STRUCTURAL FACTORS AFFECTING THE IMPLEMENTATION OF RAINWATER SYSTEMS IN THE AMAZON. THE CASE OF BELEM

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ABSTRACT

Purpose: This paper analyses the socio-political structural elements that influence the implementation of rainwater systems in Belem (Brazil).

Methodological approach: The paper presents an explorative research based on the application of Social Network Analysis. Interviews were made to experts in the field and the data was codad and analyzed. A stakeholders map was made to summarize the information collected and visualize the identified factors

Findings: The key finding is based on the identification of key players and issues in the implementation of rainwater systems; the absence of interaction with some of them and the canalization of decision making powers in few agencies.

Research limitations: The scope of the study is limited to the region analyzed and consequently is context specific. Due to the limitations of the data collection in the field the full potential of SNA could not be explored in this analysis.

Implications: The paper makes evident some of the redundancies in the management of water in the region. Also it makes evident issues related with lack of inclusion in the decision making process and planning for the implementation of rainwater systems in the region. In this sense, the paper can inform policy for the planning of the further expansion in the implementation of this source of clean water.

Originality and value: This istudy if is the first of its kind in the region. The use of methods to map stakeholders and visualize the relations of influence, as well as the identification of previously unseen key actors is a contribution of great value for the planning of further expansion in the implementation of ain water systems in the region.

1. INTRODUCTION

1.1. The Sustainable goal 6:

The United Nations Development Program (UNDP) defined the provision of clean and secure water for all as a priority developmental goal (UN, 2015). Water scarcity and limited access to clean and secure water affects more than 40% of world's population and it is reported that 41 countries experienced water stress in 2011. Consequently, the projections made by the UNDP suggest that by 2050 one in four people will experience recurring water shortage. Although 2.1 billion people have gained access to improved water sanitation since 1990, dwindling supplies of safe drinking water is a major problem impacting every continent.

In this context international and local efforts are necessary to protect and restore water-related ecosystems to mitigate water scarcity; as well as to encourage water efficiency and support treatment technologies in developing countries.

1.2. Millennium Development Goal 7:

The UN Millennium Development Goal 7 sought to ensure environmental sustainability (UN, 2012); and one of its four sub-targets aimed halve the proportion of the universal population without sustainable access to clean and safe drinking water and basic sanitation.

By 2015 the Millennium challenge (UN, 2015) reported that globally the number of people using improved drinking water sources has increased from 76 percent in 1990 to 91 percent; 2.6 billion people have gained access to better drinking water since 1990. Of these, 1.9 billion have access to piped drinking water on premises, with 58 percent of the global population enjoying this level of service in 2015 and 147 nations in the world have fulfilled the drinking water target. In general, between 1990 and 2015, the proportion of the world population using improved drinking water source and using improved sanitation facilities have increased significantly, surpassing the MDG target in 2010.

1.3. Millennium and development goals in Brazil - clean water in the Amazon states:

Oliveira (2015) reports that over the last decade 28 million Brazilians have moved out of poverty and 36 million ascended to the middle class. Despite these enormous efforts of social mobility and alleviation of inequality with positive impacts on the development of the internal market and the growth of the economy; this progress needs continuity. The Brazilian Institute of Geography and Statistics (IBGE, 2010) reports that about 16.2 million people still live in situations of social extreme vulnerability. To achieve this purpose, the Federal Government implemented the “Brazil Without Misery Plan”: A set of actions involving the creation of new programs and the expansion of existing initiatives, in partnership with states, municipalities, public and private companies and civil society organisations in order to include the most deprived populations in the dynamic of economic and social development of the country.

One of the most challenged regions is the Amazon, in which the local municipalities in these areas have to cope with the complexities of logistic access in these region, being largely reliant on the river as the key transport link. This factor significantly impacts the distribution and supply of products and services, principally the provision of clean water. This is highlighted by high local rates of waterborne disease, which are often aggravated by untreated water supply systems, inadequate/inappropriate sewage treatment facilities and open-air dumps. These issues are outlined in further detail within local Municipal Sanitation and Management Plans reporting that 91% of the municipalities have water supply systems. However, in 100% of the Amazon municipalities the water quality does not comply with the minimum standards for human consumption defined by the Ministry of Health (International Workshop on Of Solid Waste, Manaus / AM - 2013). According to Brazil's National Water Agency (ANA, 2010), about 70% of the population of the North region is deprived of access to potable water. This situation is ironic as the Amazon area is widely recognised as being the largest reservoir of fresh water on the planet. In response to these challenges rainwater has

been explored as an appropriate solution for the provision of clean water to rural communities in the Amazon basin.

1.4. The case of rainwater - international context

Harvesting rainwater for human consumption is not a new concept and it has been used by many different cultures in the past (Gnadingler, 2000; Tomaz, 2003; Kautsoyiannis et al, 2008). Contemporary methods mostly depend on the use of roofs to collect the rainwater. This technique - Rooftop Rainwater Harvesting (RTRWH) - is used successfully to cover basic water needs in many different countries, for instance:

Zhu *et al.* (2004) and Zhu and Yuanhong (2009) report that in Ganzu, one of the poorest regions in China, this technology benefits 2.5 million people; in New Zealand for 11% of the country's population the rainwater the main source of water for consumption (Ministry of Health, 2006); in Thailand, 4.3 % of the Urban population and 25.7% of the country's rural population access drinking water through the collection and storage of rainwater (ONESDB/UNCTT, 2004). This technique has been extensively documented (UNEP, 1998); there are good examples from Venezuela, Maldives, Turks and Caicos and Bermuda. Oliveira (2008) also documents the collection of rainwater in insular territories of Portugal and Greece.

UN-HABITAT (2005) further describe the experiences of Bangladesh, Singapore, Honduras, the United States, Tanzania and Kenya. In these countries, different actors are involved in the promotion of rainwater harvesting systems including governments, national and local authorities, international development agencies and social organisations.

Most of these documented cases utilize roofs as primary mechanism to collect water. Such initiates may be private or publically owned; and utilised by individual and/or multiple users.

In general, the advantages and growing interest for the use of RTRWH are related with problems of contamination of superficial and groundwater sources; systems failures, maintenance and operational problems; increasing

water demand in rural areas due to population growth; the increasing availability of impermeable low cost materials such as tiles, veneers and galvanised iron roofing components as replacement for straw roof as well as the more economical and effective water storage devices (Fawkes, 1999).

1.5. The use of rainwater in the Amazon. The case study of Belem.

Rainwater has been considered as an appropriate source for human consumption in the Amazon due to the logistic challenges experienced in this region and the wide geographical dispersion of the rural communities that would adversely impact alternative distribution methods for clean water. The first documented of use of rainwater harvesting in this region, was by imperial troops using the roof of the Saint Antonio de Ratones on the island of Saint Catarina in the 18th century (Veloso and Lopes, 2014).

In modern times the use of rainwater collection systems in Brazil has been extensively implemented in the semi-arid region of Brazil via the '*One Million cisterns*' program. The Semi-Arid Articulation (ASA) program has been fully implemented providing concrete plaque cisterns for multiple users. This was implemented through partnerships with individuals, the private sector, cooperation agencies and the federal government. However, concern has been expressed regarding the the quality of water, this issue has been documented by a range of independent studies carried out by Gnadlingler (1999, 2007); Joventino et al (2010); Souza et al (2011) and Silva et al (2012).

More recent studies have documented the informal adoption of this technology by riverside communities in the amazon as an attempt to solve the issue of access to clean water (Veloso, 2012). However, such technology proved not suitable for the bioclimatic conditions of the amazon; particularly to the riverside communities subject to the river tides and high levels of instability and humidity of the subsoil (Veloso, 2012).

To go around this issue, in Belem the University of Para developed a project to use rainwater as source of clean fresh water for the riverside and rural communities in the region. This solution has been well documented both, in

the convenience and advantages in response the bioclimatic conditions f the region - when compared against the national plan of cisterns - and the impact to the riverside communities in terms of health and economic viability (Veloso et al, 2013).

Belem is illustrative for the provision of potable water to the riverside communities of the Amazon due to its complexity and diversity in terms of population, number of organizations related to the management of water distribution and exploration of solutions. It is also one of the best documented examples in the Amazon region.

In Belem, ⅔ of the district is composed by 39 river islands, in which the provision of water has not been officially registered and managed. The region suffers from the widespread degradation of water springs due to the increasing pressure of urban development. Whilst, the levels of Iron emanating from the local groundwater table are above the limits for human consumption. The underground aquifers are at a depth that makes unviable for use; especially when considering the widespread distribution of population across this region - For example, the underground system in Ilha grande is inoperative (despite its good condition) and the quality of the water delivered is questionable in terms of its iron content (Veloso and Lopes, 2014).

Technical studies about the availability of potable water began, for both Belem and the wider Amazon region in 2004 as an UNESCO initiative. These studies concluded that despite the immensity of its hydric resources, the main limitation for their use for human consumption is related with the qualitative aspects of the water (Aragon, 2004). Veloso (2012) investigated the consumption of water for the islands Ilha Grande and Murutucu; finding that 45% of the riverside population buy water from informal distributors: boatmen (20lt barrels of - untreated - water collected either from surface of underground sources), and 20% consumed water directly from the river. However, the study also revealed that the common practice is to combine the use different sources of water; for instance, to buy water from the mainland to drink and to use water from the river for cooking. Souza (2012)

documented the case of Ilha Nova, where 100% of the water for human consumption comes from rainwater collectors; and Fenzl et al (2010) registered the case of the only two islands where the water is distributed via public aqueduct (Mosqueiro and Outeiro islands).

As documented by Veloso et al (2013), In recent years some initiatives have been implemented to guarantee access to water in adequate quantity and quality using rainwater systems. These implementations have been supported by extensive technical and socio-economic analysis. However, a systematic identification of stakeholders and issues affecting the implementation and subsequent maintenance of the rainwater systems has not been documented. This is particularly relevant as the Amazon region is characterized by being under the jurisdiction of several offices at different administrative levels in the Brazilian government; and contains a multiplicity of communities that makes of the region a case of high complexity for policy making and socio-economic and technical interventions. In this sense, this paper's intention is to make a first exploration of such complexity through the identification of issues and stakeholders affecting the implementation of Rainwater systems using methods related with the management of complexity.

2. METHODOLOGY

Standard techniques for the mapping of stakeholders were used and enhanced with the use of Social Network Analysis (SNA), developing on the methodological developments previously developed by Prell et al, (2007); Lim et al, (2010) and Lienert et al, (2013).

The collection and analysis of data followed a two stage process where Stakeholders were identified and classified on the basis of an iterative process that drew on a combination of of methods (e.g. expert opinions, semi-structured interviews) following the suggested multi method approach by Brugha and Varvasovszky, (2000) and Reed et al, (2009). To identify stakeholders, the respondents were asked to: 1.) mention all stakeholders and issues that may influence or are affected by the implementation of water

infrastructure - rainwater systems. 2.) quantify the influence each stakeholder exerts on water infrastructure planning (Brugha and Varvasovszky, 2000). We merged very similar stakeholders (e.g. community organizations).

A relational categorization matrix was created based on a typology to classify them along the vertical axis, i.e. from national, federal, county, local, and off-site levels to a local, on-site level. A further typology also made a distinction between those agents who affect (determine) a decision or action, and those affected by this decision or action. The matrix also included the issues identified in the conversations with experts and how these issues were connected with the different actors.The data were analyzed in UCINET (Borgatti et al., 2002). The potential influence of actors in a policy process can be assessed in network terms via its connectivity to others. To assess this feature we used measures of centrality as described by Freeman (1979). More specifically, we took into consideration the measurement of degree centrality , which takes into account the ties that an actor shares directly with other actors. It looks at the local structure in which an actor is embedded (Ansell, 2003; Crona and Bodin, 2006). In policy networks, actors with high degree centrality have better and more direct access to information and have considerable potential for framing the planning process. Power and importance were assessed via betweenness centrality (Freeman, 1979; Ingold, 2011). Betweenness centrality calculates the number of times an actor is on the path between two not-interlinked nodes. An actor with high betweenness centrality can thus act as a gatekeeper or mediator. If absent, the network would fall apart. Hence, the more central an actor is, the better he or she is integrated in the network and can influence the planning process in resource management policy.

3. RESULTS AND ANALYSIS

- SNA. Describe clusters and brokerage

RESULTS

The graph that despeines the relationships registered between the different stakeholders is presented in figure 1. By organising the issues based on how they are related to actors (connectivity, number of parts involved) suggest that the top 6 issues are Education, funding, training, relationships and regulation.

Education:

Funding: This is probably the most critical issue with impact on the implementation of rainwater systems as the sources of funds are reduced to just two organisations: the Public Bank of Brazil and significantly less important in magnitud, a charity (Caritas). There is no record from the interviews of funding coming from other sources, particularly from the private sector or the recipient communities - however, to apply fro public funds (bank of brazil) the communities must prove that they are organized and must provide a contrapartida. The current financial situation of the public sector makes uncertain the future expansion of the rainwater systems depending mostly of public funds.

Training: This aspect seems to be well covered as the connection between recipient communities and the generators of the technology and knowledge is effective and uses different channles (UFPA creates the technology and transfer it to the organized communities either directly or with the participation/mediation of other agents such Caritas).

Relationships:This issue connects with many actors as in general the interviews with experts highlighted the neeed to develop and improve the relationships between the multiple actors involved, particularly between the different institutions (as it is evident the existence or overlapping functions and redundancy/duplicity of functions in the public administration

Regulation:

Conflict: This issue was recognised in the interviews as related with the interaction of delivery agents (e.g. Cáritas, UFPA) and the different organisations of the recipient communities (Furun das ilhas, community associations, unions). The resort for this can be related with the high level of complexity and variety of the social structures in the region. For instance, in

one island it may be ust one community organisation and it makes the approach to the community simple whereas in the next island is possible to find multiple community organisations with conflictive interests. It makes the approach to the recipient communities a case of negotiation on individual basis. In consequence, this high number of entities at the community level makes the promotion and implemention of the rainwater system expensive in time and negotiation efforts, and the whole process of promotion and implementation difficult to standardise.
Is interesting that despite the multiple agencies involved at gubernamental level with overlapping functions was not highlighted as the main source of conflict for the implementation of the system in the region. (!!!).

On the observation of agents and how they are connected (based on the number of connections) the ranking of ht stop 6 are: Residentes, community associations, forum das ilhas, UFPA, SEASTER and Caritas.
Residentes: They are the recipients of the rainwater systems. All delivery agencies relate with them either directly of via community organisations. However, issues where rised regarding the quality and functionality of such multiple connections.
Community associations: Thgese are the principal (initial and functional) point of contact for the implementaton of the system. Yet presented in this graph as a single entity, their number and variety is enormous and varies form one island to another. These are the main source of camplexity for the implementaton of the system in the region.
Forum das ilhas (NGO): Any comments?
UFPA: The pivotal role of this organisation si justified by the fact that this institutions generatew the technology and leads the implementation of the rainwater systems int he region.
SEASTER:
CÁRITAS (Charity/NGO): A charity related with the Catholic Church. Very influyente in the country. They provide training and funding to community based projects and play a key role in the approach to the communities and

implementation of projects in the region (?).

It is important to highlight the low level of engagement with actors such as the (building) materials traders and the water traders as these two groups are the ones who are negatively directly affected by the implementation of the rainwater system. During the interviews it became evident that these two groups have not been included in any part of the desing and/or implementation process.

Who is CNPq (funding agency?).. what is the meaning of its almost exclusive relation with UFPA?.. implications? A similar case exist with FAPESPA

The following figure (figure 1) reflects the results of the use of SNA for the mapping of issues and stakeholders related with the adoption of rainwater systems in Belem.

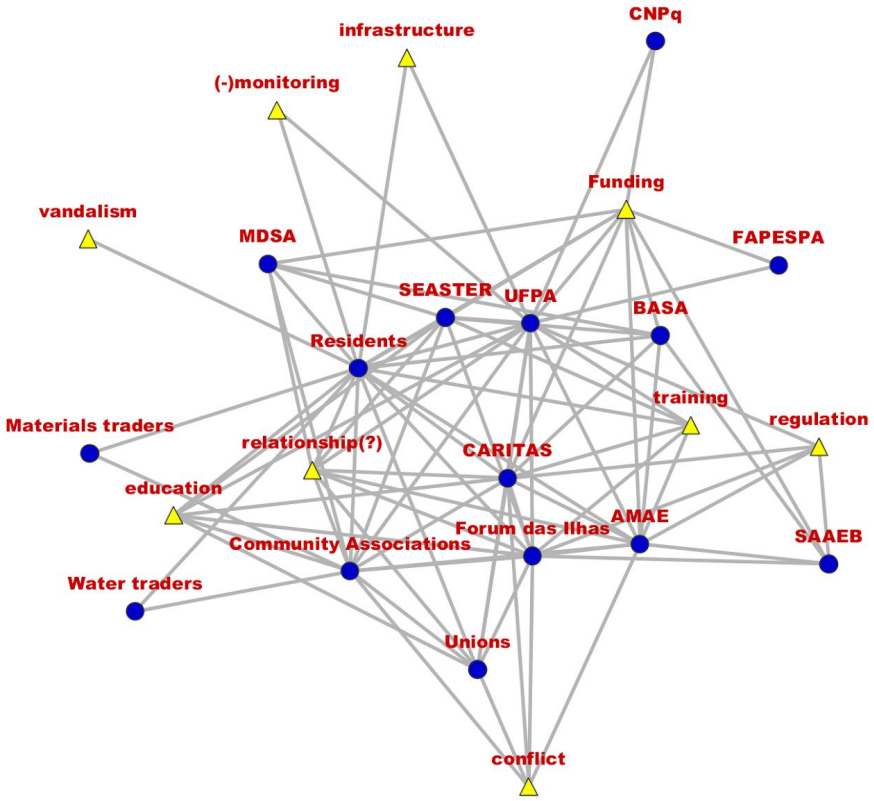

Figure 1. Identification of issues and stakeholders for the implementation of rainwater systems in Belem. In the figure the issues are represented by

triangles and the stakeholders by circles. The connections between them are represented by links.

The analysis of the connectivity of stakeholders and issues is guided by the level of centrality and betweenness where some nodes (issues and stakeholders) providing a ranking based on parameters such as degree and betweenness - with direct relation to influence in the network and functions of brokerage. Based on their structural position and the role/function within the network. these noticeable nodes are:

Issues:

- Funding: With the highest value of connectivity this issue is the most connected to stakeholders and seems to be determinant for the future implementation of rainwater systems. The fact that the funding comes mainly from two sources (government: via public bank -BASA; research funds - FAPESPA- and a charity) makes the implementation extremely dependant and sensible to the financial environment.
- Education: This issue is connected to providers (UFPA, CARITAS, Forum das Ilhas) and the recipient community (either directly or via several community organizations: Unions, community associations). In general the education related with the rainwater systems and its implementation is adequate, however it is sensible to the level of scholarity and the social dynamic of the recipient communities (peer pressure, perception of wealth).
- Conflict: This issue was connected mainly to the different organizations acting in representation of the recipient communities. Community organization is a complex issue itself as in the region is possible to find more than 100 different community organizations with different agendas and political interests. It noticeable that the issue was not raised in relation to the multiplicity of governmental agencies involved - in may cases with overlapping functions.
- Relationship: In general the issue relates to the brokerage function

between delivery organizations and recipient communities. the common perception from the interviewed is that the relationship between delivery organizations - at different gubernamental levels (e.g.: MDSA - Federal government; SEASTER - County government; AMAE - Municipal government) must improve and be more efficient.

- Training: The issue connects delivery organizations directly with the recipient community. IT confirms the protocols for implementation of rainwater systems in the region where before, during and post implementation the recipient community receive instructions on how to use and maintain the system for a limited period of time.
- Monitoring & infrastructure: Despite the training, the monitoring and infrastructure maintenance and evaluation is deficient and not connected in any form with governmental agencies. At the moment is just the UFPA performs limited observations on the functioning and condition of a limited number of rainwater systems in the region - aiming to develop a systematic approach to collect information to inform policy.

Agents:*Figure 1. Graph of Stakeholders and issues affecting the adoption of rain water systems. In the figure the blue circles represent actors and the yellow triangules issues*.

RUN ROUTINES TO IDENTIFY CLUSTERS!! And BROKERAGE!!

- RESIDENTS: Their high level of centrality is easily explained as these are the direct recipients of the rainwater systems.
- CARITAS: Is perhaps the most influential organization (Catholic NGO) at the ground level. Is well connected with all the key gubernamental organizations at all levels (Federal, County, Municipality) and has strong links with the communities and community organizations in the

region.

- UFPA: The Federal University is the following well connected organization with strong links with gubernamental agents. Its brokerage role is crucial as is the only agent in the network with links with federal institutions such FAPESPA and CNPq.
- SEASTER: Its high level of centrality is explained as it is the only organization and county level related with the delivery and implementation of rainwater systems. They act as brokers for federal agents and point of contact and coordination for local agencies.
- Community Associations: Their centrality is explained as they act as intermediaries with final users for the implementation of rainwater systems. They have high levels of complexity due their number and variety.
- Forum das Ilhas: its high level of connectivity relates to its function as broker at local level. Structurally equivalent to CARITAS, It lacks the connections with organizations at federal level.
- Unions: Their centrality relates to the connections with local organizations at community level. Structurally equivalent to community associations.
- Material traders & Water Traders: These actors are negatively influenced by the implementation of rainwater systems as they economic activity is related and dependent on the existence of such autonomous water supply systems. Is noticeable that they are not connected with any of the delivery organizations suggesting that they have not been involved in any stage of the development and implementation of rainwater systems.

4. CONCLUSIONS

This study identified as key issues for the implementation of rainwater systems in Belem the acces to funding, the complexity derived from the multiplicity of organisations involved and the conflict that emerges from the

high number of (community based) organisations of recipients in the islands.

The study also identified as key the interaction between the generator of the technology (UFPA) and delivery partners and/or intermediaries (e.g. Caritas). However, the analysis of brokerage shows that the omission of some of these intermediaries would not affect the delivery to the communities.

WHAT ELSE ABOUT BROKERAGE

WBAT ABOUT CLUSTERS

The methodology used proved to be a novel approach and effective to analyze the nature or the relationships between the multiple actors and issues identified affecting the implementaton of rain water systems. The implementation of rainwater systems is currently dependent of public funding. In this sense this study highlight the need to explore new sources of financiation based on private sources of capital and/or autonomously funded by the recipient communities (for instance via social entrepreneurship and/or social banking).

The study suggest also that the overlapping functions of gubernamental agencies at different levels (Federal, county, municipality, local) is not an issue at practical level - due perhaps to accumulated knowhow by delivery agencies at community level. However, this have the potential to be major issue for the communities at the time to claim ownership and autonomy in the implementation process - prescinding of delivery/broker agencies.

The second major issue at community level is the complexity and variety of community associations. The existence of unions with structural equivalence in the network may suggest that such unions could be used to bypass the role/function and complexity of the community associations to deliver rainwater systems.

In terms of design, is concerning the fact that not all the economic/social groups to be affected by the implementation of the rainwater systems have

been involved in the different stages of development. For further expansion on the implementation of the system in the region it would be key to include these actors, particularly if exploring forms to expand the adoption of the system not depending (exclusively) on public funding.

With regards to the methodology used in this exploration, SNA offers the possibility to map and understand better the functions and relation of the different agents involved in this initiative. The main limitation to explore the full potential of this method was related to the nature of the dataset and the data collection. Limitations to access information, public records and availability of data and time affected the depth of this exploration. The use of more complete datasets including interviews (cascade model) involving all the agents identified as well as a comprehensive review of previous documented process of implementation could provide a more detailed view of issues affecting the implementation of rainwater systems in the region by offering a better understanding of institutional aspects affecting the development of this initiative. At ground level, the use of interviews could accurately identify key actors in the communities playing enabling roles that could be used in the exploration of other forms of funding.

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