Operative Water Infrastructure as Shared Value: A Proposal to Reshape a Microeconomic Landscape

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ABSTRACT
According to the World Bank, countries need to invest 4,5% of their GDP in infrastructure to reach the Sustainable Development Goals (SDG) in 2030. This requires us to build new infrastructure and transform the existing one. We must assess how we can transform the existing infrastructure from a solely functional perspective towards a social and ecological tool to improve people's quality of life [1]. In this paper, I assess the existing infrastructure of metropolitan drinking water networks and how it can be transformed to improve the quality of life of the population in any city. The massive extension and ubiquity of the drinking water network sites can be renewed beyond its functional operation, considering social, economic and ecological opportunities. This assessment is aligned with contemporary theories about the role landscape, operative infrastructure, and technology play for equity in urban living.

Keywords: *Social Impact, operative infrastructure, urban ecology, social equality, microeconomic landscape, shared value*

1. INTRODUCTION

"A third kind of repair consists in reconfiguration. Here, the fact that something has broken serves as an occasion to make the object different from before, in form and function. The craftsman faced with a cracked vase decide that he or she can use the shatter bits to make a platter instead of a vase" [2]

Richard Sennett.

The Sustainable Development Goals (SDG) consider the investment in infrastructure and innovation as crucial drivers of development and economic growth [3]. This is particularly relevant in cities where over half the world population lives. According to the World Bank, countries need to invest 4,5% of their gross domestic product (GDP) in infrastructure to reach the Sustainable Development Goals (SDG) in 2030. Such investment must consider (i) the development of new infrastructure, (ii) an upgrade or retrofit of existing infrastructure and (iii) increase the capability of existing infrastructure to serve purposes beyond the current ones.

In this paper I assess the metropolitan drinking water networks infrastructure and how their transformation can help reach SDG by increasing the capability of its infrastructure. I discuss the obsolescence and the potential such infrastructure has to improve the quality of life of urban populations. I argue the potential of the infrastructure of drinking water networks surface as they are both extensive and monofunctional. The existing infrastructure of such networks is so extensive and present in every social strata that any change or improvement can have a considerable impact at the metropolitan scale. The monofunctional operation and structure of the network nodes or sites can be upgraded to achieve social, environmental and functional goals. I advocate we must advance in the reconfiguration of public and private drinking water companies' existing infrastructure to rebalance the demands of today's market with social equity as the next step of urban planning innovation. I propose a new scalable business model to bring economic benefits and social progress as shared value.

The structure of this paper is as follows; section I describes water systems shape from a historical and functional perspective. In section II, I review the water infrastructure as land assets. In section III, I assess the opportunities to increase the capabilities of existing infrastructure of metropolitan drinking water networks to increase social benefits. I present a case study of the drinking water network in Santiago, Chile.

1.1. Water systems

Water systems have changed their shape throughout history in response to new and diverse human needs, historical opportunities and new technology. In this section I review how water systems were shaped from ancient Mesopotamia were the need water systems were tackling was to transport water for irrigation. Centuries ahead, disease required water systems to withdraw dirty water from the cities. The last century it has been acknowledged that water systems also shape the landscape; thus the need to consider the benefits and costs for surrounding communities. The last decades, new energy technology has used water systems as a source of energy. I review these historical development using examples from Mesopotamia to New York City.

1.1.1. The origins of water systems in cities.

Water systems have been at the base of our civilization. The technology to transport and manage water irrigation has been developed since ancient Mesopotamia (6,000 BC) until today's cities water networks.

In the past, most of the human settlements were founded next to natural bodies of water (the etymology of Mesopotamia in ancient Greek means *between rivers*). The explanation is quite obvious; more than 9,000 years ago, humans turned from gatherer hunters into cultivators when they discovered how to grow crops and domesticate animals Settlements near rivers in Syria and Iraq where the origin of an agricultural revolution [4]. Seven thousand years ago, farming villages became cities when farmers in the Middle East learned to grow more food than they needed, allowing others to spend time making things useful to civilization. “Humans started to create and connect around ideas that do not physically exist under imagined orders to build networks of cooperation” [5]. People began to invent and develop technologies, including how to transport and manage water irrigation. Mesopotamia and Egypt developed the first efforts to control the flow of water with the constructions of canals and dams, followed by Assyrians’ underground tunnels and Greeks’ water wheels, syphons and pipes [6].

Over the ages, cities became bigger and their inhabitants were forced to transport water from rivers further away and develop more complex systems of water transport. Such was the case of the capital of the Roman Empire, where nine aqueducts and 247 water tanks were required to transport and store 992,200 cubic meters of drinking water per day for its one million inhabitants [7]. Such system was built throughout hills, valleys, long distances, with all the complexities that the geographical setting supposed [8].

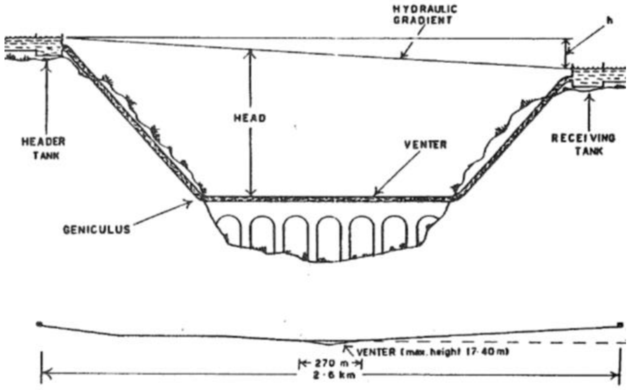

Figure 1. Typical roman syphon.

Roman cities were the first to reshape the watercourse into a massive interregional scale. More than 500 kilometers of aqueducts were required to carry water from a source to a distribution point to ensure water supply and sanitary conditions for their citizens. The extensive scale of the roman aqueducts and its main role as provider of public health made it one of the first examples of “Metropolitan water system as Infrastructure” for our civilization.

1.1.2. Water systems as Infrastructure.

Water systems infrastructure was developed beyond transportation and water storage when such systems served sanitary purposes. Such purpose required not only bringing clean water into the cities but also taking dirty water out of them. The Yellow Fever epidemic in the 1700s and Cholera outbreaks in the XIX century explain the development of sanitary engineering, eliciting the separation of drains and sewage systems in most European cities. Probably the best example was the acute transformation of subterranean Paris in 1850 by Baron Haussmann and Eugene Belgrand as part of the city reconstruction during the Empire of Napoleon II. During those years the word *infrastructure* referred to "*the installations that form the basis for any operation or system*” [9]

A close use of the term *infrastructure* was used in the United States (US) in the 1900s. Sanitary engineer George Waring Jr in his book “Draining for Profit, Draining for Health” , described how to make drainage and the importance of reducing the excess of water in the soil in order to improve public health. However, Waring Jr not only pursued the improvement of public health but also considered the importance of drainage to add value and create new development. Such was the case in his estimations of real estate market value of drained lowlands in New York City:

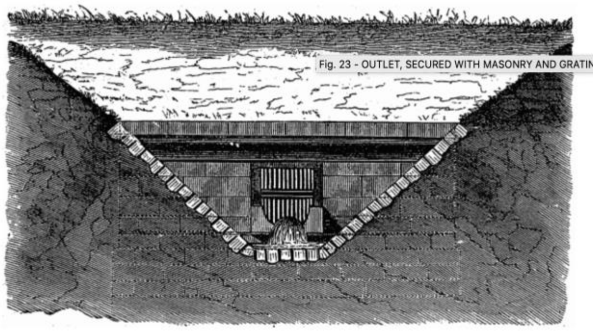

Figure 2. Outlet secured with masonry and grating.

¨*It has been estimated that the thorough drainage of the lowlands, valleys and ponds of the eastern end of the island, including two miles of the south shore, would at once add $5,000,000 to the market value of the real estate of that section*¨.[12]

After his publication, George Waring Jr. reformed the New York Street Cleaning Department in 1895 to solve the street sanitary crisis created by horses' disposal and carcasses (1,250 tons of hours manure and 227,000 liters of urine per day) [13] and was responsible for the Central Park main drainage. Such infrastructure was successful, and it echoed in the construction of massive drainage and sewer mechanization of cities like Boston and San Diego.

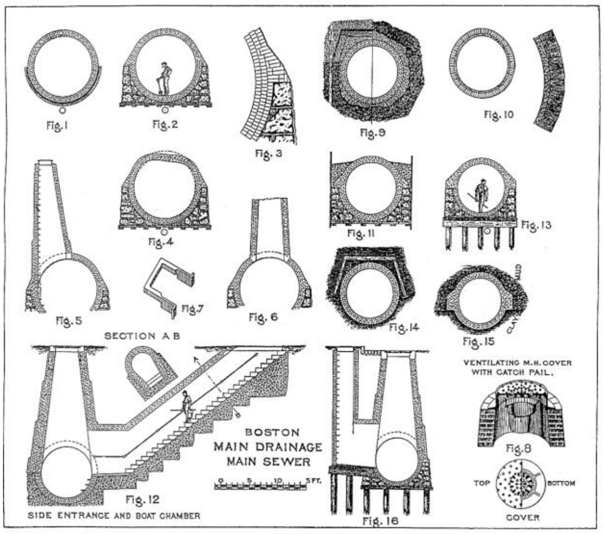

Figure 3. *Eliot C. Clarke, Main Drainage of Boston*.

1.1.3. Water System Infrastructure as Landscape, the mechanization of the park.

Water systems in its different shapes creates or contributes to the city landscape. As such it can contribute benefits or costs to the surrounding community. A highly appreciated water system is New York City's Central Park. The park was designed in 1857 to clean the air, water, and ground with the purpose of combating disease in an increasingly crowded city. This major interdisciplinary work was led by Chief Engineer Egbert Viele, Landscape Architect Frederic Law Olmstead as Superintendent of Central Park and George Waring Jr as Superintendent of Drainage. They transformed the nature of the ground from its existing hydrology into a comprehensive system of underground drainage tiles, "a mechanical improvement" that took advantage of the topography and existing basins to remove all excess water of 3.41 km2 and transform it into eight water bodies as a massive infrastructural machine where landscape is contingent to drainage [14]

Figure 4. Map of Drainage System of Central Park, 1858. The red lines represent the tile drains, red circles are the silt basins, and the heavy black lines indicate the sewers.

Today, with more than 160 years old, New York City's Central Park remains until today as one of the best world examples of a reshaped landscape turned into a successful Metropolitan drain water infrastructure.

1.1.4. Water system for electricity, infrastructure as an Interregional System.

More than 60 years passed after New York City's Central Park was built until the word "Infrastructure" was formally recorded in the US. It was in 1927, when the Mississippi river basin was massively flooded displacing more than 600,000 people and inundating more than 68,000 km2 which enabled a reconstruction under the US Army Corps of Engineers to manage and protect all the infrastructure and resources (including the future of energy generation) [16]. In those days' infrastructure was formally defined as:

"*The collective networks of roads, bridges, rail lines and similar public works that are required for an industrial economy to function*" [15]

A few years after the flood, President Roosevelt signed the Tennessee Valley Act to stimulate the economy, which led into a new Federal Corporation named as the Tennessee Valley Authority (TVA) across seven States, setting up a massive complex infrastructure of 207,199 km

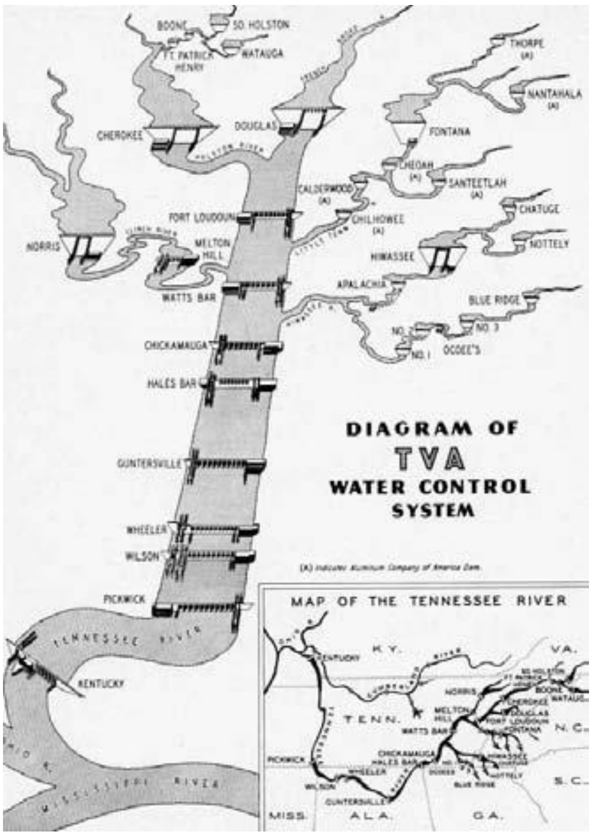

Figure 5. Diagram of the TVA water control system. 26 dams work as a unit.

The TVA was the first massive interregional infrastructure water system, which involved engineering design to mitigate flood control, electricity generation, fertilizer manufacturing and the economic development of public resources and private land in America to make 26 dams work as a unit.

Today, TVA provides electricity to approximately ten million people through a diverse portfolio that includes nuclear, coal-fired, natural gas-fired, hydroelectric, and renewable generation with a service area, covering most of Tennessee, Mississippi, portions of Alabama and Kentucky, and small slices of Georgia, North Carolina, and Virginia. It was the first large regional planning agency of the federal government and remains the largest in the US[17].

2. WATER SYSTEM INFRASTRUCTURE AS LAND ASSETS

2.1. Water Infrastructure as Real Estate Assets.

Half of the world population lives in cities. Perhaps due to the economic benefits of productivity (i.e., higher salaries). In the US a person who works in a metropolitan area earns 30% more than people working in rural areas [22].

Today most of the world's city's water supply companies are public or work under the private sector participation (but not fully privatized), excluding England, Chile and some states in the United States where the water companies are mostly private. The term privatization or the private ownership of the water infrastructure (private sector participation and public-private partnership) are used to refer to a range of contracts whereby private companies build, manage and operate infrastructure on behalf of governments. The contract includes concessions, lease, management and services contracts, consulting services and public-private partnership with non-governmental organizations (NGO) [23].

2.2. Water Infrastructure as Private Assets.

In 1989, the English government privatized the water industry, selling the nine English regional water services to private firms. These firms have continued to operate as monopoly service providers in these regions. Today England and Wales have 10 private water services that own 1,715 km2 of land.

Chile followed the example of the government of Margaret Thatcher. In 1981, under the water code, Chile defined two categories of water use rights: consumptive and non-consumptive [24]. This generated a water market where you can buy, sell or mortgage the water rights. Then in 1999 during the government of Eduardo Frei, the metropolitan public water system (EMOS) turned into the private company named as Aguas Andinas S.A. Today Aguas Andinas owns more than 70 hectares of land property and 230 water tanks serving more than 7 million people in Santiago, Chile.

Figure 6. Drinking water tanks in Chile next to a flee and farmers market (purple and blue squares above the water tanks).

In the US, the private water industry serves more than 73 million Americans [25]. Today, 25 states in the US have private water companies that serve less than 10 percent of the population, while 3 states (New Jersey, Connecticut and, Idaho) have private water companies serving more than 35 percent of their population [26]. According to the National Association of Water Companies (NAWC), more than 2,000 facilities operate in public-private partnership contract arrangements [27].

2.3. *Water Infrastructure as Public and Private Assets*

Despite the debate over privatization versus public ownership of water systems (discussion beyond the scope of this paper, for references see Bakken, Karer. *Archipelagos and Networks: Urbanization and Water Privatization in the South*), the evidence of failure has often involved market, State and governance problems. Failure examples can be found in Argentina, Philippines and Bolivia among others. In Argentina there was a massive cancelation of all the private concession contract in 2001 which served 60% of the population under the economic crisis dragged by the Argentinian peso depreciation. In 2003 the westside city of Manila water company bankrupt in Philippines. In Bolivia, the Cochabamba private dam construction ended with a series of demonstration and general strikes that provoked deaths in the year 2000, after water tariffs were raised by 35% by the controller company. [28]

Successful stories of public and private participation in water systems are also available. Such is the case of the French water system. This system is jointly managed by public and private sector, where privately owned companies (like Veolia and Suez) control 60 percent of France's water market. The lease contracts (*affermages*) make the private operator only responsible for operation and maintenance, whereas major investments are responsibility of the municipalities [29].

3. RETHINKING WATER INFRASTRUCTURE AS SOCIAL LANDSCAPES

3.1. *Operative Infrastructure generic condition.*

Public and private water companies own extensive land across every social strata of our cities. This land is mainly used for operative water infrastructure. In some opportunities this land is sold or leased to estate developers, but this is rare. The land is generally not sold to guarantee and safeguard the integrity of the water system required to provide drinkable water to the citizens.

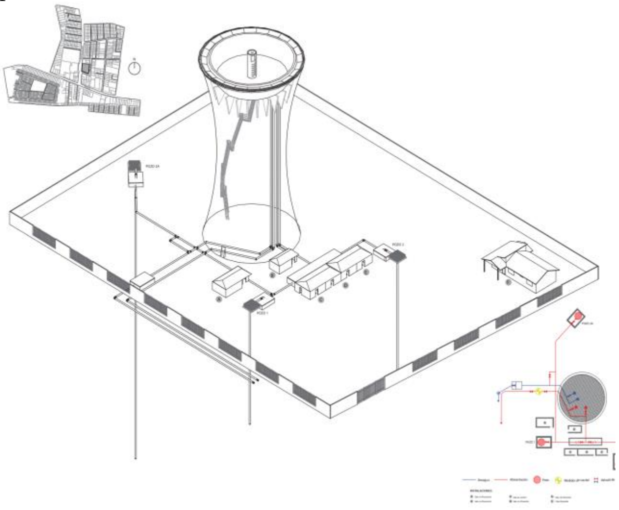

Figure 7. Operative drinking water infrastructure in Chile

The value of the water system sites is not in the real estate marketplace. Operative water infrastructure usually allocates pipes, pumps and water tanks. These infrastructures usually occupy half (or less) of the sites where it is located. This 24/7 nonstop utilities makes most of the land of the water companies a mid-term non-tradable asset. However, there is some present value in the free space of the sites. Value that is not in the real estate marketplace;

but in the potential use of the space.

3.2. *Shared Value. Operative Infrastructure opportunities in low income areas.*

The capability of water system sites can be increased to improve the neighboring community's wellbeing. Commonly most of the low-income operative sites are walled and fenced to the streets or neighbors, to prevent the manipulation of sanitation infrastructure by third parties and to protect the integrity of the system. However, large isolated and often dark spaces can produce a conducive environment for crime and other illicit activities creating a negative perception from neighboring communities. This can be reverted if we focus on the non-tradable and non-occupied operational space to encourage the participation of its residents, increasing the economic activity and ecological good practices.

Figure 8. Walled water tank in a low-income area in Chile.

Economic benefits for society improve when companies move beyond corporate social responsibility and gain competitive advantage by including social and environmental consideration in their strategies**.** For water companies, the non-occupied space of the water utilities sites located in low income areas have the potential to become social platforms. By Opening the doors of a small percentage of their site to create a new microeconomic landscape.

Any social oriented physical action on the operative site will regenerate the value chain of public and private water companies. It will create an opportunity where clients can create and consume value instead of just consuming the value that is created upstream (drinkable water); creating high value exchanges, as a new disruptive model based on technology [30]. In terms of Sangeet Paul Choudary's book "Pipelines and Platform Strategies" (2018), this strategy would go against most of the business models where value is produced upstream and consumed downstream as a linear flow, much like water flowing through a pipe.

The solution lies in the principle of shared value, which involves creating economic value in a way that also creates value for society by addressing its needs and challenges. Businesses must reconnect company successes with social progress. Shared value is not social responsibility, nor philanthropy, but a new way to achieve economic success, it is the next major transformation in business thinking [31].

3.3. *Operative Water Infrastructure as Microeconomic Landscape. Case Study / Santiago,Chile*

In this section I propose an intervention model for non-occupied land of water tank sites of Aguas Andina S.A. in Santiago, Chile.

Aguas Andinas S.A. is the largest private drinking water supply company in Chile, where it serves more than eight million people in the 15.403 km2 of the Metropolitan Area with a distribution network of 13,258 km placed on 70,000 hectares of land concession [32]. The company owns more than 230 drinking water tanks of operative infrastructure that work 24/7 in almost all the metropolitan area of Santiago, distributed throughout all the socioeconomic stratum of the capital city.

Figure 9. Existing landscape inside operative drinking water infrastructure in Chile

Drinking water tank sites were selected to generate interventions that generate great social impact. During 2018, I analyzed and categorized all the operative drinking water tanks sites using the IBT index (Territorial Wellbeing Index) -a robust GIS database developed by the Territorial Intelligence Center of Universidad Adolfo Ibáñez and the Chilean Construction Chamber in Chile. I selected a few sites with the highest social segregation index and lowest socioeconomic stratum. I aim to target vulnerable communities with interventions based in these water tank sites. In 2019 the selected sites were informed to Aguas Andinas S.A. The company selected a short list of six sites where it is feasible to open their doors to propose a new landscape of high social impact initiatives.

Figure 10. Operational free space of operative water infrastructure in low income areas in Santiago de Chile.

Any drinking water company's non-occupied operational space located in low income areas could be reconfigured into a powerful socio-ecological tool. Tool that can become an upward mobility ecosystem of shared value. A model of the new 21st century gathering space, where a public and private partnership bring together multiple actors. I propose the ecosystem considers four pillars:

1) Open space which takes 30% of the non-occupied space of the water tank site. Located next to the street. In this space people can meet and escape from overcrowded houses. The landscape must be designed with low maintenance vegetation with a low water demand that encourages the citizens about the good use of hydric resources. Preferably planting with no dirt fruits that can minimize cleaning. The surface must be mostly porous to increase rainwater management. Drip irrigation will be provided by the water utilities. (Coexistence is a key factor, a different access from the street must be maintained for the water company to keep working on the water tank and the existing operative infrastructure).

2) A small recycle point, where children can learn about the importance of modern waste reduction and get the daily habit to reduce, reuse, and recycle. Youngsters and adults can take pieces of wood, aluminum or plastic that are in good shape for reuse.

3) High speed Wi-Fi free point inside the water utility site.

4) A Fab Lab, or a small-scale workshop offering (personal) digital fabrication to work with pre and post consuming pieces of wood, plastic or fiber concrete. The Fab Lab which will be managed by a Public or Private University where the students will get elective class credit for being in charge of the Fab Lab a few days a week to help the neighbors to design, build and replicate their ideas on a CNC router and 2D laser cutter machines.

The Fab Lab physical space must be designed and built in wood because it is:

- Modular, repeatable, quick to build and detachable.
- Carbon neutral as wood absorbs and stores CO2 atmospheric.
- It has excellent rigidity and resistance performance for seismic areas.

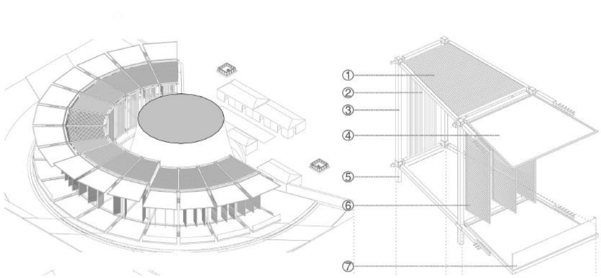

Figure 11. Fab Lab Modular wood structure design / Workshop of digital fabrication in low income areas.

To implement and operate the Fab Lab and the landscape around it, several actors must be involved in the following task:

- The Water Companies will provide the water for landscape irrigation and land concession to situate the Fab Lab.
- Public or Private Universities will manage and run the workshop of the Fab Lab.
- Private Impact Investors will develop funding associated with the Fab Lab functionality and maintenance as an online marketplace to sell the neighbors' products.
- NGOs will be welcome for financial support at low interest rates to encourage production and commercialization.
- Municipality and neighbors will take care of landscape maintenance.

Through the Fab Lab workshop, the low-income Neighbors will be taught by university students to learn something new to improve their income and quality of life. In the first weeks, they will start designing and building tools and furniture which they need for their own daily life. But in the following weeks, with the help of university students, the goal is to give them access to the multiple social platforms for open collaborative product development like wiki factory (https://wikifactory.com/), to improve their product designs and start selling in a marketplace. The children will start to recycle but in a couple of weeks it is expected that they will learn how to reuse materials with the help of adults moving into the next step to create, design and re-build.

Figure 12. Fab Lab Aerial view around a water tank.

The neighbors of the water operative infrastructure site are the captive clients of the water companies (public or private). Eventually, all the welfare neighbors can get will return to the company as a reduction of bill delayed payments. As an asset, the neighbor welfare will also be trespassed as appreciation in the land price where the utilities are located delivering measurable social impact that also enhances the company economic performance through a scalable business model that faces nonmarket barriers to be implemented.

Figure 13. Coexistence between drinking water operative infrastructure (back yard) and high social impact project (front yard) as the new 21st century plaza where people can meet, learn and create.

In the short term the workshop of digital fabrication in the low-income area will become a practical and functional social tool allowing a civic meeting connecting students with neighbors of scarce resources.

In the long term this new public and private initiative may turn into a leadership and entrepreneurship workshop, used to spread knowledge and complement public education with pragmatic education that impacts and generates real changes in the people who want to participate in it.

From the perspective of society, it does not matter what type of organization created the value, what matters is that benefits are delivered by those organizations that are best positioned [33]. Any company that supplies drinking water owns a ubiquitous system, which gives them the lead to take this opportunity on every social strata of our cities.

4. CONCLUSION

The meaning of the word "Landscape" in English has change every 100 years according to professor Charles Waldheim who states that: "*In the beginning of the XVI century, landscape was a genre of painting imported from the continent; then in the XVII century it was a way of seeing the world or a mode of subjectivity associate with the tour, turning to refer to the land looked at in this way in the XVIII century and finally described as the activity of refashioning* *the land so as to allow it to be looked at as if it were a painting in the nineteenth century*". [34]

Most of the companies that manage operative infrastructure sites have the unique opportunity to reinvent the meaning of the word "landscape" and migrate from old painting backgrounds into our cities most important social actor as a new urban model where the daily activity of the company can coexist with societal improvement as long as they are open to reconfigure a small piece of their land without losing ownership.

The reconfiguration of any operative infrastructure site located in a low income area will create a place of engagement and knowledge where a workshop of digital fabrication (Fab Lab) will become a feasible alternative to mitigate the unequal distribution of income that comes from the interchange of goods and ideas that shapes our cities creating value at the end of the value chain, turning water company customers from users into providers.

Sustainability is not only the good management of basic resources, but also the good welfare of the communities where the assets of the company are located to provide social services and support private sector economic activity.

Figure 14. High social impact project in operative water tanks. New social landscape in Santiago de Chile.

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Eugenio Simonetti Toro (Harvard MAUD 2008) has been leading a social-oriented research on urban operative water infrastructure in the most segregated areas in Santiago for few years supported by Aguas Andinas S.A., the largest drinking water company in Chile. In 2019 Simonetti taught the Studio named "Social Operative Infrastructure, Sustainable Water Models in Chile" at the Harvard Graduate School of Design together with Tomas Folch to analyze and research six operative sites that allocate water infrastructure in low income areas with 12 Harvard students, a research supported by Aguas Andinas S.A and the Interamerican Bank of Development. The six operative sites in low income areas of Santiago, Chile were chosen using the IBT index developed by Professor Luis Valenzuela from UAI and the Chilean Construction Chamber.

https://www.gsd.harvard.edu/course/social-operative-infrastructure-sustainable-water-models-in-chile-fall-2019/

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