CONNECTING NATURAL AND SOCIETAL DOMAINS FOR SUSTAINABLE RURAL COMMUNITY-BASED WATER SYSTEMS IN ODISHA, INDIA

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ABSTRACT

The purpose of this thesis is to develop a conceptual framework for analyzing whether the interactions between natural and societal domains of rural drinking water infrastructure are complementary in nature. Much of this framework is based on the literature on community capitals in water resource management. The study was set in Odisha, India and the methods for analysis were mainly qualitative, built on program documents, field surveys, interviews and focus group discussion with relevant actors. The research reveals that while there is a strong presence of natural capital in Odisha, the state government and the rural communities lack the technical expertise and social skills to best manage it. In the face of these challenges, Cornell University-based research organization, AguaClara provides low-cost, innovative and intelligible water treatment solutions and Odisha-based NGO, Gram Vikas mobilizes, trains and develops skills of the rural communities. Hence, the partnership between AguaClara and Gram Vikas exhibits collaborative synergies that fit perfectly within the conceptual framework. However, more research should be done on lowering the O&M costs of such projects to benefit the community at large.

BIOGRAPHICAL SKETCH

Born and raised in New Delhi, India, Disha was fascinated by how bureaucracy and corruption rather than fuelling development through public service delivery has stalled the growth of the city she loves the most. She was astonished to see how the capital city turned from being the most desirable to the most unlivable and the most unsafe place in the country. She joined School of Planning and Architecture, New Delhi in 2011 for her Bachelors in Physical Planning and since then she has been researching on the government's role in effective public service delivery, particularly specializing in water governance.

She joined Cornell University in 2015 for her Masters in Regional Planning where she got in touch with AguaClara. And so her journey towards water and sanitation research began, embarking upon the intersection of service delivery, bureaucracy and social equity. She believes that her regional planning background will help in attaining her professional interests of inducing entrepreneurial sustainable practices in local government service delivery in the global south.

“Please understand, Your Excellency, that India is two countries in one: an India of Light, and an India of Darkness. The ocean brings light to my country. Every place on the map of India near the ocean is well off. But the river brings darkness to India—the black river.”

- Aravind Adiga, The White Tiger, p. 12

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EXECUTIVE SUMMARY

In this research study, I use insights from the literature on rural community-based water systems to create a theoretical framework to analyze their strengths and weaknesses. The framework I develop rests on three principal concepts. First, is the natural domain – water quality, and quantity, water treatment technology and ecosystems — second is the societal domain – community participation, social values, cultural norms, local institutions, economic and human resources – and lastly, the interactions of these domains within a political context, that are essential for sustained success in water treatment and delivery. I apply this framework to the partnership between AguaClara and Gram Vikas to set up sustainable drinking water systems in the villages of Kaliabeda and Lahanda in Odisha.

Odisha presents an interesting case study as it still remains one of economically and socially backward states in India. Half of the population has no access to safe drinking water and only a few have access to sanitation facilities. Funds are not being provided by the state to local gram panchayats for rural water and sanitation programs. In this context, Gram Vikas aims to mobilize these communities to bring about 100% household-level clean piped water supply and toilets in the villages. Similarly, AguaClara, a Cornell University initiative with fourteen successful water treatment plants in Honduras, is seeking to develop its water treatment technology on a global scale, starting with a pilot project in India.

My analysis, builds on program documents, field surveys, interviews and focus group discussions with key members of the project and villagers. I found that AguaClara succeeds in the natural domain especially in terms of sustainable, low cost, limited energy use designs, but fails within the societal domain as it lacks the capacity to deal with the issues of caste, gender, poverty and politics in the provision of drinking water. On the other hand, Gram Vikas shows a strong societal domain as they mobilize, train and develop skills of rural communities on how to construct, operate and maintain their own water systems. Hence, for equitable and sustainable safe drinking water provision, these NGOs can form a symbiotic relationship where AguaClara can benefit from Gram Vikas' strong societal domain and Gram Vikas can benefit from AguaClara's strong natural domain. Neither groups can really address the political domain as the Indian state and local water institutions have not been able to work efficiently due to mismatch of roles, absence of capacity building mechanisms and necessary funding. Another challenge is cost recovery for water treatment plants, considering the low purchasing power parity in rural communities in India. The report concludes with suggestions for strengthening equity and sustainability in water treatment and delivery.

INTRODUCTION

The Millennium Development Goals (MDG) target 7 required that the proportion of the population without improved access to safe drinking water to be halved between 1990 and 2015. During the MDG period (2000-2010), it is projected that globally consumption of improved drinking water sources increased from 76% to 91%. The MDG target of 88% was achieved in 2010, and in 2015; 6.6 billion people used an improved source of drinking water (UNICEF & WHO, 2015). The post-2015 Sustainable Development Goal (SDG) six calls for the "availability and sustainable management of drinking water and sanitation for all," and target 6.a calls for actors to "support and strengthen the participation of local communities in improving water and sanitation management". While many advancements have been made towards this goal, progress in rural areas is lagging in comparison to urban areas (United Nations, 2011). Globally, 80% of the people who have inadequate access to drinking water sources live in rural areas (United Nations, 2010). This lack of improved sanitation access contributes to a large global health burden, including mortality, diarrhea, trachoma, and helminth infections. Even where rural water supply systems are developed, many are in disrepair or not functioning properly.

Several elements may affect the development of sustainable rural water supply systems. Firstly, numerous improvement projects in the rural water supply sector have been neither sustainable nor replicable. Swiftly growing population has made this job more cumbersome. Extensive failures of new water supply systems mostly from inadequate maintenance have surpassed the gains. Moreover, communities in rural areas may have limited capacity to raise the capital needed for water infrastructure, or they may lack the technical expertise needed to operate and maintain water systems (Khan, 1999).

Rural communities need cost-effective, transparent and intelligible systems which should take into consideration the natural as well as societal elements as well. These elements include mutual trust, reciprocity, collective identity, cooperation and a knowledge-based adaptive framework. A study about rural community-based water systems in India in which Briscoe et al. (1988, p. 1) reinforced this point - “it is vital that all parties involved in efforts to improve rural water supply – government agencies, donors, advisors, community leaders, and residents - to mobilize the local people so that they become the primary decision maker, the primary investor, the primary maintainer, the primary organizer, and the primary overseer.”

A primary goal of this thesis is to offer a theoretical framework to evaluate the strength and weaknesses of rural water supply development and explore how this framework can be applied in India. This thesis will incorporate a set of tools that allow for engaging both state and non-state actors in rural water supply services. The non-state actors are – AguaClara, a Cornell University based network of organizations that aims to create and implement revolutionary pro-poor water treatment technology; and Gram Vikas, a proactive India-based NGO extensively working in water and sanitation sector. The framework will then be tested and implemented in the villages of Kaliabeda and Lahanda in Odisha, India. Project personnel from AguaClara and Gram Vikas are already working there to set up water treatment and delivery mechanisms

The theoretical framework I develop rests on three principal concepts. First, is the natural domain – water quality, and quantity, water treatment technology and ecosystems — second is the societal domain – community participation, social values, cultural norms, local institutions, economic and human resources – and lastly, the interactions of these domains within a political context that is essential for sustained success in water treatment and delivery.

To start with, I will first study the governance models of AguaClara and Gram Vikas and how they successfully develop their natural and societal domains to withstand the benefits of their water projects. I will also evaluate if these models are complimentary to each other and, how they can build a foundation for developing a first-of-its-kind rural water supply pilot project in India. I will specially focus on the literature from rural community-based water supply systems and what challenges and issues they face according to academic researchers. I describe various policies and regulations in rural water supply systems in India and how they can well accommodate the AguaClara and Gram Vikas models. The framework will be tested in two villages of Odisha in India. The core of this thesis is to develop a framework where the state government, AguaClara and Gram Vikas, could work together in establishing a sustainable and replicable water supply system and at the same time, mobilize rural communities of Odisha.

Before going forward, I will provide some context on how India and Odisha in particular, are performing in terms of rural drinking water provision.

Article 47 of the Constitution of India allocates top priority to the provision of clean drinking water, devolving the function of delivering safe drinking water to the State (Sankaranarayanan, 2014). However, the pressures of development are changing the distribution of water in the country with the average accessibility of water plummeting with the rising economic and social heterogeneity among the communities. Whereas providing drinking water has always been a key issue, guaranteeing that it is safe is a task in itself. Achieving the drinking water needs in India's villages where huge populations are spread across numerous diverse ecological areas is an overwhelming challenge (Khurana & Sen, 2008). This is further aggravated by the lack of education and awareness, poverty, diverse socio-economic characteristics, and cultural practices among the communities. The state of Odisha is one of the many examples where rural water systems are unsustainable.

Odisha is one of the poorest states in India, and has the dubious distinction of being the state with the poorest coverage of water and sanitation. Less than 20% of the population have access to a protected water supply and less than 1% to piped water supply (Government of Odisha, 2004). Villagers mostly do not take initiatives themselves to agitate for basic services as they are often divided along economic, caste and tribe lines. Inadequate access to safe drinking water is a significant issue in the state of Odisha, resulting in loss of time spent on productive activities as water sources have very poor quality and are often very far from households (Keirns, 2007). Hence, considering water as a basic human right, there arises a need for holistic and people-centered approaches for water management with emphasis on simple and sustainable technology. Programs such as AguaClara and Gram Vikas demonstrate that the managerial and governance domains must be addressed for rural water systems to work efficiently in the long-run, as will be evident from the AguaClara and Gram Vikas models in the later sections.

Gonzalez et al., argue that AguaClara uses a form of "cooperative governance" where engineers and local communities share information and develop innovative solutions (Gonzalez, Beers, Weber-Shirk, & Warner, 2008). It has had a successful implementation in Honduras, where its water treatment plants continue to provide safe and potable water to the rural communities and self-finance their operations and maintenance. The program is currently looking into improving its technological and financial capacity with the social dimensions of water provision (Beers, 2012). AguaClara is seeking to expand its technology on a global scale, starting with a pilot project in India. In their meeting with Gram Vikas in 2015, AguaClara saw a potential to build social capital while managing a project might garner the institutional strength to take a pilot to scale.

Gram Vikas is a rural development organization working with poor and marginalized rural communities in Odisha since 1979. In water and sanitation, Gram Vikas has identified an entry point activity, which addresses the issue of unsafe drinking water and thereby water-borne diseases. Simultaneously, it makes 100% inclusion a pre-requisite, not only ensuring the entire community benefits, regardless of caste, class and gender, but also ensuring effectiveness of the program (Keirns, 2007). In addition to working in partnership with communities to enable every household in a village to have their own private toilet and bathing room, Gram Vikas constructs a water supply system, ensuring every household has a 24-hour supply of piped water to their home. Wherever possible gravity flow water supply systems are used, overcoming the difficulty of having to pump water where there are no electricity connections, or having to pay expensive electricity bills for pumping water. They are currently using bleaching powder and semi-filters to treat well waters for disinfection. In some of the areas in Odisha that Gram Vikas is planning to work, there is a chance that they will require chlorine dosing. Hence, they have expressed their interest in AguaClara's sustainable and pro-poor water chemical dosing system, to address the major need in these villages (AguaClara LLC & Tata Cornell Initiative, 2016).

Objective

In the following sections I engage the literature on capitals framework and community-based water systems in order to come up with a model incorporating state and non-state actors in rural water supply, particularly in India. Based on the literature review, I develop a theoretical framework consisting of the interactions of the natural and societal domains within a political context. The natural domain consists of variables such as natural and physical capitals (water quality, and quantity, water treatment technology and ecosystems). The societal domain consists of elements like social, financial and human capitals (community participation, social values, cultural norms, local institutions, economic and human resources). Political context means the presence of an enabling policy environment (political capital). This framework will guide me in evaluating the partnership between AguaClara and Gram Vikas to set up successful drinking systems in the rural communities of Odisha. I will define this framework more comprehensively in the sections on literature review and methodology, and then apply it in the villages of Kaliabeda and Lahanda Odisha. After analyzing this framework in these villages, I will offer some recommendations and suggestions for future research.

LITERATURE REVIEW

This chapter explores the insights gained from literature on community-based water management. The literature, much of which is based on community capitals framework by Flora et al (2006), addresses the issues of collective action in terms of water provision, failure of government to provide safe drinking water to rural communities, role of NGOs in mobilizing the rural communities, caste and gender heterogeneity in provision of water and financial management of rural water supply systems. Based on the conclusions drawn from the literature review, I develop a theoretical framework to analyze the partnership between Gram Vikas and AguaClara.

Water – Common good or commodity or somewhere in between?

Water does not possess the quality of a pure public good, as it is usually rivalrous and often excludable. Subject to the nature of supply, water can be both public and private good, as well as somewhere in between. Additionally, there exist temptations to free ride on water infrastructure as it is difficult to make the provision of water fully excludable. Hence, water is considered to be an imperfect public good, confined in nature, and is often managed as a common-pool resource, for which vigorous community-controlled cooperation and management tools exists (Ostrom, 1990) . The combination of public good characteristics, market failures and common property rights makes water an important good, but complicate how to best provide it (Bakker, 2004).

In simpler terms, water is a flow resource over which property rights are difficult to establish. It is characterized by a high degree of public health and environmental externalities. These costs of are difficult to calculate and reflect in water prices. Water is a non-substitutable resource essential for life with important aesthetic, symbolic, spiritual, and ecological functions. Private property rights can be established for water resources or water supply infrastructure, but complete commodification does not necessarily follow.

Significant disparities are present between the role of government, market, and community in provision of drinking water (Table 1). One important distinction is the role of the user: a citizen, a customer, or a community member. Each role implies different rights, responsibilities, and accountability mechanisms. Yet this tri-partite categorization tends to compartmentalize water supply into ideal types. In fact, many governments have chosen to create hybrid management models particularly in the developed countries. However, this tripartite classification is clearly inadequate when applied to the global South, where public water supply systems often provide water only to privileged neighborhoods, leaving the poor and the marginalized to self-organize through community cooperatives or informal and private provision by water vendors (Swyngedouw & Swyngedouw, 2004).

Table 1: Water Supply Delivery Models: The Cooperative, the State, and the Private Corporation

		State	**Market**	**Community**
Resource management institutions	**Primary goals**	Public interest	Maximization of profit	Serve community interest
		Conformity with legislation	Efficient performance	Effective performance
	Regulatory framework	Command and control	Market mechanism	
	Property rights	Public or private property	Private property	Public or private property
Resource management organizations	**Primary decision-makers**	Administrators, public officials	Individual households, experts, companies	Leaders and members of community organizations
	Organizational structure	Municipal department, civil service	Private company, corporation	Cooperative, association/ networks
	Business models	Municipally owned utility	Private corporate utility	Community cooperative
Resource governance	**Accountability mechanism**	Hierarchy	Contract	Community norms
	Key incentives	Voter	Price, customer opinion	Community opinions

	Key endorsements	Political process via elections, litigation	Financial loss, takeover, litigation	Livelihood needs, social pressure, litigation
	User role	User and citizen	User and customer	User and community member
	Participation of users	Collective, top-down	Individualistic	Collective, bottom-up

Source: Bakker, K. (2004). The "commons" versus the "commodity": Alter-globalization, anti-privatization and the human right to water in the global south. Antipode, 39(3), p. 435

Rural drinking water systems are common-pool resources (CPRs). Ostrom et al. (1994) defines common pool resources as natural or manmade assets that produce a flow of functional resource units over time. The authors admit that it is costly to develop institutions to effectively provide resources to potential recipients. At the same time the resource units secured by one individual may not be accessible to others. As a result, these goods share the features of both public as well as private goods and hence, the dynamic and systemic interactions of technical, social, financial, institutional, and environmental capitals hinders their sustainability. For instance, rural communities often lack the necessary capacity to maintain their water systems. Water systems often fail to respond to local needs, desires and demands, resulting in communities often abandoning them and finally, a lack of harmonious coordination between actors is involved. An inefficient use of resources often stifles effective capacity building of the community, government, and local institutions.

This complex relationship between technical, social, financial, institutional and environmental capitals can lead to water system failure. More than just static outcome, sustainability of a rural water system often depends on the system-based integration of these capitals. As such, planning for sustainable rural water services largely becomes a process of interpreting and adapting to the dynamic interaction of the capitals that influence long-term functionality. Thus, in order to create long-lasting solutions to water poverty, the systemic and dynamic interaction between these capitals must be considered.

Why rural community-based water systems fail?

Research has shown that rural water supplies in the global south often demonstrate low levels of sustainability due to numerous reasons. While rural community based water systems are universal in nature, they might fail if the following issues in the domains of politics, society and nature are not addressed in a timely manner (Table 2).

Table 2: Issues in Rural Community-Based Water Systems

Issues	**Reason**
Political Domain	Government bureaucracy and corruption
	Lack of continued support from local, regional and national level government
	Lack of legal, regulatory and policy frameworks
	External top down development efforts
	Political interference in planning and resource allocations
	High turnover of leadership
	Overstretched or under resourced governments
Societal Domain	Rent-seeking behavior
	Lack of access to funds for capital infrastructure costs
	Costs of services are unacceptable, impracticable and/or unaffordable
	Financial mismanagement
	Communities not convinced of the desirability of a new project
	Lack of participation by women, poor and marginalized sections
	Lack of motivation to self-initiate a project
	Lack of maintenance and monitoring
	Lack of capacity to manage assets
	Lack of ownership of the new infrastructure
	Influence of the rich and powerful in the project
	Caste/Religion/Social Heterogeneity
	Lack of public health awareness amongst communities

Natural Domain	Lack of adequate service level metrics of a project Inappropriate technology Distribution system unattended Poor design Unprepared for severe weather Capital intensive project with no O & M programs Swiftly increasing population and sprawled up development exploiting the carrying capacity of a natural resource Eroded soil in streams, bacterial contamination, altered stream flows and soil exports Climate change and global warming Land use degradation

Source: Beers, K. (2012, May). Governance Models for Community Water Systems: The Case of AguaClara. Ithaca: Cornell University. p. 7

The six forms of capital for sustainable rural community-based water systems

Flora et al (2006) identified six forms of capital that communities need for sustainable community-based water resources management: natural, cultural, human, political, financial and built capital (Table 3). These forms gave rise to the community capitals framework which offers a way to analyze community and economic development efforts from a system perspective by identifying the assets in each capital, the amount of capital invested, the interaction amongst the capital and the resulting impacts across capitals.

Table 3: Summary of the Six Forms of Capital

Capital	**Question**	**Definition**
Natural	What does the water give us?	Assets in a particular location, including geography, natural resources, amenities, and natural beauty.
Cultural	How do we think and act in our community?	The way people "know the world" and how they act within it, as well as traditions and language.
Built	What is the infrastructure for provision of water?	
Human	What can I do?	The skills and abilities of people to develop and enhance their resources.

Social	What can we do together?	The connections among people and organizations or the social "glue" to make things happen. Bonding social capital = close redundant ties that build community cohesion. Bridging social capital = loose ties that bridge among organizations and communities. (Gasteyer & Taylor, 2009)
Political	What about our political activities?	Access to power, organizations, connection to resources and power brokers. The ability of people to find their own voice and to engage in actions that contribute to the well-being of their community.
Financial	How do we pay for water infrastructure now and in the future?	Financial resources to invest in community capacity building, civic and social entrepreneurship, and accumulate wealth for future community development.

Source: Emery, M., & Flora, C. (2006). Spiraling-up: Mapping community transformation with community capitals framework. Community development, 37(1), 19-35.

According to Warner (1999), community social capital is more difficult to create, as it requires explicit attention to its three features: autonomy, linkages and returns on investment. When the government initiative is successful in involving participants as partners in program design, they are more effective in building community social capital. The author states that horizontal ties are key to broad community involvement and vertical ties to broader system change. Returns on investment in community level social capital require comprehensive mutuality and an egalitarian, approachable government. Correspondingly, according to Gasteyer et al (2009), not all forms of capital need to be present at the community-level, they can be found at higher, regional or national levels. They proposed using the concept of 'nested governance'. Nested governance necessitates the horizontal and vertical linkages between different levels of institutions in which they support and complement each other's work.

To that end, Gasteyer & Taylor (2009) modified Flora's framework by splitting the social capital into bridging and bonding social capital to assess a community's strength and resilience for sustainable development. Bonding social capital are the close redundant ties that build the community structure, and bridging social capital involves loose ties that connect organizations and communities. Various factors including awareness, inter-related descriptions of the situations, commitment, trust, inter-dialogue processes and negotiations of interests, roles and identities are impertinent in determining which type of them are built. The basis for these factors is that knowledge is socially distributed in different and unequal forms in a community. Co-operation between various actors is a process of re-distributing this knowledge of identifying the relationship between the knowledge of various actors involved, from there, starting to negotiate knowledge for mutual purposes. This framework uses a broader definition of social capital than Flora's in a sense that it considers political capital – the connections to governing institutions and resources – as part of social capital.

Hardoy et al. (2001, p. 39) similarly recognized the importance of political capital: "[T]he capacity of low-income groups to build, to work collectively in addressing common problems and to negotiate effectively with local, city and (often) national government will continue to have the greatest influence on the quality of their living environment". In their study analyzing the failure of governments to supply clean water in Latin America, Africa and Asia, the authors refer to the challenges of provision from a lack of investment capacity for installing or expanding basic infrastructure and the inadequacy of basic capital equipment. Additionally, they state that even when capital investment is there, the community's capacity to manage and maintain the infrastructure is very limited.

In a more a recent study, while analyzing community-based natural resource management (CBNRM), Fabricius et al. (2007) discussed the need for goal-setting and planning, clearly defined property rights, developing management capacity, understanding the financial and legal frameworks as well as monitoring, adapting and creating sustainable incentives, for increasing the likelihood of success of CBNRM. The authors cite six shocks that could interrupt a CBNRM initiative. These include – 1) conflict, including competition that arises at the time of success, tension between various state and non-state actors; 2) financial mismanagement, such as corruption and poor accounting skills; 3) mismanagement of natural resources; 4) high turnover of leadership; 5) political and economic change at higher levels; and 6) top-down approach (Fabricius & Collins, 2007).

Furthermore, they point to a set of strict execution challenges that result from weak governance which further threatens CBNRM initiatives, especially at the early and most fragile stages of implementation. These include, a slow pace of development; weak participation by state actors; and poor coordination. According to the authors, the six types of capital act as cushions that absorb shocks and support CBNRM initiatives. They suggest dedicated efforts to strengthening the “harder” forms of capital - human, financial, and physical - without overlooking the social and natural capital already existing in a local community. (Fabricius & Collins, 2007).

The authors use a broad definition of governance in a CBNRM initiative, which includes both the formal decision-making structures and informal social networks and the relationships of trust that sustain them. According to this definition, governance would encompass aspects of social and political capital, and would be responsible for caring for, building and marshaling all the other forms of capital. The authors emphasize some characteristics of governance should be strengthened in the early stages of projects to overcome the challenges to CBNRM. These are - knowledge networks composed of diverse and experienced actors; legitimate decision-making structures with formalized membership and procedures; conflict resolution practices; formal commitments to duties for main actors, and incentives to meet these commitments; and facilitating communication between actors in the knowledge network. (Fabricius & Collins, 2007).

Finally, the authors recommend the actors involved in the knowledge network engage in a form of “cooperative governance” where scientists, government and local communities collectively share information and develop innovative solutions (Fabricius & Collins, 2007). In this context, each of the three actors plays a crucial role. Local communities are aware of local circumstances and can respond to them by creating appropriate rubrics for natural resource use on a local level. Scientists or outside experts gather and share information that might not be obvious to local communities and the government. They facilitate two-way communication between communities and policy makers. In addition, scientists have access to advanced technology, which helps with planning and monitoring. Moreover, government guarantees long-lasting stewardship of the natural resources. The absence of any form of hierarchy makes this three-actor model distinct from 'nested governance', but it highlights the importance of external support to local governance.

Cooperative forms of governance are multi-dimensional in the policy instruments employed; the make-up of actors, and the types of rationalities that actors use to debate the problem and proposed solutions. Cooperative governance requires even more emphasis on the management of processes and people. Extensiveness of decision making suggests that bottom-up approaches should be strengthened to put more importance on the multi-disciplinary production of knowledge. Tropp (2007) suggests that it is important to develop knowledge and capacities that can respond effectively to situations characterized by intricacy, uncertainties, changes and trade-offs. People who can bring about transformation are needed and therefore more attention needs to be paid to the knowledge and capacity that are critical to developing water governance system that are inclusive, flexible and that can respond to changing social and hydrological conditions. Tropp also recommends that the water governance system should aim for political and social stability. Robust and flexible governance structures should be able to cope with such problems by providing mediation between conflicting water uses, compensation to disfavored groups and benefit sharing.

Community participation and the potential of social capital

Various literatures have hailed community participation as an important component in the water sector. As involvement of civil society can promote cooperative forms of governance, because the community can actively screen policy implementations (McIntosh, 2003). Moreover, civil society involvement increases the sense of ownership over water infrastructures, which leads to appreciation and shared responsibilities to ensure continuous and reliable operation and maintenance.

Much literature also maintains that a community driven approach builds social capital through active participation from the early stages of an infrastructure project. A community-based approach is a feasible solution to overcome the lack of central and state government attention given to rural areas. The primary goal of involving the community from the beginning is to increase ownership and appreciation of water supply infrastructures (Rockler, 2015). Community-driven projects and community-based organizations (CBOs) provide opportunities to non-governmental organizations (NGOs) and local private entrepreneurs and individuals to participate in project design and procurement (Binswanger, Jorgensen, & de Regt, 2010).

Araral (2009) notes that the involvement of communities as active partners in development is in itself valuable. Criticisms arise around the susceptibility of the community to elite capture, effective management, costs, and the sustainability of development projects in terms of operation and maintenance. These criticisms are valid in water resource and water supply developments, which require long-term commitment from communities. There needs to be clarity of institutional forms in the specific program implementation and the stages in which the community should be participating (Phillips & Orsini, 2002). Hence, the success, effectiveness, and sustainability of the community-driven projects, is precisely the responsibility of the public sector to provide continuous monitoring and guidance to the community organizations.

In the study of community-based water services in Sri Lanka and India, Isham et al. (2002) claim that household participation in service design and the ability to design and enforce monitoring mechanisms are not automatic. In communities with high levels of social capital, participation in the design process is more likely to be high and monitoring mechanisms are more likely to be in place (Isham & Kähkönen, 2002). In those communities, households are adapted to working together, and social ties discourage free riding. This suggests a way to place an economic value on community-level social capital in the context of water projects, namely, as the net present value of the marginal increase in health associated with active civic associations.

The following three factors have led to successful rural community-based water systems. Firstly, demand responsive-approaches ensures full participation of communities in decision-making, control, and management (Sedegah, 2014). Secondly, governments should perform the role of a facilitator in planning, policy formulation, monitoring and evaluation, and partial financial support (Helmsing, 2002). Thirdly, there should be a partial capital cost sharing, in either cash or kind or both, and 100 per cent responsibility of operation and maintenance by the communities (Cullet, 2006). The strategies include awareness generation programs, monetary assistance to the local governments to ensure their support, use of politicians or key personalities in the local area to garner the trust of people and the use of scientific knowledge to interest people in the health and safety associated with drinking water. While discussing the challenges with regards to planning for sustainable water systems in North America, Britain, the European Union and Asia Pacific, Wheeler (2013) argued that the sustainability of the program comes through community empowerment, capacity building, women empowerment and social mobilization guided by holistic perspective on people's participation, ecological conservation, sanitation, appropriate technology, attitude and behavioral change.

The effect of caste and gender heterogeneity in provision of water

In a community, numerous connections rely on the cooperation of others. Trade often requires trust, providing public goods needs collective action and the rule of law and is only possible if everyone accepts the rights of others. Homogeneous societies, thus, have an advantage because there may be more contact across the population, which builds understanding, trust and empathy, and shared interests. This makes it more likely that they will all be on the same side in the decision-making processes (Banerjee, Iyer, & Somanathan, 2005).

However, collective action also has the potential to benefit marginalized groups through the equitable distribution of resources. Yet, existing predispositions in social norms and the risk of elite capture that tend to exclude women and minority groups, thwarts collective action (Meinzen-Dick, Pandolfelli, Dohrn, & Athens, 2005). One would expect economic aspects such as poverty and inequality to play an essential role in shaping access to public goods, these factors are complicatedly related to the age-old social divisions (Banerjee, Iyer, & Somanathan, 2005). India has had a long past of annexations and external occupation, which ended with independence from British colonial rule in 1947. As a result, Indian society is deeply disjointed along social lines, and these divisions have a key role in both politics and the distribution of limited public resources even after more than sixty years of independence.

The principal form of social division in India is the caste system, which has profound historic roots in the majority Hindu religion. Historically, the purpose to create caste divisions was to simplify the credentials of social groups on the basis of their skill levels. But, due to power differentials, certain groups became more dominant than others, founding the origin of social discrimination. Although discrimination based on caste is prohibited in India, there exists a sharp difference between the higher and the lower castes. The highest caste being the Brahmans, while Scheduled Castes (SC) and Scheduled Tribes (ST) are at the bottommost of the social ladder.

Caste divisions control the access to drinking water. The form of social stratification and the rivalry it produces limit the provision of drinking water sources. Several authors, like Kruks-Wisner (2011) and Waring (2012) in their study on caste-based stratification in India, highlight the necessity for coordination within communities to gain access to public goods. In this context, social divisions based on caste can either obstruct or enable this coordination mechanism. Contrastingly, social disintegration may result in unambiguous or inherent rivalry for limited public goods and, over time, may in turn make the dominant caste hoard much of the welfare of public goods. Drinking water, being crucial to economic activity and to basic human right, is hence at the focus of this competition. In contrast, robust legal institutions could also lead to more acceptance and cooperation amongst social groups over time, so that communities may profit from this cooperation in the form of higher access to public goods.

Similarly, for religious and sociocultural reasons women are not considered as equals in the decision-making process in rural areas of India. The decisions are mainly made by men on matters related to the home, local self-government and developmental programs and hence, women are consistently denied their rights to take decisions about themselves in all walks of life. They are directly or indirectly denied access to various types of resources and these factors contribute to the subservient position of women in the rural society of the country (Devasia, 1998).

Women and minority groups have distinct social networks, a higher dependence on such networks, and potentially greater group homogeneity (Agarwal, 2000). They build social capital through local networks since their access to economic resources and their mobility is more restricted than that of men. There is abundant evidence of their everyday forms of cooperation, extending linkages to other women and minority groups with whom they interact regularly (Sharma, 1980). Such forms of cooperation can influence their propensity to act collectively in more organized activities (Agarwal, 2000). Hence, an analysis of collective action on caste and gender lines is crucial since institutions themselves are biased and can reinforce social roles (Pandolfelli, Meinzen-Dick, & & Dohrn, 2008). It is important for policies to address a group’s social composition and its relational and institutional social capital, which means looking closely at power relations among women, minority groups and men and their interdependence for effective collective action (Westermann, Ashby, & Pretty, 2005).

The role of NGOs in community mobilization

Mulgan et al. (2007) claim that NGOs play an important role in the first stage of water upgrading, as both subsidy and social marketing are needed to establish a critical mass, to raise user awareness and to convince communities about economic and health impacts of safe drinking water. Issues such as social marketing and giving credit to users are very difficult for local government institutions, as they have insufficient capital and knowledge to do this. For lower income households, NGOs are crucial for partial funding of the water points as these households cannot afford to buy a tube well and hand pump or other water points themselves.

Shahrukh Rafi Khan (2000), while studying the role of state and non-state actors in social sector delivery in rural Pakistan, hailed the role of NGOs in effective participatory development in rural villages. The author claimed that there could be a natural complementarity between state and NGOs. Even when state and local institutions are performing well, there is a chance that the most vulnerable members of the society are bypassed. Addressing the needs of these groups is the primary focus of the NGOs. NGOs could also mobilize government expertise for training its own staff and service the community organizations. The idea is to organize the poor to make government services accessible to them.

Therefore, this approach is more likely to reach the poor, to scale up quickly, to have high rates of return, and to have faster and more efficient disbursement. NGOs are not confined to a particular community but are expected to spread and benefit many. This means that the social returns on information and services provided by NGOs exceeds the returns on philanthropy. Altruism is not the pre-condition for the functioning of NGOs. Most NGOs hire professionals for social mobilization, training and other technical functions (Araral, 2009). Therefore, NGOs can induce the spirit of self-help and reduce delivery costs by means of contributed labor and materials.

Willingness to pay and building financial capital

If rural water projects are to be both sustainable and replicable, an improved planning methodology is required that includes a transparent and accountable procedure, and tariffs must be designed so that at least operation and maintenance costs can be recovered. A key concept in such an improved planning methodology is that of "willingness to pay" (Whittington, Briscoe, Mu, & Barron, 1990). If people are willing to pay for the full costs of a particular service, then it is a clear indication that the service is acceptable to the community. Most attempts to incorporate willingness-to-pay considerations into project design however have been ad hoc, in large part because of the absence of tested methodologies for evaluating willingness to pay for water in the rural communities of developing countries (Jordan & Elnagheeb, 1993). Thus, incentivizing citizens to pay for their service would increase the ability of the local water committee to maintain the system and result in the provision of higher quality water services.

The cost involved in providing water services to the rural community include: (i) creation of physical facilities, (ii) operation and maintenance, and (iii) replacement due to wear and tear. Financing the capital cost, and recurring costs such as Operation and Maintenance (O&M) of rural water supply installations are major expenditure items of local government as much as for the state government (Fonseca, Smits, Nyarko, Naafs, & Franceys, 2013). Moreover, the financing and delivery systems for rural water supply system will have to meet the expanding needs of a growing population as well as the increasing demand for higher and better quality levels of service. Hence, they must accumulate enough cost recovery to make necessary replacements as well.

Overall, the role of governance and events outside the water sector is critical to the success of getting an effective water governance system in place. The reform of the water sector goes hand-in-hand with overall governance reform. It is highly unlikely that effective participation, transparency and accountability will take place in the water sector unless the particular country's overall governance system allows this (Solanes & Jouravlev, 2006). Until water concerns are made part of broader national-level policies, the chances of achieving the water targets in rural areas, remain poor. Therefore, there is a need to cooperate with government, technical experts, NGOs and rural communities to form more inclusive water development networks.

In that sense, the rise of new forms of governance in the water sector has unlocked the likelihood of seeing politics as not just the problem but as a part of the solution as well (Tropp, 2007). Technical capital-intensive solutions to water issues are insufficient to ensure sound water development. Decision-makers should be centrally active to water governance. Knowledge and capacities relating to managing people and processes and negotiation will be crucial to improving water governance (Tropp, 2007). It is also vital that the knowledge itself be more diversified and multidisciplinary to mirror the complexities of how water is utilized and governed.

Discussion and theoretical framework

The above readings on community capitals, nested governance, caste and gender heterogeneity and the role of NGOs have helped me in creating a framework through which I can analyze the partnership between AguaClara and Gram Vikas for successful rural water systems in Odisha. Through the literature review, the community capitals framework presented by Flora et al (2006), Gasteyer et al (2009), Fabricius et al (2007) and Hardoy et al (2001) can be bucketed into three key domains: Natural, Social and Political (Table 4).

Table 4: Variables for Evaluation Based on Literature Review.

Domains	**Capitals**	**Variables**
Natural	Natural	surface water availability, quality and quantity
	Physical	water treatment technology
Societal	Human	social values, cultural norms, collective identity amongst local communities
	Social	mechanisms for garnering mutual trust, community participation and mobilization

	Financial	accessibility of funds and willingness to pay tariffs to cover capital expenses, and O & M
Political	Political	enabling central, state and local level policy environment for water service provision

Within the natural domain, the interplay between two important variables – natural and physical capital (water quality, and quantity, water treatment technology and ecosystems) – can lead to conflict. Within the societal domain, there are equally complex interdependencies and feedback among social, financial and human capitals (community participation, social values, cultural norms, local institutions, economic and human resources). Political domain includes the presence of an enabling policy environment (political capital). Therefore, a key goal of my research is to create a better way to link these complex interactions in the natural and societal domains within a political context (Figure 1). Doing so will help in evaluating whether the partnership between AguaClara and Gram Vikas demonstrates collaborative synergies for successful drinking water systems in rural Odisha.

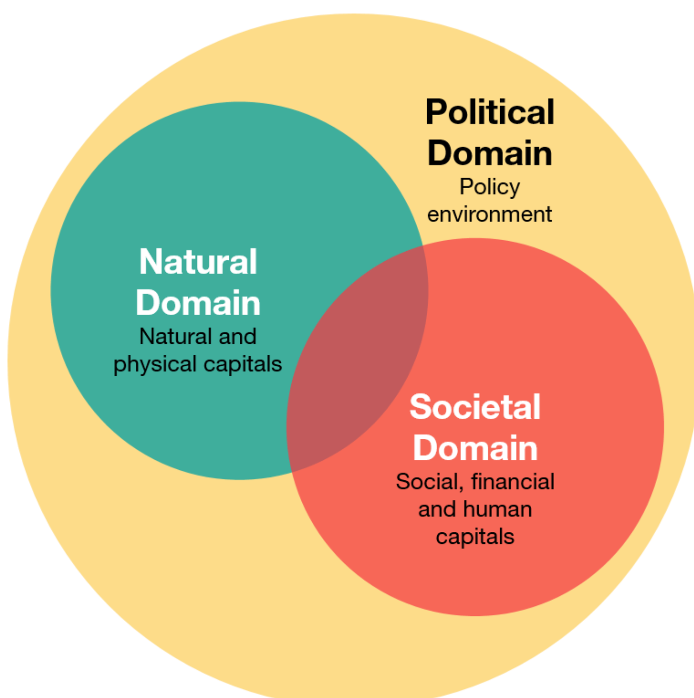

Figure 1: Theoretical Framework for Analysis.

Physical and natural capitals need be innovated to fit the local context (Fabricius & Collins, 2007), human and financial capitals need to be identified (Fonseca, Smits, Nyarko, Naafs, & Franceys, 2013) and social and political capitals need to be addressed to enable positive policy environments for successful rural drinking water systems (Gonzalez, Beers, Weber-Shirk, & Warner, 2008). It is also evident that existence of social capital is utmost essential for successful rural community-based water systems, but it is also necessary to study this domain within a political context (policies and regulatory environments, and external support) (Gasteyer & Taylor, 2009). These inferences will guide me in coming up with a theoretical framework for this research.

As each water management problem is highly sensitive to its particular context: because knowledge about the interactions among the three domains is both local and contextual, management interventions need to be sustainable. Hence, another overarching challenge of my thesis is find out a way to integrate multiple kinds of knowledge from the natural and societal domains that water professionals can use to deal with complexity of water management networks in any particular location.

My method will be to concentrate on the dominant variables in the natural, societal and political domains within Odisha. The study is limited to two villages in Odisha – Lahanda and Kaliabeda – where AguaClara and Gram Vikas are already working to set up successful drinking water systems. The presence and strengths and weaknesses of one or more variables in the domains should help me to differentiate whether the partnership between Odisha, Gram Vikas and AguaClara is synergistic or not for these rural community-based water systems.

BACKGROUND TO THE CASE

Indian Governance Structure

In this section, I look at the country and state-level policy, legal, and regulatory frameworks, as the literature refers to these as the enabling environment for proper water system functioning.

The primary responsibility of providing drinking water facilities in the country rests with State Governments. The efforts of State Governments are supplemented by Government of India by providing financial assistance under Accelerated Rural Water Supply Program (ARWSP). ARWSP has been under implementation since 1972-73. Under ARWSP, the following norms are being adopted for providing household-level drinking water to rural population (Ministry of Rural Development, 2004)

- 40 liters per capita per day (LPCD) or 11 gallons per capita per day (GPCD) of safe drinking water.
- One hand pump or stand post for every 250 persons.
- The water source should exist within 1.6 kilometers (0.6 miles) in the plains and within 100 meters (110 yards) elevation in the hilly areas.

ARWSP was renamed as the National Rural Drinking Water Program (NRDWP) in 2010. NRDWP is a central government sponsored scheme to provide adequate and safe drinking water to the rural population of India. The scheme focuses on the creation of water infrastructure, and ensuring service delivery and sustainability of water supply schemes.

Under the Twelfth Five Year Plan, NRDWP is focused on surface water based schemes rather than on groundwater based schemes to decrease the pressure on groundwater extraction. There is also a focus on piped water supply through stand posts and on increasing household connections through extensive IEC (Information Education and Communication).

Service levels are proposed at 55 LPCD (15 GPCD) from 40 liter per capita per day (LPCD) or 11 gallons per capita per day (GPCD) and all new water supply projects account for life cycles costs and not just capital costs. Additionally, priority has been given to minority areas and funds have been earmarked for coverage of minority groups. Schedule Caste (SC) and Schedule Tribes (ST) population concentrated areas (Ministry of Drinking Water & Sanitation, 2013).

Additionally, NRDWP has proposed to achieve 100% piped water supply to households in a timely manner through intensive monitoring of the water supply schemes. Subsequently, Integrated Management Information System (IMIS) has been upgraded and the focus has shifted from household-wise monitoring approach to a scheme wise one. About 77% of rural communities in India have achieved a fully covered status (40 LPCD / 11 GPCD), under the NRDWP, and 55% of the rural population have access to tap water. However, in some areas, implementation of rural drinking water projects has been delayed over the past few years. Some reports suggests that until December 2016, only 44.5% funds under NRDWP were utilized and 53.5% works were completed (Jacob & Lala, 2017).

In Odisha, rural drinking water supply facilities are controlled by Department of Rural Water Supply and Sanitation (RWSS) organization since 1991. However, the management of drinking water supply projects was transferred to Gram Panchayats in 2006 for their management, operation and maintenance. Generally, provision of drinking water supply to the rural population is made through hand pump, tube wells and piped water supply schemes. Priority is given to not covered and partially covered communities. 45% of the annual NRDWP funds are earmarked for this purpose which is spent for piped water supply schemes along with installation of spot sources (hand pumps, tube wells, and stand posts). The Government of India & Government of Odisha share the cost of these schemes in 50:50 ratio. Priority is also given to fluoride affected communities followed by salinity and iron contamination. 20% of the annual NRDWP funds are earmarked for this purpose. 10% of NRDWP fund are also utilized for operation and maintenance of existing rural water supply systems though these functions are yet to be transferred to the panchayati raj institutions (PRIs) as they lack human resources and knowledge capacity to do so. RWSS is also responsible for water quality monitoring and surveillance, communication and capacity development, management of information system (IMIS) & digitization of all the data (Odisha Rural Development Department, 2017).

With several schemes being initiated by the state and central government, it is essential to get a view of the entire program in order to evaluate the extent of success on ground. For investigating the political domain of my theoretical framework, I will examine whether the communities in Kaliabeda and Lahanda have actually benefitted from these schemes and whether the government assistance and provisions have actually reached them.

AguaClara

AguaClara was initiated in 2005 in a partnership with a local NGO, Agua Para el Pueblo (APP) which focused on providing piped water to poor communities across Honduras. The organization was started by its current director Monroe Weber-Shirk, senior lecturer at Cornell's School of Civil and Environmental Engineering. The principal goal is to develop and implement innovative water treatment technology that both provides sufficient drinking water to meet national standards and does so at an affordable price for low income communities. The AguaClara technology is engineered to be operator friendly, robust and easy to run with one operator. AguaClara and APP have together built 14 plants in low to moderate income rural communities.

AguaClara plants are constructed using local labor and locally available materials. They make use of generic suppliers rather than specialized components. Since the plants are gravity-fed, they can operate without electricity. Also, use of valves and moving parts are minimized to reduce costs. The plants are robust and resilient and are optimized for low-cost and high-performance as they are easy to construct using low-precision construction techniques

Karim Beers (2012), while studying the governance models of AguaClara in Honduras, noted that community water boards associated with AguaClara facilities have invested in reforestation of watershed, upgraded distribution systems, extended distribution systems to add new customers, and funded ongoing maintenance of water supply infrastructure. Customers are willing to pay for clean water. This is particularly noteworthy in Honduras where most water treatment plants for large cities do not reliably meet drinking water standards, and users resist rate increases. Several towns with AguaClara facilities are experiencing reverse migration from the capital, Tegucigalpa, due to their superior water.

AguaClara is seeking to extend its technology on a global scale, starting with a pilot project in India. They have certain constraints relating to the presence of natural physical capitals for their site selection process given their technology focus. Through this process, Odisha was selected and AguaClara visited the state in 2015 to evaluate the local context. In their meeting with Gram Vikas, AguaClara found a potential in them to manage a project that will be long-lasting, and they have the institutional strength to take a pilot to scale.

AguaClara's projects in Honduras demonstrate that they have strong natural and physical capital but whether these will be replicale in the context of Odisha will be analyzed in this research.

Gram Vikas

Gram Vikas, is a non-governmental organization based in Odisha, which has implemented its Movement and Action Network for Transformation of Rural Areas (MANTRA) water and sanitation program in more than 1000 villages since 2002. The program involves household-level piped water supply and toilets coupled with community-level mobilization in minority areas in particular. The water and sanitation intervention is rolled out in a three-phase process. During the first phase, representatives of Gram Vikas visit the selected village to assess village interest and progress towards a set of Gram Vikas norms, including: (1) commitment of every household to participate, (2) formation of a village corpus fund from contributions from every household and (3) creation of village rules for maintenance and use of facilities.

Once this set of norms is established, the village advances into the second phase of the intervention where each house constructs a pour-flush toilet and a separate bathing room. The households provide their own unskilled labor and locally available materials to complete the structure. Gram Vikas provides materials such as PVC pipes and porcelain pans. At the same time, a water tank, community meeting space and piped water distribution system connected to every household, with taps in the toilet and bathing rooms and a separate tap in the kitchen, is constructed through a collective process.

All households must construct a toilet and bathing room for the village to progress into the final phase of the intervention, in which the water system is turned on. This model is different from government-led NRDWP schemes, which do not require community-level participation and do not offer piped water supply at the household level.

For treatment of water, wherever possible gravity flow water supply systems are used, overcoming the difficulty of having to pump water where there are no electricity connections, or having to pay expensive electricity bills for pumping water. Gram Vikas is currently using bleaching powder and semi-filters to treat well water for disinfection. In the villages of Kaliabeda and Lahanda, there is a chance that they will require chemical dosing. Hence, they have expressed interest in AguaClara’s Chemical Dose Controller (CDC) to provide chlorination, as they saw that it might address a major need in these villages.

STUDY AREA AND METHODOLOGY

Site selection

During my time as a part of AguaClara's regional planning team in spring 2016, we were given a task of examining potential sites in India for AguaClara to set up a pilot project plant. AguaClara requires a list of certain criteria for successful implementation of its water treatment plants in a specific location, these include –

(1) The population is between 5,000 and 25,000.

(2) There is a certain amount of population growth and average per capita daily water use.

(3) Surface water is available consistently all year.

(4) There is a consistent aquifer recharge (rainfall or mountain runoff).

(5) The surface water must be between 10 nephelometric turbidity units (NTU) and 1000 NTU.

(6) There is a distribution system and surface water treatment plants available.

These criteria fit well into the natural domain of my theoretical framework. For analyzing the societal and political domains in a region, I included a set of following social variables including –

(1) The consumers are willing to pay a tariff for plant operations and maintenance.
(2) The government set up is accommodating of the technology.
(3) There is a little political conflict or sufficient stability to allow for community engagement.
(4) Local partnership is available.

As previously discussed in the literature review section, for successful rural community-based water systems, the interactions amongst the natural, societal and domains need to be analyzed. Hence, the site selection analysis, focused on the needs assessment: why this place and nowhere else? It looked at two geographical levels: states and districts, analyzing the existence and potential of the aforementioned capitals in the areas. After going through the literature review and AguaClara's criteria for potential sites as mentioned above, I decided that a successful site for a pilot project will have the following eleven characteristics encompassing the natural, societal and political domains. The plants must be placed where:

(1) The population is between 5,000 and 25,000.
(2) There is a certain amount of population growth and average per capita daily water use.
(3) Surface water is available consistently all year.
(4) There is a consistent aquifer recharge (rainfall or mountain runoff).
(5) The surface water must be between 10 NTU and 1000 NTU.
(6) There is a distribution system and surface water treatment plants available.
(7) The consumers are willing to pay a tariff for plant operations and maintenance.
(8) The government set up is accommodating of the facility.
(9) There is a little political conflict or sufficient stability to allow for community engagement.
(10) Local partnership is available.

As the analysis was done at state-level for this research due to time and data constraints, I focused on characteristics (2) There is a certain amount of population growth and average per capita daily water use; (3) Surface water is available consistently all year; (7) The consumers are willing to pay a tariff for plant operations and maintenance; and, (10) Local partnership is available.

The preliminary analysis was done on ArcGIS using Jenk's optimization algorithm and weighted overlay method. I am focused on the selection of a potential site in India. The country already had AguaClara LLC workers on the ground meeting with local partners and building connections. My job was to approach through the research angle, gathering data on India's water sources, demographics, geography, and economy (Appendix A).

According to the analysis, the state of Odisha was selected for its utmost need for safe drinking water and sanitation facilities. The entire geospatial analysis is attached in the Appendix A. Odisha already has Gram Vikas working on the ground with AguaClara LLC in the villages of Kaliabeda and Lahanda. These villages are the two case studies of my research and their characteristics are discussed in the following section.

The setting

The study was conducted in the Keliabada and Lahanda villages of Odisha, the Indian state which lies on the eastern coast along the Bay of Bengal (Figure 2). Odisha is primarily rural and agrarian in nature, and 36% of rural households are classified as living below the poverty line, according to the Government of India (Planning Commission, 2014). Additionally, it ranks among the lowest of states nationally in terms of access to household-level latrines, with only 14.1% coverage in rural settings (Census of India, 2011). Odisha with a high tribal minority population, has consistently scored poorer in both the human development index and gender development index (Government of Odisha, 2004). Female literacy is also low compared to other states. While Odisha has made advances faster than the average state in recent years, the disease burden remains high with infant mortality at 50 out of 1000 births in 2013, and above average incidence of underweight children (Government of Odisha, 2004). Odisha's performance in the provision of safe drinking water has been reasonable with 75% of households having access to an improved drinking water source in 2011 (Census of India, 2011).

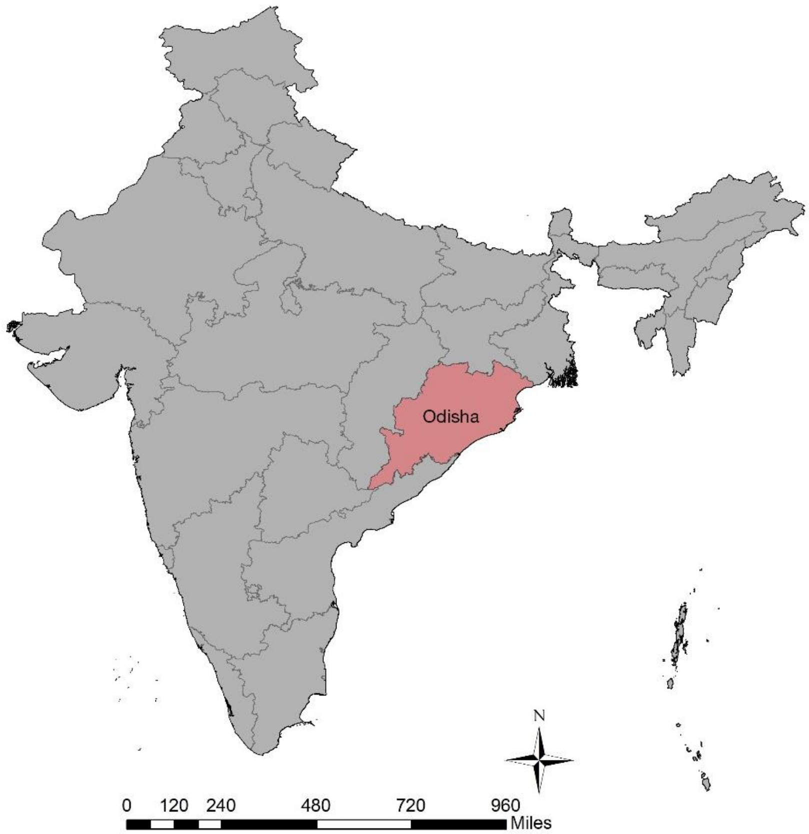

Figure 2: The State of Odisha Lies on the Eastern Coast of India
Source: NRSC, ISRO/DOS at www.nrsc.gov.in

In 2001, Odisha was tagged under the Empowered Action Group (EAG) states besides other 7 socio-economically backward states (Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Rajasthan, Uttaranchal and Uttar Pradesh) and hence, was designated a major proportion of the funds under the Rural Connectivity Scheme and Drinking Water Supply Scheme (Kumar & Das, 2014). Coupled with political will and advocacy from the central government in 2015, the programs of water, sanitation and hygiene were reinforced. Since then, the state faced a daunting task to drive the programs against the community rigidness and current acceptability of open field defecation. This was due to disparity between the socially acceptable pour-flush toilets and the levels of water access. Coverage of improved water sources, is comparatively high in the rural areas of Odisha, but it may not be sufficient for flushing purposes on top of other daily water needs.

On the whole, Odisha still remains economically and socially a backward state in India and hence it presents an interesting study for this research.

The villages of Kaliabeda and Lahanda are located in the Kedujhar (or Keonjhar) district of north-eastern Odisha (Figure 3). Over 75% (Table 5) of the population in these villages is recognized by the Government of India as scheduled castes or scheduled tribes (Census of India, 2011). As of 2011, a majority of households in both villages had access to an improved community level drinking water source, while over 2.7% of households in Lahanda have access to any sanitation facility, compared to 0% of households in Kaliabeda. The majority of population is categorized as "marginal workers"[1] and the literacy rate is just 42% in Lahanda compared to 71% in Kaliabeda (Census of India, 2011).

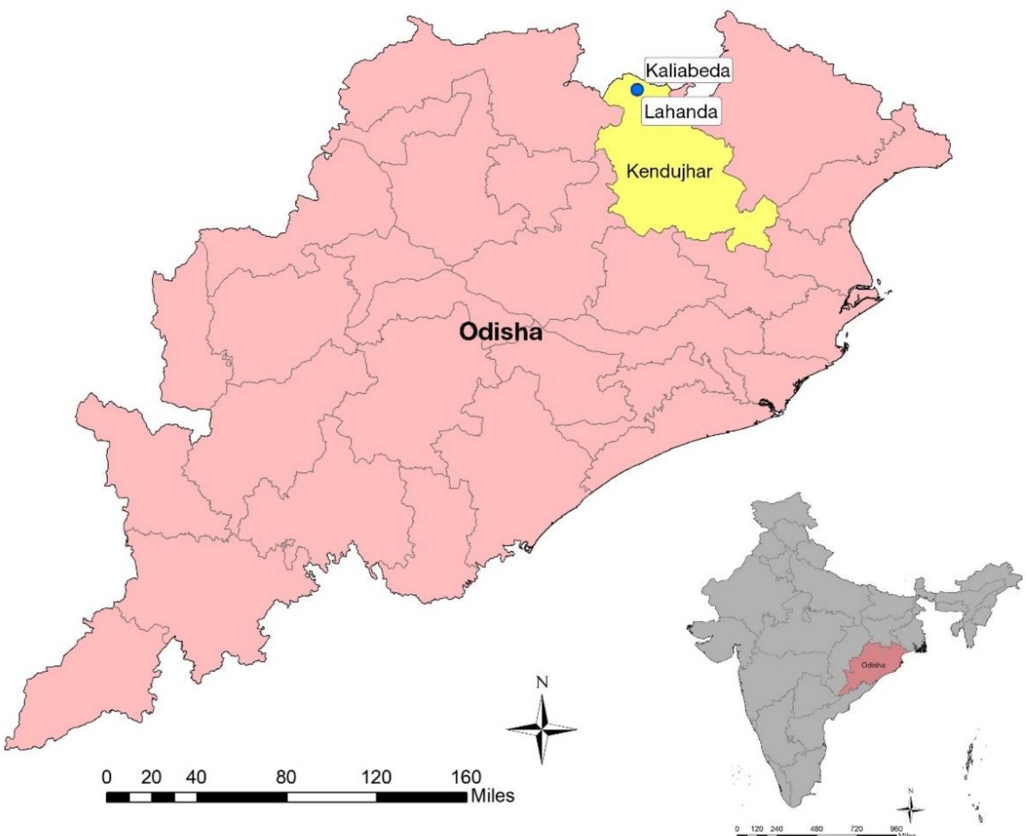

Figure 3: Lahanda and Kaliabeda Villages are Located in the Kendujhar District of Odisha.
Source: NRSC, ISRO/DOS at www.nrsc.gov.in

[1] Those workers who work less than 6 months in a year are termed as Marginal Workers.

Table 5: Demographic Data on Lahanda and Kaliabeda Villages

	Population	Households	Male	Female	Schedule Caste	Schedule Tribes
Lahanda	104	26	50	54	38	0
Kaliabeda	865	298	450	415	76	584

Source: Census of India, 2011

The villages are situated adjacent to each other, separated by national highway 215 (Figure 4). The nearest town is Joda, which is 4 miles away and the state capital, Bhubaneswar is 146 miles away. Tata Sponge Iron Factory and Jindal Steel Factory are located near these villages and are one of the major employers of the community (Figure 5). A stream, Sona Nadi goes past these villages in the south, which also acts as the main water source.

Figure 4: Location of Study Area

Source: Google Earth (December 20, 2016.) "Lahanda" 22° 3'9.68"N and 85°27'23.15"E. Retrieved on August 1, 2017

Figure 5: Tata Sponge Factory is just half a mile away from the study area

Data collection

The main hypothesis of this research is - the collaborative synergies between natural and societal domains will lead to successful rural community-drinking water systems. These domains have been discussed in detail earlier in the literature review section. The key variables in natural, societal and political domains were assessed through questionnaires, focus group discussions, interviews and field observations (Table 6). The questionnaires were used to evaluate the existing conditions of water supply systems and the degree and type of participation by community members. They were also used to evaluate the institutional support during the design, construction and maintenance phases. The questionnaire included questions about community contribution (capital, labor and material), female participation, technical factors (construction, operation and maintenance), financial factors (water tariff, willingness to pay), health factors and environmental factors (water quality and quantity and sustainability of the water source) (Appendix B). Information was verified using cross check questions.

Table 6: Data Collection According to the Theoretical Framework

Domains	Capitals	Variables
Natural	Natural	✓ Site Selection Criteria for potential sites – AguaClara program spring 2016
	Physical	✓ Interview and discussion with Prof. Monroe Weber-Shirk and Ms. Maysoon Sharif on AguaClara treatment technology ✓ Karim Beers and Maren Hill – Thesis projects
Societal	Human	✓ Household survey in 20 Households (HHs) in Lahanda ✓ Household surveys in 100 HHs in Kaliabeda ✓ Focus group discussions with women heads of every HHs
	Social	✓ Interviews with Mr. Debiprakash Mishra, Mr. Ashutosh Bhatt and a local project manager of Gram Vikas
	Financial	✓ Household surveys – willingness to pay ✓ Gram Vikas interviews – O&M costs in past projects ✓ Micheal Adelman et al. – AguaClara's cost recovery in Honduras
Political	Political	✓ Interview with Mr. Janmejoy Sethi and deputy engineer in Odisha RWSS ✓ Interview with Mr. A.K. Srivastava in Ministry of Drinking Water and Sanitation

These questionnaires were divided into three major criteria: (a) for state actors – state government and Gram Panchayats. (b) NGOs (c) local communities of Kaliabeda and Lahanda. Chief engineer, Mr. Janmejoy Sethi and local engineers from Odisha Department of Rural Water Supply and Sanitation (RWSS) were questioned. Members of the Gram Panchayat in charge of Lahanda and Kaliabeda villages were interviews. For NGOs, executive director at Gram Vikas, Mr. Debiprakash Mishra and Mr. Ashutosh Bhatt were interviewed. Lastly, over 100 households in Kaliabeda and 20 households in Lahanda were surveyed and information was recorded. Moreover, focus group discussions were arranged with 55 women of the villages to obtain information about their participation in the decision making processes, issues related to collecting water and its quantity and quality as well as health issues. Interviews were also arranged with local village executive committees, village water committees and local Gram Vikas staff, concerning water supply assessment and their technical support, women and minority groups' participation, training and water service management.

To understand the realities of the water supply system, field visits were conducted in the villages. Information discussion with users and Gram Vikas field staff were conducted to get direct information about the water point. The field observation helped me to identify the realm of water supply issues in terms of quantity and quality, distance travelled to the water source, waiting time to fetch water, duration of water supply and community decision-making processes.

Apart from that, secondary data tables for demographics, amenities and drinking water services at the state and local levels were collected from Census of India, Ministry of Rural Drinking Water, Ministry of Rural Development and Odisha Department of Rural Development websites. Reports from AguaClara and Gram Vikas were also analyzed to study their models. Previous projects of AguaClara in Honduras and Gram Vikas in Odisha were also studied to give a clear understanding on their concept and technicalities.

In India, rural water supply systems are constructed by local and state government offices, NGOs and other concerned organizations. In Lahanda and Kaliabeda villages, these organizations are Odisha Department of Rural Development, Tata Corporate Social Responsibility (CSR) Group and Gram Vikas. The installed systems are either stand posts, hand pumps or bore wells with public taps.

Lastly, my spring 2016 academic course with the AguaClara program and my summer internship with them helped me collect data on the AguaClara water treatment technology. During these periods, I held discussions with Professor Monroe Weber-Shirk who is the director and founder of AguaClara, and Ms. Maysoon Sharif, founding director of AguaClara LLC.

Data analysis

Many water management problems stem from competition, interconnection and feedback among natural and societal domains within a political domain (Figure 6). Within the natural domain, the interplay between two important variables – natural and physical capital (water quality, and quantity, water treatment technology and ecosystems) – can lead to conflict. Within the societal domain, there are equally complex interdependencies and feedback among social, financial and human capitals (community participation, social values, cultural norms, local institutions, economic and human resources). Political domain includes the presence of an enabling policy environment (political capital). Therefore, a key goal of my research is to create a better way to link these complex interactions in the natural and societal domains within a political context. Doing so will help in evaluating whether the partnership between AguaClara and Gram Vikas demonstrates collaborative synergies for successful drinking water systems in rural Odisha.

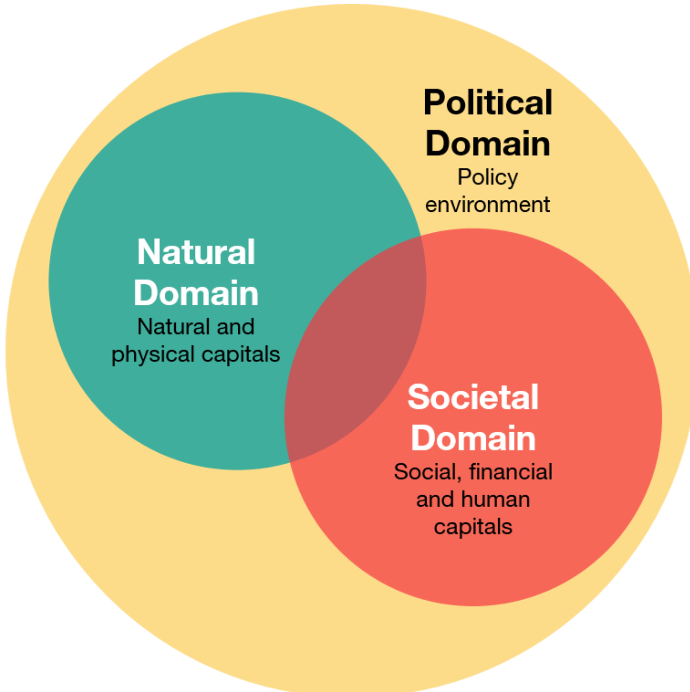

Figure 6: Theoretical Framework for Data Analysis

In this research, I am exploring the question of whether the partnership between Odisha, AguaClara and Gram Vikas could be a successful initiative for sustainable rural community-based water systems. For this purpose, I need to connect the aforementioned interacting variables in the natural, societal and political domains. I will start off by concentrating on the dominant variables in the three domains and analyze where AguaClara and Gram Vikas stand with their partnership. The presence or absence of one or more variables within the natural, societal and political processes in the study area shall help in guiding my thesis.

Prioritization of variables in the domains is difficult as the methods for characterizing these variables are not yet developed. It is difficult to calculate the effects of governance structures with similar accuracy and certainty as in measuring water quantity. The best method of capturing context specific information about interaction of variables in the three domains is to involve representatives of all relevant actors and groups. For such a purpose, Islam & Susskind (2012) while coming up with a water diplomacy framework hailed the use of an adaptive learning approach. Through the literature review section, it was inferred that adaptive learning occurs at the intersection of natural, physical, social, human, financial and political capitals. Physical and natural capitals need be innovated to fit the local context, human and financial capitals need to be identified and social and political capitals need to be implemented to enable positive policy environments for successful rural drinking water systems. It starts with the identification of water management network, in this case, the villages of Kaliabeda and Odisha. Then, possible changes in past practice will be considered. The implementation strategy will emerge from the structure and actions of the network.

Henceforth, the essence of community-based approach to water delivery is a collaborative design and construction among community members, government officials, external technical experts and NGO staff. Their incentives will determine whether, in practice, they actually collaborate, and institutions affect these incentives.

ANALYSIS

The goal of this research is to assess whether the partnership between AguaClara and Gram Vikas present a collaborative synergy in the context of Lahanda and Kaliabeda villages in Odisha. To measure this collaborative synergy, I am studying the strengths and weaknesses of some key variables in the natural, societal and political domains. The natural domain, includes natural and physical capital (water quality, and quantity, water treatment technology and ecosystems). Within the societal domain, the presence of social, financial and human capitals (community participation, social values, cultural norms, local institutions, economic and human resources) is very important. Political domain includes the presence of an enabling policy environment (political capital). The theoretical framework for analysis is based on in-depth reading of the literature on community-based water management, and was included in the methodology section above.

Political context

In this section, I study the existence and quality of the relationships the communities of Lahanda and Kaliabeda, and connection the organizations have to power structures, which determine to a great extent the degree of ongoing support that the communities require for sustaining the projects.

At present, Odisha Rural Water Supply and Sanitation (RWSS) Department is responsible for the installation of piped water supply systems and spot sources (stand posts, hand pumps and bore wells) in rural villages. According to RWSS chief engineer, Janmejoy Sethi, at an operational level, piped water supply schemes pose some problems - the 73rd Constitutional Amendment Act (1992) has vested the operations and maintenance of rural water systems upon Gram Panchayats, but still RWSS carries out major maintenance of piped water supply systems. The maintenance of the spot sources has been assigned to Self Employed Mechanics (SEMs) to be carried out on a weekly basis, under the guidance of the

Department. However, while interviewing the Gram Panchayats (GPs) in charge of Kaliabeda and Lahanda, it was noted that these GPs are short-staffed especially with engineers. Therefore, shifting to piped water supply often entails involving private operators which have problems of expensive tariffs and accusations of profiteering. In the villages, connections costs are generally between INR 1500-2000 ($23-$25) per house. The monthly tariff is fixed at about INR 30 (50 cents) per house. Gram Panchayats are responsible for collecting these tariffs but 90% of the fees have not been collected in the area. According to RWSS chief engineer, this issue is prevalent in many villages of Odisha and hence these government-funded schemes recover only about 40% of their running costs.

Throughout the interview with Mr. Sethi, it was also noted that from the year 2006-07, the maintenance work of the spot sources has been delegated to the Gram Panchayats (GPs) with budgetary support from the Government of INR 200,000 ($ 3112) per year. Under this initiative, the GPs should pursue technical assistance for major repairs of spot sources from the RWSS department. There should be a mobile maintenance unit for regular operation and maintenance of water supply systems and sources within the Panchayat area. Although the GPs in these villages have been authorized to carry out all responsibilities, the question is whether their practical involvement and technical hitches have been attended to. The transparency of the activities of GPs is also questionable. Hence, this section on political domain will involve evaluating the functioning of Gram Panchayats and State government in the study area.

In spite of clear instruction to the RWSS for carrying out the maintenance activities, the outcome is far from satisfactory. The poor quality levels of various hand pumps and stand posts installed by RWSS in Lahanda and Kaliabeda were evident. The reasons given by the questioned RWSS personnel pertain to shortage of funds, for both spare parts, and staff salary.

The chief engineer at RWSS also stated that their maintenance record is not up to the mark. While looking at the maintenance expenditure by RWSS, it was observed that only

7% of the allotted funds were spent last year and about 12% in the preceding two years. He stated that this was due to the decrease in allocation of funds from central government to the state in the last two years. He also reported that due to this, no new projects were undertaken by the department. Only existing systems were being repaired.

Another RWSS staff engineer recounted that the piped water supply systems installed till now have been less consistent than hand pumps. They failed due to power outages that burnt out pumps. Leaking pipes were also a common incidence. It was more expensive to repair these than a spot source and the local engineers were not qualified or prepared for the job. The rural people in the villages still do not appreciate the value of safe drinking water. Hence, according to RWSS, piped water systems are difficult to install and are financially unviable.

These issues are supported by the fact that the availability of drinking water facilities remains very poor in the state of Odisha. Only 22% of rural households are covered by piped water supply systems or spot sources in the State as against 90% households at the national level (Census of India, 2011). Regular breakdowns in tube wells and rural piped water supply units is an added issue.

However, when it comes to village participation in the decision-making processes of such schemes, communities are only considered when the placements of spot sources are to be determined. The villagers are not involved from the initial phases of the design and hence do not feel a sense of ownership towards the projects. User satisfaction surveys are not carried out after the project is completed, nor do the officials from RWSS visit the villages for monthly check ups of the water supply schemes. In the literature review section, it was identified that high levels of participation can only occur in situations where villagers are truly given a choice about what type of project they want, when they want it and how they want it. In other words, presence or absence of social capital influences the existence and effectiveness of water supply systems. A community’s sense of ownership and pride for their water system could be expected to arise from their participation in its planning and construction. Whereas it is possible to have ownership without choice, choice could improve the sense of ownership. Pride, in this case, is the result of contributions toward constructing and maintaining the water infrastructure and satisfaction from the quality of drinking water. In this case, villages of Kaliabeda and Lahanda show very low levels of participation in the government-led projects.

While interviewing Tata Sponge Iron Limited's (TSIL) Corporate Social Responsibility Head in Joda, it was mentioned that the company has already provided 45 open wells, 96 hand pumps and 18 bore wells in the surrounding villages, school campuses & public health centers. The company maintains the hand-pumps to ensure annual consistent water availability in these villages. Also, during peak summer months, drinking water is provided to a few villages situated in hilly regions. However, Gram Panchayats had a different story to tell. They reported that officials from TSIL rarely visit to check and maintain their hand-pumps. They do not involve villagers in the decision-making of their water supply projects at all.

During field visits, it was observed that in Lahanda, 2 hand pumps and 1 bore well have been installed by Government of Odisha under the NRDWP scheme, 2 other hand pumps have been installed by TSIL CSR group and 5 stand posts by Jindal Industries. In the village of Kaliabeda, 2 hand pumps, 6 stand posts and 3 bore wells have been installed by TSIL CSR group and Jindal Industries. Out of these, one is out of order while most of them need regular maintenance.

Gram Panchayats in the study area also reported that at present the electricity tariff for community based water systems is charged at public institution rates, even if it is only for domestic use. High income groups have installed pumps at their residences to extract water from these pipes, depriving other minority residences of consistent water supply. These high-income groups were charged domestic rates for private bore wells or pumps, while the low-income groups were charged at public institution rates as they collected water from spot sources. Also, many of the spot sources in the villages were not functioning properly due to high electricity charges and the community not being able to pay the bills.

The 73rd amendment (1992) made the Gram Panchayats a critical link between the village community and the state. They determine which development projects can be planned and initiated. It is questionable if these panchayats are capable to operate and maintain the water supply systems in the rural areas due to lack of staff and necessary funds.

This is perhaps the weakest domain out of the three (natural, societal and political) as presented in the theoretical framework. While many authors have underscored the significance of governmental support for the sustainability of the water system, in the villages of Kaliabeda and Lahanda, substantive state and local government support seems distant (Hardoy, Mitlin, & Satterthwaite, 2001) (Fabricius & Collins, 2007) (Emery & Flora, 2006). While there is an enabling national-level policy framework, the relevant local institutions do not seem to have the resources to help much.

By and large it is clear from the literature section that that communities need a definite role in decision-making and implementation (Araral, 2009) (Isham & Kähkönen, 2002). It is necessary to incorporate village-level participation, if any, in the government-led schemes. However, this level of participation is only incorporated in the schemes when capital costs and, operation and maintenance of water supply systems are concerned. Unless communities are involved from the initiation of such a project, they would not associate themselves with the project and hence, will not be willing to pay for it. Community ownership and trust are the essential for any community-based resource management program (Binswanger, Jorgensen, & de Regt, 2010). Hence, it is important that government solutions to safe drinking water need to be supplemented with a social response in terms of the end users' participation and the deployment of native capabilities.

Societal domain

This is the main focus on my analysis. As can be seen in the figure presented earlier I have bucketed this into three key variables: Human, Social and Financial Capitals.

1. Human Capital: The local communities

Various literatures have hailed community participation as an important component in the water sector as it can promote cooperative forms of governance, because the community can actively screen policy implementations. Moreover, it can increase the sense of ownership over water infrastructures, which leads to appreciation and shared responsibilities to ensure continuous and reliable operation and maintenance (McIntosh, 2003). Therefore, it is important to note if the local communities in Odisha and Kaliabeda visually perceive the importance of safe drinking water and have the garnered the mutual trust to cooperate and work collectively towards sustained drinking water supply systems.

In Kaliabeda and Lahanda villages, the villagers are mostly tribal and indigenous. They are mostly employed as marginal workers in the neighboring Tata Sponge Iron Industry and Jindal Steel Industry with average monthly income of INR 3000 to 4000 ($47-$62). The community is religiously composed of Hindus, Christians and Muslims. Most of the community belong to either Scheduled Caste or Schedule Tribe. The tribals living here are namely Gonds and Mundas. The latter are most prominent in the villages. The Gonds speak Gondi, a language belonging to the Dravidian family. Presently, the Gonds of the villages know and speak Oriya. They are settlers from the central part of India and their superiors are called Mahapatras and Singhs.

The Mundas are divided into numerous clans known as "Killi", a name taken from some animals, plants or material objects. Nuclear family is common among them. All the clans participate in the communal activities. Their traditional headman is known as Munda who overlooks the everyday matters of the tribe. Mundas are chiefly daily laborers. They occasionally travel to distant places to work as laborers in mines and quarries.

During the surveys and interviews I conducted in 2016, I noted that, in spite of caste differences, the villagers showed various instances of collective action. Both the villages were neat and well maintained. The households took turns to look after the operation and maintenance of the villages. The young men in the communities carried out any minor repairing work required and the expenditure was shared amongst the occupants. However, none of the members of the community were aware of NRDWP schemes or self-employed mechanics (SEMs).

Villagers appeared to be somewhat well-off financially. They owned cell phones, had a color television in their homes and a two-wheeler to commute. Such a comparatively good standard of living would be possible with a salary of less than $60 per month working as marginal workers. Typically, in a household consisting 4 to 5 members, there was only one wage-earner.

During field visits in these villages it was observed that some of the hand pumps and bore wells in the villages were of poor quality and dysfunctional. There were some issues of water logging in the surrounding area as well (Figure 7). In the village of Kaliabeda which is divided by the state highway, villagers had to cut their way through the busy traffic to walk to the other side in order to collect water as the bore well near the homes was not working. Houses on the hilly terrains had no water point available to them at all and had to walk downhill to collect water every day. Focus group discussions with the women groups indicated that due to poor water infrastructure in these villages, they sometimes end up taking water directly from Sona Nadi (Figure 8). Hence, it was also reported that diseases such as cholera, malaria and diarrhea are prominent in these areas.

Figure 7: Poor Quality Government Installed Public Stand Post Regularly Clogs Water in the Surrounding Area

Figure 8: Villagers frequently collect water directly from Sona Nadi

I conducted household-level interviews (Appendix B) and focus group discussion with women (Figure 9) asking them about water and sanitation issues before Gram Vikas intervened in the villages with their RHEP project.

Figure 9: Focus group discussion with the women of Kaliabeda village

In the village of Lahanda, it was found that the average consumption of water is 300 liters daily per household (79 gallons). The villagers (especially women) travelled 100-300 meters (328-984 feet) daily to collect water. Time taken to fetch water was 30 minutes to 1 hour and 10-15 trips per household were taken to collect water daily. Also, the duration of water supply in government constructed water sources (tube wells, stand posts and bore wells – Figure 10) was less than 4 hours and quality of water is muddy and brackish especially during the rainy season. No maintenance fee was collected but all villagers usually spent INR 500 ($8) on electricity bills and a one-time charge of INR 2,000 ($31) per household was collected whenever the water supply infrastructure failed.

Figure 10: Clockwise - Public stand post, public hand pump and public bore well in Lahanda and Kaliabeda villages.

Similarly in Kaliabeda, average consumption of water is 200-300 liters daily per household (53-79 gallons). The villagers (especially women) travelled 100-300 (328-984 feet) meters daily to collect water. Time taken to fetch water was more than an hour and 10-15 trips were taken per household to collect water daily. Also, the village faced erratic supply of electricity which resulted in pumps not working properly. The villagers ended up collecting water directly from Sona Nadi. Quality of water from the government installed sources was smelly, muddy and brackish especially during the rainy season. Water tariffs (INR 30), electricity bills (INR 500) and maintenance charges (INR 2,000) remain the same.

The villages also lacked toilets and almost everyone in the community practiced open defecation. The toilets constructed by Tata CSR lacked water supply connections required for flushing (Figure 11). It was common to see men defecating on the roadsides or in the fields, usually in the mornings or evenings. Also, people defecating outside at night lived in fear of snakes and scorpions. With the increasing population, many wastelands and small woodlands that were previously used for defecating were now fenced off for farming or construction. This is why women were driven to this twice-daily round of humiliation on the roadsides, which have effectively become open-air toilets for the majority of the population.

Figure 11: Tata CSR group constructed some toilets in the region. All of these toilets lack water connections required for flushing.

It is important to make them aware of the health consequences of such a practice, women in particular. The women bear most of the health responsibilities: they are the ones who take care of the household chores. Giving women a voice in decision-making processes is crucial therefore to ensure the system is designed in a way that meets the consumers' needs. Like in most rural communities of the third world, women in these villages are not afforded equal standing; so it is important to make them aware of the implications of open defecation and poor hygiene.

Water and sanitation, though spoken about together in debates, are not promoted together in practice. This is a serious flaw, since the improper disposal of wastes lead to continued contamination of water bodies. The government schemes need better convergence: in the absence of a holistic approach, total safe drinking water provision and sanitation will not be achieved. The communities need to be mobilized, trained and educated on the health impacts of safe drinking water and sanitation facilities. This is where Gram Vikas comes into play.

2. Social Capital: Gram Vikas

Social capital is in fact strongest within the societal domain and much of this contributed to Gram Vikas.

Gram Vikas, through their Rural Health and Environment Program (RHEP) intervention, uses water and sanitation as an entry point for creating equity and enabling communities to initiate their own development. Their work is mostly in underdeveloped and tribal areas, where they feel that there is cooperative leadership and villagers would be willing to support the program. Government officials and elected representatives also help Gram Vikas identify new villages. To date most of Gram Vikas' development has been in marginalized communities, that is, the south, south west and northernmost areas of Odisha. They have not reached out to communities in the coastal regions as most of the State elected representatives belong to these areas and hence, most of the Odisha development funds are directed there. These regions are also concentrated with the rich, privileged populations of the state.

Gram Vikas started off their RHEP project in Kaliabeda and Lahanda in 2015. Currently, they are constructing toilets and bathrooms at the household level in these villages. This was done with the help of project teams (12-15 staff members) and volunteers from the villages. These volunteers primarily consisted of women groups.

100% participation by villagers, built in financial stability, paying for use, taking responsibility and participatory management were the key elements of Gram Vikas RHEP approach. Before the intervention in water supply and sanitation project in the villages, Gram Vikas put forward some key non-negotiable rules that must be followed by all community members:

- All male and female heads of households must participate in the program, ensuring 100 percent participation of all community members (all-or-none aspect).
- The water supply will not be connected to the households until they have a latrine. This is done to stop the practice of open defecation.
- Each household must contribute INR 1,000 or $16 (one-time fee) on an average to the community corpus fund, which is held in a deposit account and will help further expansion of the program. It is done to ensure that each new family entering the village will have a toilet and bathing facility.

Flora (2004) points out that the more elements of participation employed, the greater the strength of the societal domain. It is important, therefore, that in the villages community participation is not limited to decision-making. Community participation should also be present in the construction of the plants. Therefore, these rules were crucial. In order to make villages open defecation free and eliminate water borne diseases completely, it was vital that 100% of villagers participate in the program. Involving male and female heads from every household, eliminated caste and gender barriers and raised the self-esteem of the minority groups.

The water and management program provided an opportunity for the villagers to manage resources through village committees. Gram Vikas took the role of trainer and later on facilitator, building the capacity of the villagers to run their own activities so that Gram Vikas could withdraw from these villages in a phased manner upon completion of the program. This prevented creating dependency on an external agency. This in fact would increase the sense of ownership and appreciation over water infrastructures, and the villagers would be able to collectively work to ensure continuous and reliable operation and maintenance of the system.

While interviewing Ashutosh Bhatt from Gram Vikas, he stated that good quality infrastructure is essential to restore dignity of communities; low quality and dysfunctional piped water systems and sanitation facilities hinder more than help mobilizing communities. He insists that what is needed is “cost-effective solution, low cost is an added advantage, but not a pre-condition. Gram Vikas only build systems that they themselves would use.”

Hence, to evoke a sense of pride and ownership among marginalized communities, Gram Vikas took on the initiative to build identical, good-quality twin-pit pour flush toilets for all households, be it from higher caste or lower caste, in these villages. By the end of 2017, they also plan to provide piped water supply to toilets, bathrooms and kitchens, which is critical as the burden of fetching water rests solely on the women. Also, bathing rooms with treated piped water supply will reduce the incidence of skin diseases as during the rainy season the water is more turbid.

Gram Vikas is represented in Kaliabeda and Lahanda by village volunteers and project supervisors. The supervisor facilitated projects in both of these villages as well as some neighboring villages. The project and supervisor were in turn overseen by the project coordinator and his staff in the regional office, which consisted of an accountant and an assistant for planning, monitoring, evaluation and documentation. The RHEP manager and his assistant in the head office coordinated the efforts of the different RHEP project offices.

The preparatory phase in the villages of Lahanda and Kaliabeda began with a series of meetings with the community leaders (mostly men). During these meetings, Gram Vikas talked about health issues, women, their income, the environment, and the RHEP and how it could help them generate more income. As soon as Gram Vikas felt that the program was likely to be adopted by the villagers, its staff started to work intensively with the people to ensure they are fully motivated and reach a consensus. A village general body of all the male and female heads of each household was formed. Gram Vikas held meetings with this body to negotiate RHEP norms and adjusted them to suit the village's circumstances. During these negotiations, conflicts were resolved and the fact that the majority of Gram Vikas staff were drawn from the local area helped smooth negotiations. After a consensus was reached, a written agreement detailing what Gram Vikas will do and what villagers will have to do was legally drawn up and signed by the villagers. Every household signed this formal agreement. This is because participation of all male and female heads of households is essential to bring people together and cut through the barriers of gender, caste, political and economic differences.

This is another sphere where the Gram Vikas initiative is successful. Involving communities from the start of a water infrastructure project, increases community ownership and trust. This concept is also supported by Ostrom (1990) who presented some structural variables that promote collective action in the form of small communities, face-to-face communication, and repeated interactions.

Because communities in these villages are dominated by patriarchal outlooks, separate men's and women's general bodies were formed first to allow the women to gain experience speaking about their needs to a larger public. These meetings went on until women felt confident to come to a joint meeting and voice their concerns in front of the entire village and men showed a greater acceptance of women's opinions. At this point, the two bodies merged to form one single village general body. It is this village general body which decides whether the village will take part in the RHEP or not. If even one family says no, Gram Vikas will not implement the program. The idea here is that if you persuade majority of the village, they will convince others as well.

Once the Agreement was signed and the RHEP was implemented, the general body met every month to examine accounts, discuss progress and any issues arising.

Around the fifth meeting between the village leaders and Gram Vikas, Gram Vikas informed the men that the women must also be involved as they bear most of the health responsibilities. Odisha is a very conservative state and women usually do not leave the house other than for domestic chores. In this context, Gram Vikas has put a lot of effort into getting the women to venture out of the house, also in raising their self-esteem.

On men's agreement, Gram Vikas' female extension workers started contacting women on a house to house basis and they had an informal discussion. From there on, the extension workers helped women in forming Self-Help Groups (SHGs) and educated women about savings and credit and sensitive issues relating to health, sanitation, hygiene, family planning and immunizations. The SHGs met once every month, giving women a reason to leave the house. In this non-threatening environment, women made contact with each other and discussed their problems; they were free to voice their concerns and gradually they gained confidence in public meetings.

The women's general body is made up of only the headwomen of every household. The field supervisor from Gram Vikas said that initially women from different castes would sit on separate mats and there was not much interaction, but with encouragement from Gram Vikas extension workers they came to understand that they must work together or else Gram Vikas would not implement the RHEP. Thus, clean running water was used as a key to cut through caste barriers. Once the women learnt how the RHEP could improve their lives, they became active in getting 100% support needed for the initiation of RHEP.

Gram Vikas Executive Director, Mr Debiprakash Mishra mentioned that it is relatively easy to convince people about the advantages of having clean water at the turn of a tap, but it is still not easy to convince them of the need for sanitation.

> Gram Vikas works on the value of getting people to agree to get together for the clean running water and from the start tell them that they will get running water only on completion of latrines. If Gram Vikas did not insist on toilets before, it would take a long time to end the traditional practice of open defecation, and extensive diseases would remain prevalent in their lives. Gram Vikas works at steering villagers all the way through the project cycle with the help of informal discussions, exposure visits, films, street plays and influential experts.

After the Agreement was signed, the general body in both Kaliabeda and Lahanda villages nominated and selected four men and four women from among themselves to form the Village Executive Committee (VEC), which had the final responsibility of implementing the program. During meeting with the members of the VEC, they mentioned the VEC had proportionate representation of all sections of the community. Hence, the communities could relate to the VEC and trust that they will work efficiently towards safe water provision.

A meeting of the village general body and VEC happened once a month to discuss progress, problems, future plans and accounts. Details of major expenditures, activities and contribution are displayed publically so that the system remains transparent and accountable. Gram Vikas provided training and capacity building of such committees by holding workshops, leadership development programs and practice sessions.

Once the corpus fund was collected and all the committees were set up, people started the foundations and brick work for the toilets and bathing rooms in the villages (Figure 12). Gram Vikas staff provided the infrastructure layout. It also provided master masons to train local youth and to supervise construction work. It also started a barefoot-engineers training program to develop a body of trained people to carry out basic engineering tasks and supervise the construction work. This in turn, empowered the villagers to take responsibility of their own water and sanitation infrastructures.

Figure 12: Toilet and Bathroom Superstructure Initiated by Gram Vikas

The Sona Nadi stream flowing through the southern end of these villages was identified as a suitable water source for the piped water connections. Gram Vikas tested the physical and chemical content of the stream: levels of arsenic, nitrate, chloride, fluoride, hydrogen sulphide. Iron as well as concentration of e-coli were tested. However, the stream showed a higher NTU and is turbid during summer seasons. Gram Vikas wants to treat its water using cost-effective pro-poor technologies. It is in this phase that their partnership with AguaClara will be of utmost help.

Gram Vikas has taken the responsibility of mobilizing the communities for their projects. In fact, they are able to convince communities to undertake comprehensive water and sanitation interventions – they build water and sanitation infrastructure together, and sanitation facilities are meant to be user-friendly (they include not only a toilet, but an area for bathing) to promote high utilization. Moreover, Gram Vikas has a policy of bringing interventions to an entire village at once, which means if the AguaClara-Gram Vikas partnership is taken to scale, it is more logistically and economically feasible to establish post-construction support services in the future. In addition to mobilizing communities, Gram Vikas has substantial internal technical capacity. They have multiple engineers on staff who have participated in the design and execution of the supply systems. These engineers can be easily familiarized with the AguaClara technology. The analysis on Gram Vikas is further supported by the literature, which indicated that the NGO approach to social sector delivery is more likely to reach the poor, to scale up quickly, to have high rates of return, and to have faster and more efficient disbursement (Khan, 1999).

3. Financial Capital

In order to assess whether the partnership between Gram Vikas and AguaClara will be able to access and leverage financial capital it will be useful to look at the different areas of financial management, water tariffs and cost recovery incurred over a project's lifetime. Therefore, I have divided this section into two parts: i) Capital costs and, ii) Operation and maintenance costs

i) Capital Costs

Corpus funds ensured that even the poorest, marginalized communities meet the capital costs of constructing toilets and bathrooms and the capital costs of water supply systems. Collecting corpus funds (collected one-time) from every household ensured that the responsibility of meeting some of the construction costs is taken over by the village. It also created a sense of pride and ownership among the villagers unlike the projects solely under NRDWP schemes.

Payments to the corpus fund were calculated in an equitable manner by the village general body, which decided how much each household will pay. Usually the better-off families cross-subsidize the poorer by paying more than INR 1000 ($16) and the poorer pay less, but even the poorest contributes at least INR 100 ($1.6).

Usually, the total cost of constructing a toilet and a bathroom per household was INR 8,500 ($132). Gram Vikas subsidy per household was INR 3,000 ($55) which accounted for

35% of the total costs. The rest of the costs were borne by the households (INR 1,000 ($16) corpus fund and INR 4,500 ($61) which is paid in the form of local materials and labor). The villagers themselves work as laborers and provide local materials which offsets labor and local materials costs. Costs of externally available materials such as cement and PVC pipes are incurred by Gram Vikas. The households below poverty line (BPL) received a subsidy of INR 1,200 by Government of India under NRDWS scheme. Overall, each household contributed about a month's salary to the construction of toilets and bathrooms.

The forthcoming water supply system will be funded by Government of India under their NRDWP scheme. Water supply systems are estimated to cost around INR 9,000, 50% of the costs being funded by central and state government under NRDWP scheme. The households will contribute INR 2,250 in terms of local labor and materials, in addition to INR 4,500 for the construction of toilets and bathrooms (25% of the costs). All the other costs including software and institutional costs will be funded solely by Gram Vikas foreign donor agencies (25% of the total construction costs). Software costs include capacity building and training programs, leadership building, gender equity programs and education and livelihood programs for the villagers. The foreign donor agencies include – Christian Aid, UK; Interchurch Cooperation, the Netherlands; and the European Union.

Overall, the community corpus fund and subsidies by Gram Vikas and central and state government, completely cover the constructions costs of toilets, bathrooms and piped water supply systems at household-level (Table 7). Villagers demonstrated ownership of the project by raising 36 percent of the capital costs, with rest of the funds being borne by external agencies. The operation and maintenance costs of the project will be described in the next section.

Table 7: Capital Costs and Funding Per Household

	Costs (INR)	**Household contributions (INR)**	**External funds (Gram Vikas and Government funds)**
Toilets and bathrooms	8,500	5,500 (65%)	3,000 (35%)
Water supply systems	9,000	2,250 (25%)	6,750 (75%)
Software and institutional costs	4,250	--	4,250 (100%)
Total costs	21,750	7,750 (36%)	14,000 (64%)

Source: Gram Vikas interview, 2017

ii) Operation and Maintenance costs

The O&M costs of a typical village water supply system consist of electricity charges, operator salary, bleaching powder charges, cleaning charges and minor repairs. In the villages surveyed, Gram Vikas Gram Vikas assisted with ideas on how to generate the fund, but they did not get involved in actually collecting the money. They helped villagers to identify potential sources of income such as social forestry, community horticulture on wastelands, fish farming in village ponds. After this phase, the villagers would need to develop the asset and manage it efficiently. For long-term sustainability of the RHEP projects, Gram Vikas thinks that the villagers should shoulder the responsibility of 100% O&M costs. The contribution could be in the form of cash or kind (labor, land or material) or a combination of both.

In both the villages, monthly contributions by individual households are made to cover some of the O&M costs of the proposed water supply. These tariffs are for the electricity bills. It is done to make villagers associate excess water usage with expenses. The fee was fixed by villagers themselves, and was around INR 30 (50 cents) per month per household. Apart from that, Odisha government contributes 10% of NRDWP funds for operation and maintenance of rural water supply systems. However, during the household surveys conducted, the monthly electricity tariff was reported as INR 500 per household, which is approximately 17 times of the monthly water tariff. Gram Vikas should therefore look out for alternate technologies like gravity-fed systems or solar panels for piped water infrastructure to offset the inflated electricity tariffs.

According to World Bank report, the 'good practice (design performance) O&M cost'[2] norm for rural piped water supply schemes in India is about INR 60 ($1) per household per month (Misra, 2008). Without any subsidies from the local or state government and with a monthly water tariff of only INR 30 (50 cents), these communities are not able to fully recover recurring O&M cost. Financial sustainability is thus very low which could eventually lead to low ownership particularly when service provision falters due to insufficient funding for O&M.

From the analysis, it is clear that capital costs are well accounted for in this Gram Vikas model. People were willing to pay for the partial costs of the construction of toilets and bathrooms, indicating that the service was acceptable to the community. Numerous scholars have written about the imperative of total cost recovery for at least the O&M costs (Fonseca, Smits, Nyarko, Naafs, & Franceys, 2013). The village communities not seemed to have achieved this. The average monthly water tariff is approximately INR 30 per household. Average monthly salary in these villages is around INR 4,000. The figure represents 0.75% of these salaries, much below the current estimate of 2 to 3 percent of the average rural family's income (Carlevaro & Gonzalez Becerra, 2011). Water tariffs are not sufficient to cover routine O&M costs, indicating that the project lacks financial sustainability. Without a subsidy from state government and no subsidy from Gram Vikas, these communities face low recovery of O&M costs.

[2] O&M expenditure to regularly run the systems, supply water at the designated LPCD, and undertake proper maintenance

Natural domain

In this section, I will be analyzing the strengths of natural and physical capitals as presented in the villages of Kaliabeda and Lahanda and in the AguaClara treatment technology.

1. Natural Capital

This refers primarily to the water source. In the methodology section, I have already mentioned the different criteria – encompassing the natural capital - which AguaClara uses to look for potential sites, and how on the basis of this criteria, Odisha was selected. On the local context, Gram Vikas has found turbidity exists in the Sona Nadi that flows through the villages of Kaliabeda and Lahanda. They are looking to install semi-filters in these areas for disinfection. Hence, AguaClara's treatment technology can come into play here. Therefore, it may be helpful to analyze the water treatment technology that AguaClara uses, which I have bucketed into physical capital.

2. Physical capital: AguaClara

The following analysis on AguaClara water treatment has basically come from my discussions with Professor Monroe Weber-Shirk, Director of the AguaClara Program at Cornell University and Ms. Maysoon Sharif, Managing Director of AguaClara LLC.

The AguaClara technology treats surface water with turbidity higher than 500 NTU. The process for surface water treatment – flow measurement, chemical metering, rapid mix, flocculation, sedimentation and filtration – is powered by gravity, with a total elevation drop of less than 1.5 meters, far less than conventional water treatment plants (Table 8). AguaClara designs are open source to facilitate technology dissemination, reducing design costs. Its parametric engineering design capability makes it possible to create customized design solutions for community water systems. This facilitates use of locally available materials that in turn lead to long-term sustainability and enhanced reliability. The open process design with no enclosed tanks reduces construction costs, simplifies maintenance, and provides feedback to the operator for optimal plant performance. The hydraulic and environmental engineering design and engineering support services costs $1000 (INR 65,000) per liter per second of plant capacity, less than 10% of total project costs (Adelman, Weber-Shirk, Amboage, & Smith, 2011). National engineering firms (nonprofit, private or government) build AguaClara treatment facilities using community labor. Community labor ensures that communities know their plant from the inside out, and experience the pride of ownership.

Table 8: AguaClara Solutions to Issues in Conventional Water Treatment Plants

Major barriers to safe drinking water	**AguaClara Solution**
electricity is absent or erratic	gravity-fed plants
Unsustainable design	components designed to sustain for many decades
treatment processes not visible, hence difficult to comprehend, resulting in poor performance	treatment processes easily observed and understood: leads to high performance based on visual feedback from the processes
frequent breakdowns with multiple failure	resilient, tough plants with few moving parts
high operating costs force operators to avoid treatment for low turbidity water in dry season	low operating costs ensure the plant is not unnecessarily taken offline
unreliable access and unsafe water make community members unwilling to pay	safe, reliable water makes community members willing to pay for services
expensive capital-intensive technologies	plants are economical to build, operate and maintain using local labor and materials
plants are not operator-friendly	plants are designed with the operator in mind

Source: Weber-Shirk, M. (2011). Municipal drinking water: Advanced technologies, powered by gravity, designed for 50-year reliability. Ithaca, NY: AguaClara Program, Cornell University. Retrieved from http://aguaclara.cornell.edu/resources/conceptpaper.pdf

If the turbidity from the source is consistently low (< 10 NTU), the full treatment process is not necessary in order to achieve effective safe drinking water. The AguaClara Enclosed Stacked Rapid Sand (EStaRS) Filter can be combined with chlorination to produce safe drinking water without requiring the flocculation/sedimentation processes. The first EStaRS was installed in the villages Gufu and Ronhe in the Khunti district of Jharkhand, India. They are paired with AguaClara's Chemical Dose Controller (CDC) for disinfection.

AguaClara's CDC features semi-automatic operation as it maintains the dose the operator sets even with varying water flow rate. Gravity powered design employs an innovative approach to chemical dosing by having the flow of chemical controlled only by the elevation difference between the end points. Coagulant for flocculation is universally available and a safer granular calcium hypochlorite is used for disinfection, avoiding chlorine gas leakage.

This is perhaps AguaClara's strongest capital, as their treatment plants in Honduras have received sustained attention and research for over 12 years. The technology demonstrated its capacity to provide consistent amounts of clean water at a relatively low cost. They produce water that meets Indian standards of NTU < 1 (Bureau of Indian Standards, 2009). The plants in Honduras supply water at the rate of 100 liters per capita per day which is high above the Indian Standards of 55 liters per capita per day. The plants furthermore meet many requirements of being sustainable and pro-poor as they are constructed and operated with locally available inputs; they do not depend on electricity and they can be run by local people. AguaClara has made the design open source, indicating that the technology can be modified as per the local context. All these features make AguaClara's water treatment technology a perfect solution to drinking water issues in the underprivileged communities of Kaliabeda and Lahanda villages.

However, one must not overvalue the importance of physical capital. Traditionally, government-funded schemes in India have been capital intensive; not taking into consideration the social capital. It has also been noted in the literature review section that infrastructure can be a means for destroying social capital. Even though, AguaClara's technology is pro-poor, if the plants are built by outside experts, they might have this negative effect. However, by partnering with Gram Vikas, which is already involving the local communities in decision-making, construction and management, AguaClara may avoid this issue.

Analysis Summary

The partnership between AguaClara and Gram Vikas demonstrates collaborative synergies to steward, develop and organize the requisite capitals needed for sustainable water delivery in Lahanda and Kaliabeda. Natural capital is already present in these villages. AguaClara's physical capital appears particularly strong, which suggests it may be able to compensate for weakness in natural and social capitals. On the other hand, Gram Vikas's social capital is substantial, especially in the areas of trust and community participation. Financial capital also seems strong in terms of capital costs. In terms of O&M costs, the communities were able to collect funds and were willing to pay for safe piped drinking water systems, indicating that the infrastructure might be able to achieve cost recovery with an additional subsidy from the state government and donor agencies. Hence, AguaClara can benefit from Gram Vikas' strong societal domain and Gram Vikas from AguaClara's strong natural domain (Figure 13). The political domain seems to be weak, with local Gram Panchayats and the state government not functioning efficiently, though there is some form of ongoing financial support from the central government.

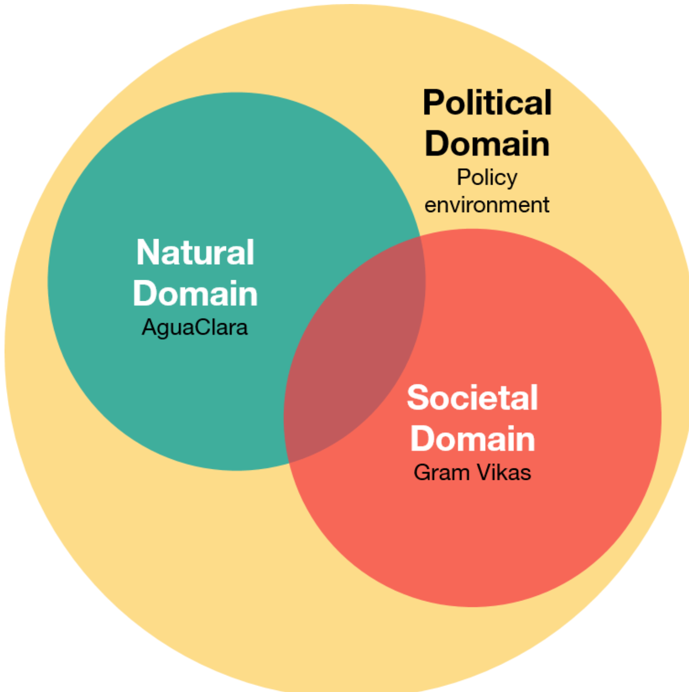

Figure 13: Analysis Indicates That Gram Vikas and AguaClara Might Demonstrate a Symbiotic Relationship

CONCLUSIONS AND RECOMMENDATIONS

Synthesis of natural, political and societal domains in Odisha

The first thing we need to confirm before concluding that the partnership between Gram Vikas and AguaClara will be successful, is the set of water quality issues faced in the villages of Kaliabeda and Lahanda. Gram Vikas has found turbidity in the Sona Nadi that flows through these villages. However, it is protected from industrial contamination and agricultural runoff that could result in fertilizer/pesticide contamination. The average annual rainfall in the region is 1,534.5 millimeters suggesting that there is a consistent aquifer recharge (Appendix A). In either case, it is evident that the main water source in the villages of Kaliabeda and Lahanda is surface water based (Sona Nadi), meaning there is a potential for AguaClara to work in these locations. As these factors fall within the criteria of a successful site for an AguaClara pilot project as referred to in the methodology section, the presence of strong natural capital is established. AguaClara can collaborate in water treatment provision using their EStaRS filters and CDC. Also, the communities deal with high turbidities during the rainy season, suggesting that AguaClara might have the opportunity to pilot their new 1 liter per second full scale plants.

Gram Vikas is planning to install piped water supply systems which are 24-hr supply systems with uphill sources that are gravity feed all the way to household taps. As AguaClara's technology is gravity fed, it could be very beneficial for Gram Vikas to use their help here. However, it would be important to know the most common range of flow rates that the supply systems deal with so AguaClara can design the most widely-applicable treatment technology for the context.

In the societal domain, the community needs to make a choice about whether or not to implement a water treatment project. They need to know what this project will deliver and how much it will cost them. They need to decide if they want to purchase the product. This is particularly difficult for pilot projects because the community members do not have a method to assess the value of the product and the likelihood of success in receiving safe drinking water. The only way for community members to really know if a safe drinking water that is being offered is being accurately described is to visit other communities that have the product. This is not possible for AguaClara as they will developing this technology for the first time in India.

As this will be a pilot project for AguaClara, there is also an opportunity for them to broaden the scope of the program to provide more comprehensive water and sanitation solutions. For instance, they can work to develop better sludge management systems both at the household level and at the treatment site. They can also work to develop strong post-construction support programs to ensure that communities have organizations to turn to when larger maintenance of troubleshooting issues arise. Gram Vikas can help train the village executive committee and local engineers in these post-construction programs. In particular, if AguaClara is able to scale the technology, they can attempt to institute a circuit rider program in collaboration with Gram Vikas, where a few highly skilled technicians will make periodic visits to the communities to ensure that everything is running smoothly.

Hardoy et al (2001) and Gasteyer et al (2009) have indicated that co-operation between various state and non-state actors is needed for successful implementation of water supply projects. However, such co-operation is often absent in most of the rural communities in the global south, leaving the poor and the marginalized to self-organize with the help of NGOs. Also, issues such as social marketing and giving credit to users are very difficult for local government institutions, as they have insufficient capital and knowledge to do this. On these similar lines, while analyzing the political domain in Odisha, the ongoing support from state and local governments seemed very weak. RWSS and Gram Panchayats have not been working efficiently with the rural communities due to mismatch of roles, absence of capacity building mechanisms and necessary funding even when there is a central government for water and sanitation infrastructure. This has led the rural communities to take assistance from Gram Vikas to construct, operate and maintain their own water and sanitation systems.

It is evident from the literature review that a community driven approach builds social capital through active participation from the early stages of an infrastructure project. Also, such an approach is a feasible solution to overcome the lack of central and state government attention given to rural areas (Binswanger, Jorgensen, & de Regt, 2010). In communities with high levels of social capital, participation in the design process is more likely to be high and monitoring mechanisms are more likely to be in place (Araral, 2009).

Henceforth, under the societal domains, human capital seems very strong. The local communities visually perceived a water quality problem and fundamentally understood the effects of unsafe water. They seemed to show increased sense of ownership and appreciation towards the Gram Vikas model. Gram Vikas mobilized them to learn basic engineering and microfinance skills so that they could have the ability set up a local supply chain for required chemicals and could contribute towards the construction of AguaClara plants as well as monitor and operate them in the future. The Village Executive Committee oversaw all the village affairs, collected corpus funds and monthly tariffs and smoothly negotiated any conflicts. The villagers trusted Gram Vikas which instilled their self-esteem by providing them with clean drinking water and sanitation facilities. As concluded in the literature review, such incidences of collective action have the potential to benefit marginalized groups through the equitable distribution of resources (Banerjee, Iyer, & Somanathan, 2005). Gram Vikas was able to cut through gender and caste barriers in the village through weekly meetings with the village general body.

The social capital apparently is the strongest. Gram Vikas already works in the delivery of potable water and sanitation for rural communities in Odisha so they believe themselves to be experts in introducing such systems into communities. Gram Vikas organizes, educates and develops skills of local communities on how to construct, operate and maintain their own water and sanitation systems. As part of the RHEP project in Kaliabeda and Lahanda, villagers collected resources to build identical toilets and bathrooms for each household, constructed by the community itself. Additionally, Gram Vikas has in-house engineers which makes it easier for AguaClara to train them on their water treatment technology. Currently, Gram Vikas is already in the phase of constructing toilets and bathrooms in the villages as well as laying down pipes for 24-hour water supply with the help of local labor and resources from the communities. Villagers, be they women or someone belonging to a minority groups, are trained on basic engineering skills to construct toilets, bathrooms and water supply equipment. This helped to reduce the barriers of caste and gender discrimination in the villages while empowering women and minority groups. Such forms of cooperation in the villages influenced their propensity to act collectively in a more organized activities, leading to successful water supply and sanitation projects.

As far as financial capital is concerned, Gram Vikas provided partial funding for the project as these households cannot afford to buy basic equipment for water infrastructure themselves. They collected corpus funds and a minimal monthly tariff from the villagers to cover some of the construction and operation and maintenance costs. From the analysis, it is clear that capital costs are well accounted for in this Gram Vikas model. Gram Vikas RHEP projects have proven to be reliable, equitable and effective in the past in terms of water tariffs. However, as there is no financial support from local and state governments, the community might not able to cover O&M costs with a minimal water tariff of INR 30 per month or 50 cents.

AguaClara possesses a strong natural domain while Gram Vikas has a strong societal domain. For successful implementation of community-based water systems in Kaliabeda and Lahanda, these can be linked together to form a symbiotic relationship between AguaClara and Gram Vikas where both can benefit from each other within the political context which has failed to provide safe drinking water to these communities. Hence, the partnership between AguaClara and Gram Vikas demonstrates collaborative synergies that fit perfectly within the theoretical framework of linking societal and natural domains for successful rural community-based water systems (Figure 14).

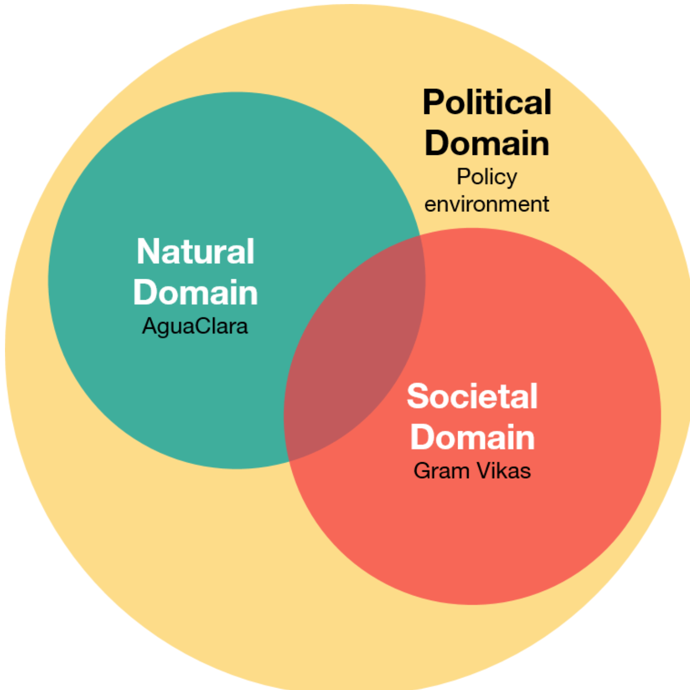

Figure 14: The Governance Models of AguaClara and Gram Vikas are Complimentary in Nature

Recommendations

It has been shown that the partnership between AguaClara and Gram Vikas could be beneficial for rural community-based water systems in Odisha. However, there are still some missing links which need to be addressed.

Some authors are convinced that community-based management may be the best approach for water provision in rural communities in the face of current political limitations (Khan, 1999). Rural communities are often excluded from the municipal focus of service delivery, as they are attractive neither to governments directing capital intensive infrastructure nor to the private providers aiming for profit maximization (Mulgan, Tucker, Ali, & Sanders, 2007). It is therefore often concluded that if rural communities do not do it themselves, no one else will. While this may be true, there are some measures that can be taken so that Gram Vikas, AguaClara and local governments can work in collaboration with each other.

Drinking water in India is a State subject. Central government develops policies and financing programs and releases funds and grants to the states. These are basically used up by public sector water boards leaving essentially nothing to rural communities. We have seen that the Odisha RWSS and Gram Panchayats have not been working efficiently with the rural communities due to mismatch of roles, absence of capacity building mechanisms and necessary funding. First and foremost, operation and maintenance functions of water and sanitation services should be handed over to local Gram Panchayats so that they receive the funds directly from the central government. Also, location-specific Gram Panchayat-centered institutional mechanisms and clarity of roles and responsibilities is essential for successful implementation of NRDWP schemes. It is important that assets belong to the Gram Panchayats and the cost of O&M is fully borne by the rural communities for sustainability of a water infrastructure project. Such schemes should also work in conjunction with the Gram Vikas RHEP through post-construction support mechanisms for rural communities to account for long-term sustainability of the projects.

AguaClara seems to avoid the areas of greater political and social conflicts altogether (Appendix A). However, it should pay attention to the fact that creation of an enabling policy environment is crucial for successful water projects, especially in India where bureaucracy and social heterogeneity are considered to be the worst amongst Asian countries (BBC News, 2012). For this, AguaClara must build relationships with relevant key actors in the local and state governments as well as garner trust within the rural communities.

AguaClara has previous experience in Honduras and this will be their second time to build a plant in India. They should be aware of the nuances of caste and gender divisions in the country and how they affect the provision of basic services. Odisha is a very conservative state with high number of minority lower caste groups. Gaining trust of these people would initially be very difficult for any external agency, even AguaClara, as villagers will be unable to relate to them. However, the presence of Gram Vikas can smooth this process. AguaClara and Gram Vikas can work together in building connections with the rural communities so that the villagers are appreciative of the AguaClara technology. The strategies can include awareness generation programs, use of key personalities in the local area to garner the trust of people and the use of scientific knowledge to raise people's interests in health and safety associated with drinking water. This will be very crucial in terms of operating and maintaining the water treatment plants in the future and dealing with water-related conflicts. This is also supported by the literature, which indicates that building close ties with the local communities increases the sense of ownership over water infrastructures, and leads to appreciation and shared responsibilities to ensure continuous and reliable operation and maintenance (McIntosh, 2003).

In Honduras, the average tariff is approximately $2.90 per household per month and AguaClara is able to achieve O&M cost recovery. However, purchasing power parity in rural India is much lower compared to Honduras. This will adversely affect the recovery costs of AguaClara-initiated water treatment projects.

In a report by World Bank on analyzing financing mechanisms for rural water projects, Going by the considerations of economies of scale, O&M cost for small community-based water systems with 50-500 households is approximately INR 500 per annum per household (INR 42 per month or $0.66 per month per household). Moreover, there is evidence that the O&M costs are relatively higher for schemes that are situated in areas with water quality problems (Misra, 2008). Therefore, a monthly tariff of INR 30 ($0.50) will be insufficient to account for total cost recovery of the water project in Lahanda and Kaliabeda which have 26 and 298 households respectively.

One way to go address this challenge is – Gram Vikas can develop comprehensive training modules for devising fair fee scales, to aid the long-term operation and maintenance of the water treatment plants. For example, Gram Vikas could develop a three-tiered income based flat fee structure to eventually cover costs and protect low-income households.

While the partnership between AguaClara and Gram Vikas demonstrate collaborative synergies, it still has a long way to go. There is a lot of research to be done and questions to be explored if this partnership wants to extend its program in India, especially considering the political and financial constraints. Key questions include the ability and willingness to pay a tariff that ensures recovery of O&M costs. Work should also be done on system design to lower O&M costs while delivering sustainable drinking water infrastructure to rural households.

APPENDIX A

Scoping Activity on GIS for Potential Sites in India

During my time as a part of AguaClara's regional planning team in spring 2016, we were given a task of examining potential sites in India for AguaClara to set up a pilot project plant. AguaClara requires a list of certain criteria for successful implementation of its water treatment plants in a specific location, these include –

(1) The population is between 5,000 and 25,000.

(2) There is a certain amount of population growth and average per capita daily water use

(3) Surface water is available consistently all year

(4) There is a consistent aquifer recharge (rainfall or mountain runoff)

(5) The surface water must be between 10 NTU and 1000 NTU

(6) There is a distribution system and surface water treatment plants available

These criteria fit well into the natural domain of my theoretical framework. For analyzing the societal and political domains in a region, I included a set of following social variables including:

(1) The consumers are willing to pay a tariff for plant operations and maintenance

(2) The government set up is accommodating of the facility

(3) There is a little political conflict or sufficient stability to allow for community engagement

(4) Local partnership is available

As previously discussed in the literature review section, for successful rural community-based water systems, the interactions amongst the natural, societal and domains need to be analyzed. Hence, the site selection analysis, focused on the utmost needs assessment: why this place and nowhere else? It looked at two geographical levels: states and districts, analyzing the existence and potential of aforementioned capitals in the areas. After going through the literature review and AguaClara's criteria for potential sites as mentioned above, I decided that a successful site for a pilot project will have the following eleven characteristics encompassing the natural, societal and political domains. The plants must be placed where:

(1) The population is between 5,000 and 25,000.

(2) There is a certain amount of population growth and average per capita daily water use

(3) Surface water is available consistently all year

(4) There is a consistent aquifer recharge (rainfall or mountain runoff)

(5) The surface water must be between 10 NTU and 1000 NTU

(6) There is a distribution system and surface water treatment plants available

(7) The consumers are willing to pay a tariff for plant operations and maintenance

(8) The government set up is accommodating of the facility

(9) There is a little political conflict or sufficient stability to allow for community engagement

(10) Local partnership is available

As the analysis was done at state-level for this research due to time and data constraints, I focused on characteristics: (2) There is a certain amount of population growth and average per capita daily water use; (3) Surface water is available consistently all year; (7) The consumers are willing to pay a tariff for plant operations and maintenance; and, (10) Local partnership is available.

The preliminary analysis was done on ArcGIS using Jenk's optimization algorithm and weighted overlay method. I am focused on the selection of a potential site in India. The country already has AguaClara LLC workers on the ground meeting with local partners and building connections. My job is to approach through the research angle, gathering data on India's water sources, demographics, geography, and economy.

India consists of 29 states, and the states are further split into 532 districts in total (Exhibit 1). Within each district, there are up to 1,000 villages. The total number of villages for us to analyze in India is roughly 700,000. To begin with, the research is looking at data on the state level. The analysis section presents the data based on the ideal site characteristics listed above. On a side note, the islands of Andaman and Nicobar and Lakshadweep and also all the Union Territories have been eliminated from this analysis.

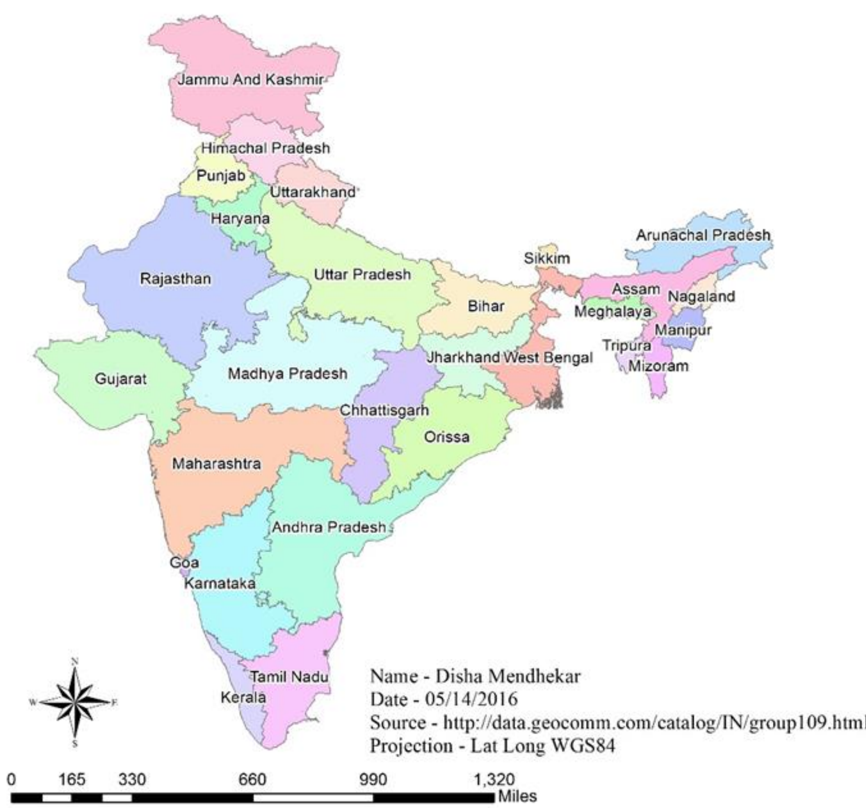

Exhibit 1: Political Map of India
Source: http;//data.geocomm.com/catalog/IN/group109.html

After analyzing the ideal site characteristics, a weight was placed on each of these characteristics. The higher the weight, the more important the characteristic is for the ideal site. The weights are a number between 0 and 1 and represents the relative importance of the characteristic. I decided the importance of each characteristic (the weight of characteristic) based on the literature review and also based on previous AguaClara Plants that have been successful in the past. Many different weights were analyzed for the optimization program and tested for validity; I decided on the current set of weights after iterating through many trials and judging which set of weights made sense in the results. For analyzing the state level first normalized the data for each of the characteristics to ensure that no characteristic overshadows other data. For example, larger numbers in rainfall might overshadow smaller numbers such as poverty ratio if one does not normalize each data. The method of normalization is the typical statistical method where one subtracts each data by mean and then divide by standard deviation. After normalizing all the data, I multiplied the weights with the corresponding normalized data for each of the characteristic for each state and then added up these weighted, normalized data for each state so that each state will correspond to one number. The higher the final number is, the more likely that the state is the optimal site for an AguaClara Plant. The output is a color-coded map that shows where each state lies on the scale from most to least ideal.

Preliminary Analysis

Surface Water Availability

According to AguaClara website (Weber-Shirk, 2014), one of the technical requirements for establishing a water treatment plant in rural communities is that the water source should be “surface water or ground water influenced by surface water”.

India has one hundred and thirteen river basins, of which 14 are large, 44 medium and 55 minor river basins. The major river basins of India in descending order of area are: the Ganga, Indus, Godavari, Krishna, Brahmaputra, Luni, Mahanadi, Narmada, Kaveri, Tapi, Pennar, Brahmani, Mahi, Sabarmati, Barak, and Subarnarekha. The major river basins form about 84 per cent of the total drainage area of the country. The natural water bodies existing in India are shown in Exhibit 2.

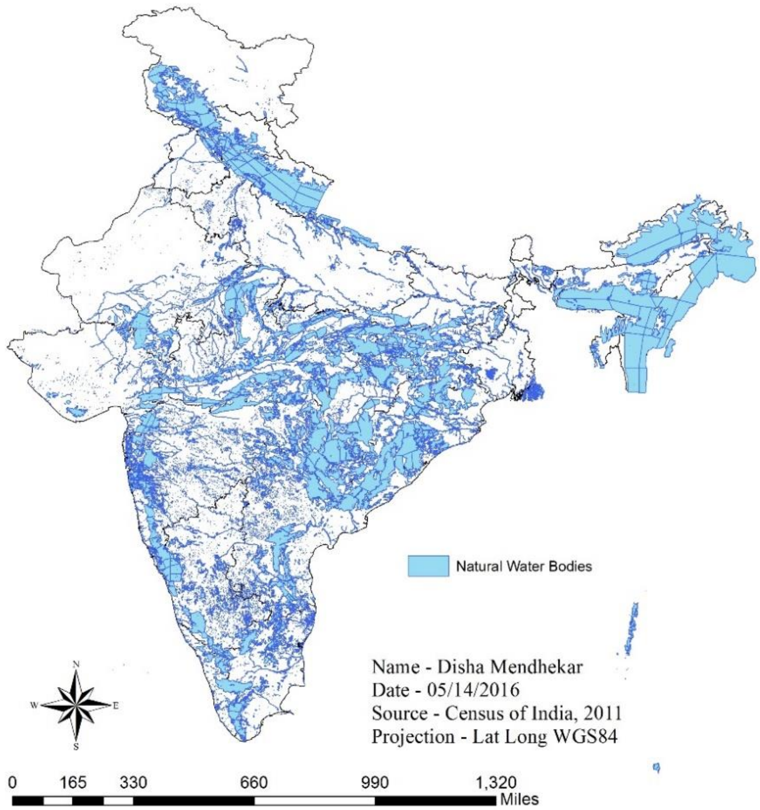

Exhibit 2: State-wise distribution of Natural Water Bodies
Source: Census of India, 2011

Also, I gathered data from Census of India on state-wise percentage of rural population dependent on surface water for domestic purposes (Exhibit 3). The surface water sources include rivers, canals, springs, tanks, ponds and lakes. This data will give us an idea of which states in India have the highest demand for surface water.

Comparing the Exhibits 2 and 3, one can see which areas have good surface water availability along with a decent amount of Rural Population dependent on Surface Water for Drinking Purposes. The states of Jammu and Kashmir, and a good portion of north-east India have a majority of population dependent on surface water for drinking purposes. These are also the states with highest amount of surface water availability.

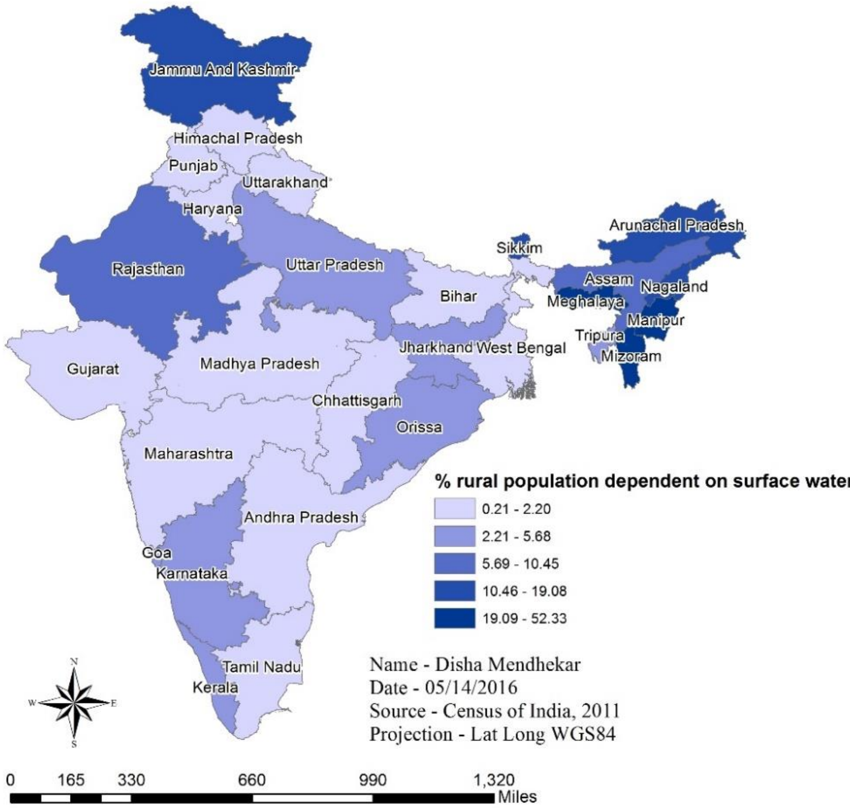

Exhibit 3: Percentage of rural population dependent on surface water for drinking purposes
Source: Census of India, 2011

<u>Annual Rainfall</u>

The annual rainfall is optimally more than 1000 millimeters. Although this is not a limiting constraint since it is possible that a drier region has a continuous source of surface water from a lake or from mountain snow runoff or other sources, the program includes annual rainfall as a factor because a helpful factor would be that the optimal site for an AguaClara plant will have an annual rainfall above 1000 mm. A map of annual rainfall data per state (Exhibit 4), sourced from the Ministry of Water Resources, India, is generated below. The regions of North-east India and states of Kerala, Goa, Odisha and West Bengal receive the highest amount of rainfall annually. In the weighted analysis, annual rainfall has a very low weight (0.05) because it is not a limiting, nor very important, factor; it is still included because it is still relevant to surface water availability, but the other factors considered are much more important.

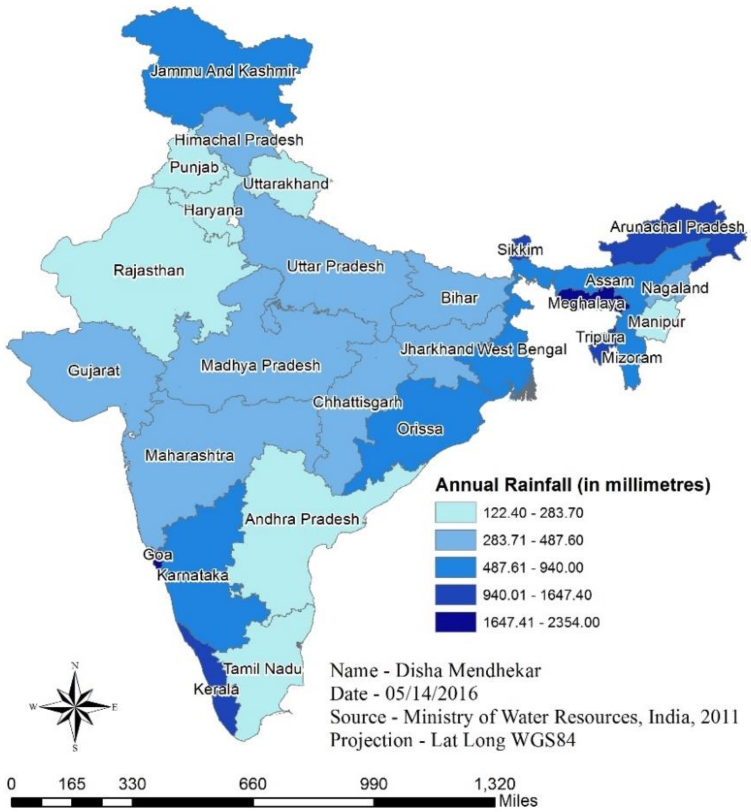

Exhibit 4: Annual Rainfall in millimeters
Source: Ministry of Water Resources, India, 2011

Socio-Economic Characteristics

Because the community itself will be paying for the operation of the plant through a tariff, the optimal community will 1) be financially able to pay for this tariff, and 2) have enough demand for water treatment that they will want to pay the tariff in exchange for cleaner water. To begin quantifying this data, I gathered data from the Census of India with poverty rates throughout India. The higher the poverty level, the more unlikely that there will be funds to pay the necessary tariff, considering that the tariff will be, at current estimate, over 10 percent of the average rural family's income. Another parameter found is data on the percentage of people with access to clean drinking water. This is an important parameter because this will correlate with a higher demand for water treatment and accessibility.

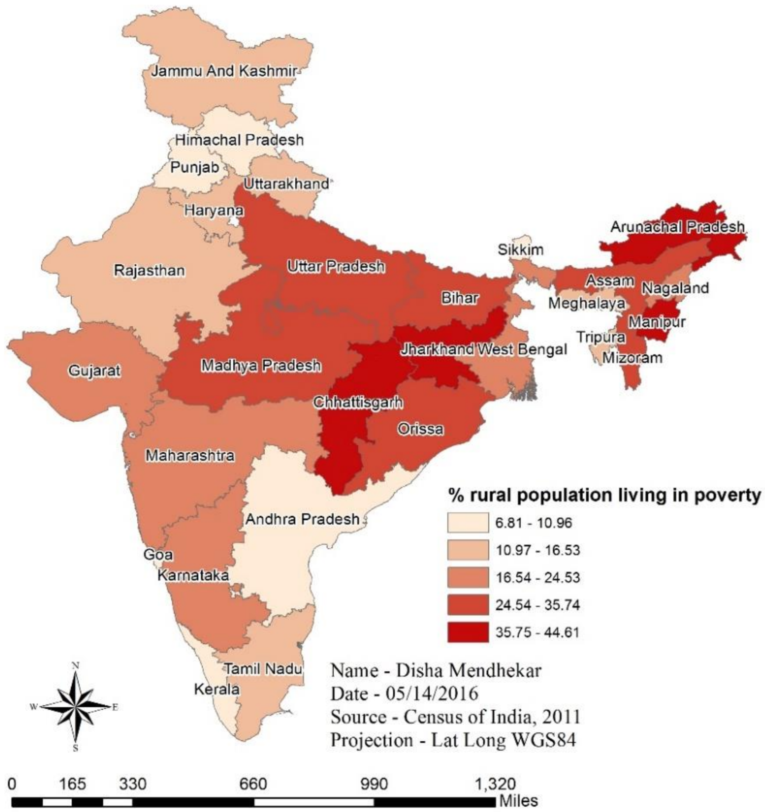

Exhibit 5: Percentage of rural population living in poverty
Source: Census of India, 2011

Looking at the rural poverty ratios of each state in Exhibit 5, the data shows that the states of Jharkhand, Chattisgarh, Arunachal Pradesh and Manipur have the highest poverty ratio averaging to 41% compared to a national average of 26%.

Also in Exhibit 6, the Human Development Index (HDI) produced by the Institute of Applied Manpower Research and Planning Commission in Indian Human Development Report, 2011, has been added, as well as the coverage of safe drinking water in the rural areas of each state. This data was drawn from Ministry of Rural Development India for the year 2011. The national average HDI was 0.52 in the year 2011 while the national average coverage of safe drinking water in rural India is 90%. The exhibit shows that the states of Bihar, Jharkhand, Chattisgarh, Odisha and Uttar Pradesh have the lowest HDI while the states of Kerala, Manipur, Meghalaya and Mizoram have the lowest percentages of rural population with access to safe drinking water.

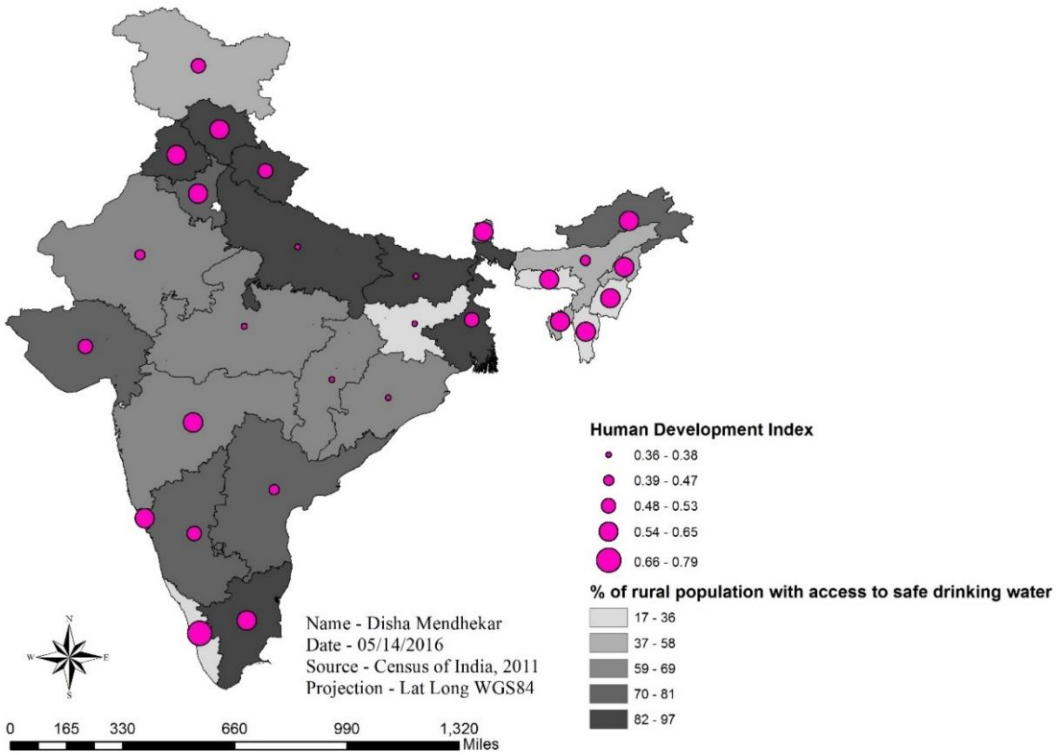

Exhibit 6: HDI vs % of rural population with access to safe drinking water
Source: Census of India, 2011

Current estimates show that households will need to pay a tariff of $1 a month. This is expensive for rural households in India, and past the upper limit for a rough figure on a rural household's willingness to pay for better quality water. This upper limit is based on a study conducted by World Bank in 2000, who analyzed 15 contingent value studies from various developing nations and found the range of willingness to pay between 3 and 5 percent of monthly income. The average annual income of rural Indian households was found to be INR 22,400, which equals a monthly income of $28.03. Based on this value, requiring $1 of tariff per month would take away 5.5 percent of a rural household's income. Therefore, the current tariff estimate is outside the range of willingness to pay that was found through multiple studies in developing nations.

Local Partner

Another consideration also included is the existence of a local partner. AguaClara LLC currently has people on the ground speaking with local partners and gauging their ability, reach, and infrastructure. John Finn, senior director at AguaClara LLC, provided a report detailing their progress on the ground in India. Within his report is a list of potential local partners for AguaClara's future work, based on the groups they have gotten into contact with to this date. The current list has 8 potential partners and spans a large regions of India (Exhibit 7). The AguaClara LLC contacts on the ground will be vital to the success of a new AguaClara plant, which is why the existence of a partner was included in the optimization program. It is not, however, the most important objective, because it was recognized that AguaClara LLC has not been able to reach many parts of India.

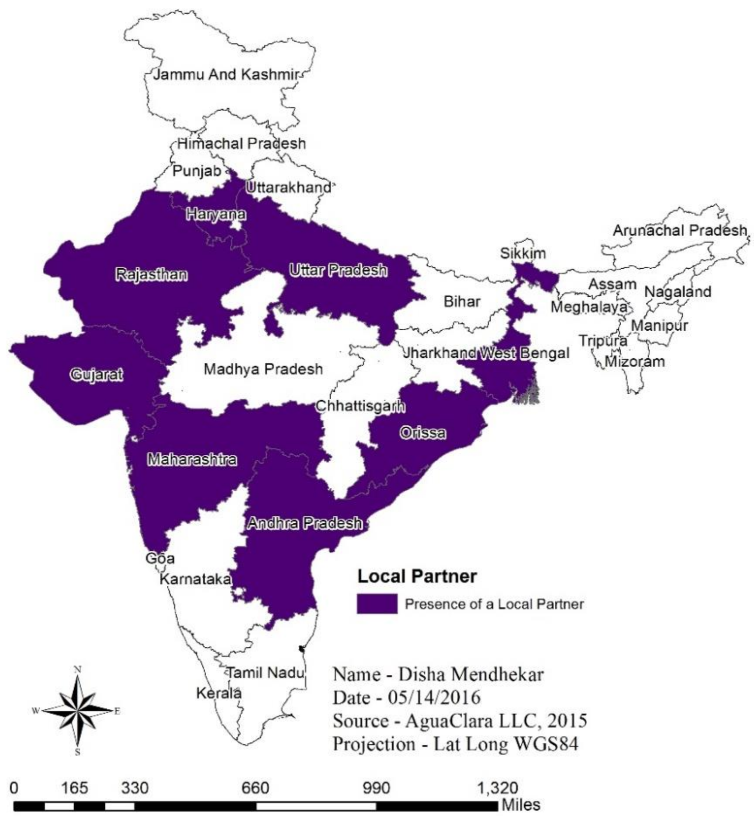

Exhibit 7: Presence of Local Partner
Source: AguaClara LLC, 2015

Final Analysis: Weighted Overlay

After normalizing the data, a program was written in Field Calculator that mirrors the steps outlined in the Analysis section. The normalization of the data allows the different parameters to be compared within the same scale. The code currently has data for seven objectives: 1) the percent of people dependent upon surface water in each state; 2) the poverty ratio in each state; 3) the annual rainfall in each state; 4) the HDI index per state; 5) the rural population of each state by the total population in the state; 6) the presence or absence of an established local partner, as supplied by AguaClara LLC; and 7) the percentage of rural population with access to safe drinking water by each state. I selected these seven objectives because they are the ones with consistent, quantifiable data for every state.

The weights assigned to these objectives are relative to each other and not absolute numbers. They were decided based upon the discussion in the literature review about which considerations are most important to choosing an AguaClara site, and upon past successful AguaClara plants that required these characteristics. The weights are as follows:

- Weight 1 = 0.2; The dependence upon surface water.
- Weight 2 = 0.2; Access to safe water
- Weight 3 = 0.2; Human Development Index
- Weight 4 = - (0.15); The poverty ratio (I need a state with lower poverty ratio, hence a negative weight)
- Weight 5 = 0.05; Annual Rainfall
- Weight 6 = 0.1; Local Partner
- Weight 7 = 0.1; The rural population in the state

The equations used is as follows (Exhibit 8):

0.2 * [Surface Water] + 0.2 * [Safe Water] + 0.2 * [HDI] - 0.15 * [Poverty ratio] + 0.05 * [Annual Rainfall] + 0.1 * [Local Partner] + 0.1 * [Rural Population]

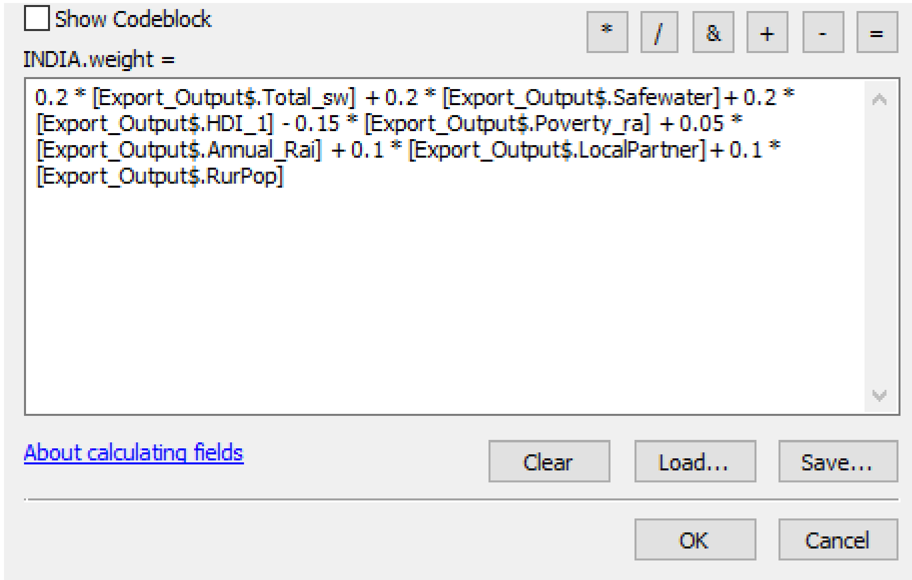

Exhibit 8: Algorithm applied in Field Calculator

After multiplying each weight by its corresponding attribute; the result is a single number, the total sum. The total sum for each state is then converted to a raster data (Exhibit 9).

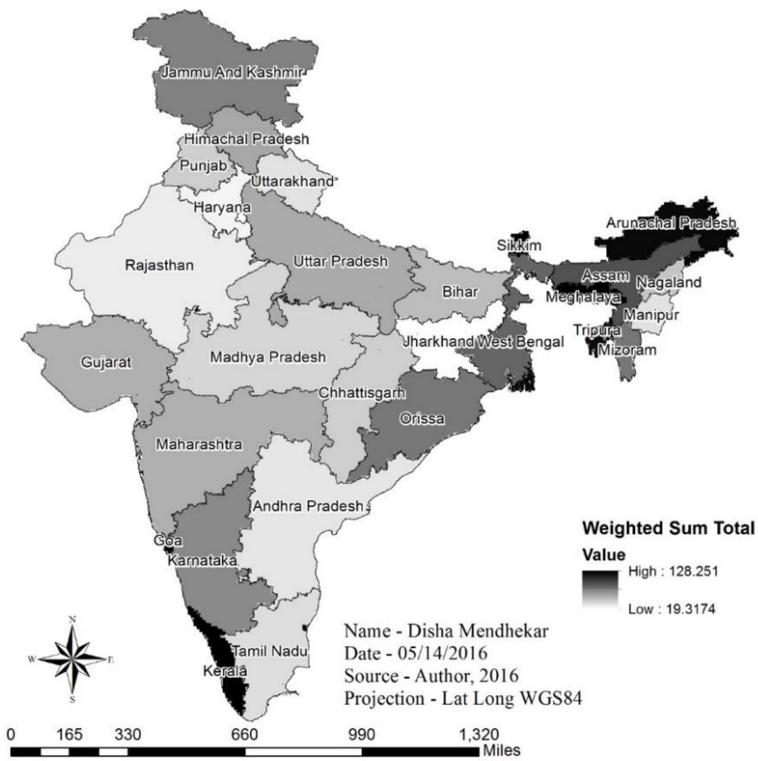

Exhibit 9: Weighted sum of attributes by each state

This raster data (IndiaWeights Raster) is then reclassified into five classes, (1-5), 1 representing the categories of lowest sum totals, the least suitable states and five representing the highest sum totals, the most suitable states as shown in Exhibit 10.

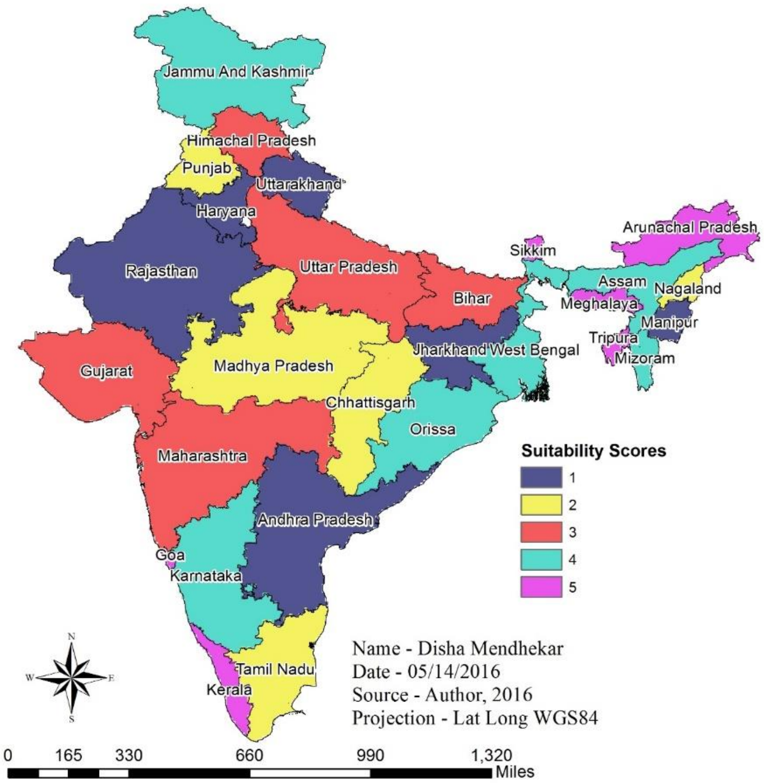

Exhibit 10: Suitability scores of each state

For optimal sites, I want to look at the states with suitability scores of more than 3. Next step is to use a conditional expression to extract only the optimal sites in spatial analyst tool. The sites with suitability score ≥ 4 are shown in Exhibit 11.

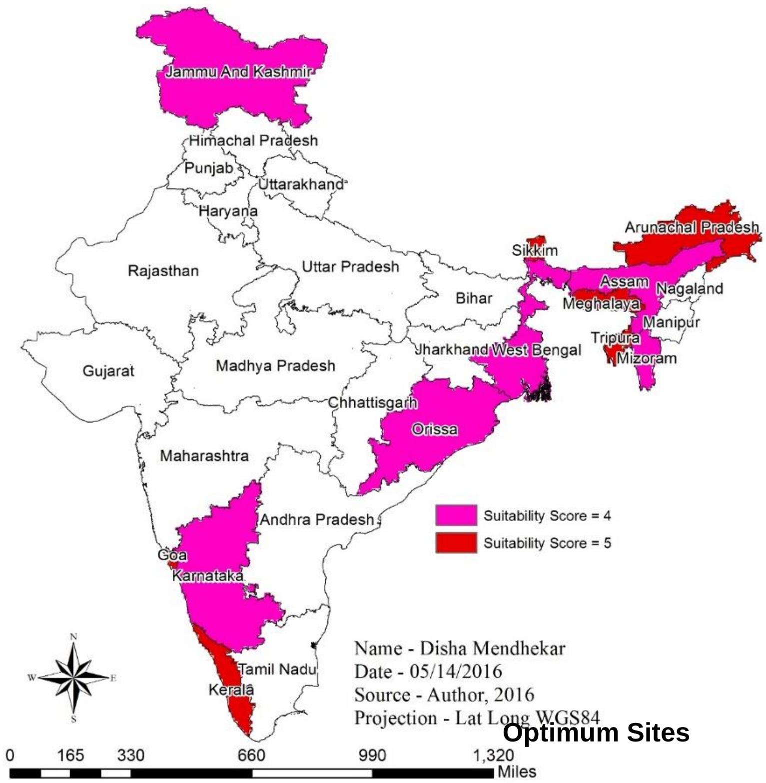

Exhibit 11: Most optimum states

According to Exhibit 11, the states of Jammu Kashmir, West Bengal, Odisha, Assam, Mizoram and Karnataka have suitability score of 4. The states of Kerala, Goa, Meghalaya, Sikkim, Arunachal Pradesh and Tripura have suitability score of 5.

<u>Conclusions</u>

According to optimum sites analysis, the states of Jammu Kashmir, West Bengal, Odisha, Assam, Mizoram, Karnataka (suitability score of 4), Kerala, Goa, Meghalaya, Sikkim, Arunachal Pradesh and Tripura (suitability score of 5) are the most optimal ones. However, I have chosen the states of Odisha for my thesis research, as this is the state which already has a local partner on ground working with AguaClara LLC (Exhibit 7).

APPENDIX B

Questionnaires

Developing an Epistemological Framework for Rural Community-based Water Systems

Key Informant Interview: (State and Local government)

This study is to survey state and local rural government leaders in Odisha, on the role of governance behind rural community-based water supply systems. I am asking for your insights, as government experts, about your experiences with service delivery mechanisms in rural development. Your insights will help identify the issues of rural water supply systems in the state.

Questions

1. After the enactment of 73rd Constitutional Amendment what is the devolution of powers and function in the agency and to what extent are these being implemented as per provisions?

2. How far the agency is efficient in performing these obligatory functions and is the staff capacity and knowledge sufficient to implement it efficiently? (Rating 1-10)

3. Do you think as in the case of center - state relations, that there needs to be specific allocation of subjects by way of state lists, urban/rural local body list and concurrent list to ensure independent functioning in urban service delivery?

4. In your opinion how strong is the local/regional capacity on the following functional spheres? Why? (Rating 1 - 10)

- Planning and Design _____
- Implementation _____
- Financial Management _____
- Operation & Maintenance _____
- Research & Training _____
- Inter-agency/dept. relationships _____
- Others specify (e.g. public relations/accountability) ____

5. Do you feel that budget/financial resources are sufficient to meet objectives?

6. How is the physical performance of the institution? (Rating 1-10)

- Ability to bridge overall demand-supply _____
- Physical health of water infrastructure _____
- Conflict resolution efficiency (low-cost and less time) _____

7. What is the procedure followed for finalization, approval and implementation of any water supply project?

8. How often service charges are revised? Often / Rarely / Not Revised & when they were revised?

9. Is service pricing based on Full Recovery / Operating cost / Full subsidy and is it different for different groups? Yes / No

10. Are there any user satisfaction surveys carried out and when?

11. How favorable are the legal provisions for private sector/Non-governmental organization (NGO)/community participation in service planning/development/management?

12. What problems are they facing in terms of delivery of rural services in the villages?

Your responses are not confidential. They will be used to identify key elements of coordinated urbanization, and local strategies in fiscal and land policy. The interview will be recorded for the future analysis but the recording won't be made public.

For more information about this study, please contact Disha Mendhekar (ddm93@cornell.edu)

Developing an Epistemological Framework for Rural Community-based Water Systems

Key Informant Interview: Gram Vikas

This study is to survey state and local rural government leaders in Odisha, on the role of governance behind rural community-based water supply systems. I am asking for your insights, as experts, about your experiences with service delivery mechanisms in rural development. Your insights will help identify the issues of rural water supply systems in the state.

Questions

1. With the enactment of 73rd Constitution Amendment Act do you feel that local bodies have adequate powers and are discharging their functions satisfactorily? Yes / No

2. How is the functioning of Panchayats and Gram Sabhas in rural water supply services?

3. What role do you actually play for non-government organizations in water supply services?

4. What is the level of people's participation in decision-making? (Rating 1-10) Is there evaluation regarding user's satisfaction?

Your responses are not confidential. They will be used to identify key elements of coordinated urbanization, and local strategies in fiscal and land policy. The interview will be recorded for the future analysis but the recording won't be made public.

For more information about this study, please contact Disha Mendhekar (ddm93@cornell.edu)

QUESTIONNAIRE FOR GRAM PANCHAYATS & VILLAGE WATER COMMITTEES

SOCIO – ECONOMIC CHARACTERSTICS

a)	Total population of the ward	________________________________
b)	No. of households	________________________________
c)	Pre-dominant community group	________________________________
d)	General occupation pattern	________________________________
e)	Presence of NGOs or CBOs	________________________________

WATER SUPPLY CHARACTERSTICS

a)	Piped water supply	**Yes / No**
b)	Frequency of water supply	________________________________
c)	Quantity of water	**Satisfactory / Unsatisfactory**
d)	Quality of Water	**Satisfactory / Unsatisfactory**
e)	Water charges	**Expensive / Economical**
f)	Water pressure	**Adequate / Inadequate**

QUALITY OF LOCAL WATER GOVERNANCE

a)	Frequency of Public meetings	**Timely / Delayed**
b)	Frequency of Panchayat meeting	**Timely / Delayed**
c)	Adequate knowledge of legal provisions	**Yes / No**
d)	Sharing of info. w.r.t decision making & implementation	**Yes / No**
e)	Regular visit to village to review service condition	**Yes / No**
f)	Satisfaction with the performance of local government as regards to water supply	**Yes / No**
g)	Problems in the village regarding urban services	**Yes / No**

QUESTIONNAIRE FOR CONSUMERS

Water Connection:

a) Metered

b) Non-Metered

c) No connection

	1	2	3	4	5
Water Supply Coverage	Individual Connection	Public Stand Post	Hand Pump and other sources	No accessibility	--
Distance in meters from source of water supply	<50mts	50-10mts	100-500mts	>500mts	--
How much time does it take to fetch water?	<15mins	15-30mins	30mins - 1hr	>1 hr	--
Duration of water supply given by Municipal/ Govt. authority (in hrs/day)	8-24 hrs	4-8hrs	less than 4 hours	On alternate days	Other than these
Do you spend on water?	Yes	No			
If yes, specify monthly charges in Rs.					
To whom do you pay?	Municipal Council/govt	Local stout	other (specify)		
Quality of water	Clean	Smelly	Brackish	Muddy	Other (specify)
Will you be willing to pay more for clean drinking water? If yes, by how much?					

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