that will be used to analyze long term functionality of rural water services in developing countries. The overarching aim of this research will be to answer the questions:

RQ1. What are the most important factors that influence sustainability of rural water services in developing countries?
RQ2. How do these factors change and influence each other over time?
RQ3. How do these factors influence the functionality of a rural water system over time?

Addressing these questions will yield new process based knowledge and understanding of sustainability of rural water infrastructure in developing countries. In addition it will contribute valuable knowledge to inform the international water sector about sustainable solutions to rural water poverty.

A system dynamics modeling approach was chosen for this research due to its ability to go beyond the inherent limitations of linear or mental models to include the dynamic interactions between factors at play in a complex, interconnected system. Specifically, system dynamic modeling can help to determine and simulate the structural influences of factors and their associated time-based affect on water system functionality. This will for the development of a hypothesized system dynamic model, collect data on the factors hypothesized to influence each other and rural water system functionality, test the model based upon the data collected, and build theory and policy to improve these systems.

The process of creating a system dynamic model follows the general iterative progression of problem identification, dynamic hypothesis creation, model building and simulation, model testing, and policy design. Per this model building process, factors must first be identified and considered for use within the systems dynamic model along with hypotheses made for how these factors influence each other and the overall functionality of the rural water system. To identify these factors, a content analysis was performed of both academic and grey journal articles within the water sector using permutations of the keywords "rural water", "developing communities, "sustainability, and "factors". This search yielded 157 unique references to a particular sustainability factor. These sustainability factors were then aggregated into model parameter groups called "capacities", all which could either aid in or hinder sustained functionality of a rural water system. These capacities were identified as: Government Capacity, Community Capacity, Management Capacity, Financial Capacity, Environment & Energy Capacity, Technology Construction & Materials Capacity and External Support Capacity.

A Delphi method was chosen as a means of systematically converging upon causal influences of the sustainability capacities and to obtain a causal loop diagram that qualitatively demonstrates the dynamic structure of influences from each capacity on the functionality of a rural water system. This study will reach consensus between international water sector experts regarding the causal connection and dynamic behavior between the capacities that influence the sustainability of rural water services in developing countries.

Once the dynamic interaction between capacities are hypothesized within the model, data must then be collected from case studies that qualitatively measure the interaction of these causal capacities and determine the influence of these capacities on rural water project functionality in the municipalities of Ciudad Dario, Terrabona and El Sauce, Nicaragua. Using the theoretical causal interactions between capacities found from the systematic literature review and Delphi study a 12 month longitudinal study will be conducted that focuses on the time based changes and interactions between these capacities in the aforementioned municipalities. These case studies will be embedded multiple case designs having multiple embedded units of analysis (each capacity) for 3 different municipality contexts as informed by the causal capacities and their connections found from the literature review and Delphi study.

In each of the municipalities, data will be collected using surveys, semi-structured interviews, first-hand observations and collection of existing documentation. Collection frequency will depend on the collection method and capacity being measured in each municipality. Connections between capacities will be inferred qualitatively from the data and a causal loop diagram will be created based on the 12 months of changes shown in the data. Once the causal loop diagram is built, the next step will be to quantify the time-based capacity data for placement within a stock flow system dynamic model.

Each capacity, along with community water system functionality, will be scored using four equally weighted indicators based on the content analysis, and each indicator will be scored based its ability or "performance" to promote long lasting water system functionality: excellent (5), good (4), acceptable (3), bad (2), very bad (1). With a time-based trend of capacity performances and hypothesized causal connections, it will then be possible to quantitatively model the systemic interaction between capacities and begin developing theories for how these capacities affect system functionality over time. This will enable a systems analysis of potential policy affects on community rural water projects on a municipality basis using iSee STELLA System Dynamic Modeling Software.

This will be the first study to use system dynamic modeling to develop a comprehensive theory on the dynamic causal interaction of causal factors that lead to or inhibit sustainability of rural water infrastructure in developing countries. In doing so, this research will not only contribute to the broader intellectual understanding of rural water project sustainability, but will also serve as a basis for future policy formation for sustainable rural water development. In addition to the impacts on rural water project sustainability efforts, this research will contribute to the development of water project sustainability frameworks that can be expanded upon by future research through inclusion and modeling of additional causal conditions and through additional analyses of cases by future researchers. More specifically these efforts might include an expansion on these data collection efforts to create more robust models and frameworks regarding 1.) the causal influence of sustainability capacities, and 2.) the dynamic trends and system behaviors that result in different country and cultural contexts. Fostering these types of research efforts will lead to multi-disciplinary collaboration between scholars to work together on this research, improving knowledge exchange between disciplines.