

An adaptive management plan to decrease impacts of water crisis on social welfare in Detroit

Emily Bondank
Graduate Student
Civil, Environmental, and Sustainable Engineering
Arizona State University

Prepared May 2015

Report No. ASU-SSEBE-CESEM-2014-CPR-003
Available online at <https://repository.asu.edu/items/35533>

Abstract

In the economic crisis Detroit has been enduring for many decades, a unique crisis has emerged with the provision of water that is normally not seen in the developed world. The oversized, deteriorating, and underfunded water provision system has been steadily accruing debt for the water utility since population began to decrease in the 1950's. As a result, the utility has instated rate increases and aggressive water shut off policies for non-paying residents. Residents have consequentially claimed that their human right to water has been breeched. In this report, I analyze possible solutions to the water crisis from both the water utility and resident perspectives. Since all utility management solutions have very serious limitations on either side of the argument, I have chosen a set of technologies to consider as a part of an impact mitigation plan that can provide alternative sources of water for the people who no longer can rely on municipal water. I additionally propose an adaptive management plan to evaluate the effects of using these technologies in the long-term. The monitoring of the effects of technological mitigations might also help determine if sustainability (efficiency and equity) could be an attainable long-term solution to Detroit's water crisis.

1.0 Introduction

1.1 Water Provision Crisis in Detroit

Detroit, Michigan is an interesting case study of the struggle of access to water in the developed world. Since 2001, around 40,000 families per year have had their municipal water shut off (Caruso, n.d.). The underlying economic issues in Detroit that have in part caused the water shut offs have origins stretching back to the 1950's. When the car companies, Ford and Chrysler, moved their manufacturing plants to other cities, Detroit was left with too few jobs to support its population. Population has been steadily declining since then so that the remaining citizens have been left with an oversized and deteriorating water infrastructure system. Where once many people could support the water provision and maintenance with their bill payments and taxes, now the small remaining population has been charged the large tab. It has been often the case that residents are unable and/or unwilling to afford these bills and thus the water utility's debt has been steadily increasing. As a measure to guide the city out of debt, the governor of Michigan hired consultants to take over management of the city. They went about reducing the number of employees and services the city provided, and as an attempt to receive higher returns, they further increased the price of treated and distributed water. They also instated an aggressive no-tolerance policy for residential debt and began shutting resident's water off when their bills were left unpaid over a 60 – day period.

There has been a huge opposition from the people of Detroit in the emergency management appointments, water rate increases, and water shutoffs. Activists claim that their human right to water has been breached by these decisions and have gained support from the United Nations on this claim (Badger, 2014). Because the United Nations has no real power over government decisions regarding the human right to water, the Detroit government has carried on with the rate increases and water shut offs to the current day.

1.2 Adaptive Management Solution Approach

Because the issue between the people and the utility in Detroit has escalated into civil unrest consisting of public protests, claiming of human rights to water, and consultation with the United Nations, the existence of a problem that requires *targeted intervention* seems to be apparent. There is no one clear solution to this problem, however, but there is a myriad of possible solutions that incur both benefits and issues. Though it is found that the government does lack *transparency* that causes citizen distrust, their perceptions of the problem are considered in a *multi-dimensional dialogue* in this report. *Real world boundaries* are explored for possible solutions to underlying problems that the different perspectives on the issue have provided. Benefits and issues that arise from a solution are evaluated on the basis of how well they fit into the physical, cultural, economic, and political landscape of Detroit.

While there are some methods that the city could take to ameliorate the economic situation, the problem of people left without water calls for immediate implementation of alternative water provision technologies that can be used on an individual level and that don't require action from the government. I have thought of possible technological mitigations to the decrease in social welfare caused by the water shut offs. An adaptive management plan is proposed to provide an

evaluation of the technologies to determine their short-term effectiveness and their long-term *emergent* effects that could contribute to solutions of the underlying economic problems. It is proposed that these effects be measured through *semi-quantitative* metrics through the administering of surveys and interviews. The gauging of the public and governmental opinions will foster *continuous learning* about the effectiveness of employed solutions. Though I express an opinion on a plan to move forward, I understand that there are many complexities within the system that I am unaware of, and thus may not design a plan for properly. I am comfortable with using the tools and knowledge that I do have to attempt to form a plan for change, however.

2.0 Possible Organizational Solutions

It would be best to solve the problem of the water crisis by going to the root of the cause of the problem. The problem is however so wicked and dependent upon economics and politics that I am only able to offer a technological mitigation plan with possible benefits to the whole situation. It is important, however to analyze the solutions that are currently posed from the different perspectives in the issue: The citizens of Detroit, and the government of Detroit. This will enable a proposal of steps in the adaptive management plan to monitor how mitigation strategies are affecting the root causes of the problem.

2.1 Providing the human right to water as the United Nations would suggest

2.1.1 Definition of human right to water:

As stated in the Human Development Report of 2006 that explored solutions the human right to water, the right is always relative to the population and income and does not necessarily mean that it should be free. The human right to water is defined as the right to sufficient, safe, acceptable, and physically accessible, and affordable water. (Human Development Report, 2006). In Detroit, a city in the first world, water is technically accessible through infrastructure that provides clean safe water. It can be debated however, that Detroit's water is not compliant with the UN suggestions for affordability, and therefore the pricing system is in violation of human rights. The suggested maximum percentage of income that should be devoted to water is 3%, and in some instances, the rates in Detroit lie far above this threshold (Human Development Report, 2006).

Highland Park's average income was around \$20,000 in 2012 (Highland Park, n.d.). The following image shows a water bill for \$2,251.46 in a 6-month period. At this rate water bills would cost this person around \$4,500 per year. If this person's income is close to the average in the Highland Park area, the water bill is 22% of his income, which is 19% higher than the United Nations suggested threshold.

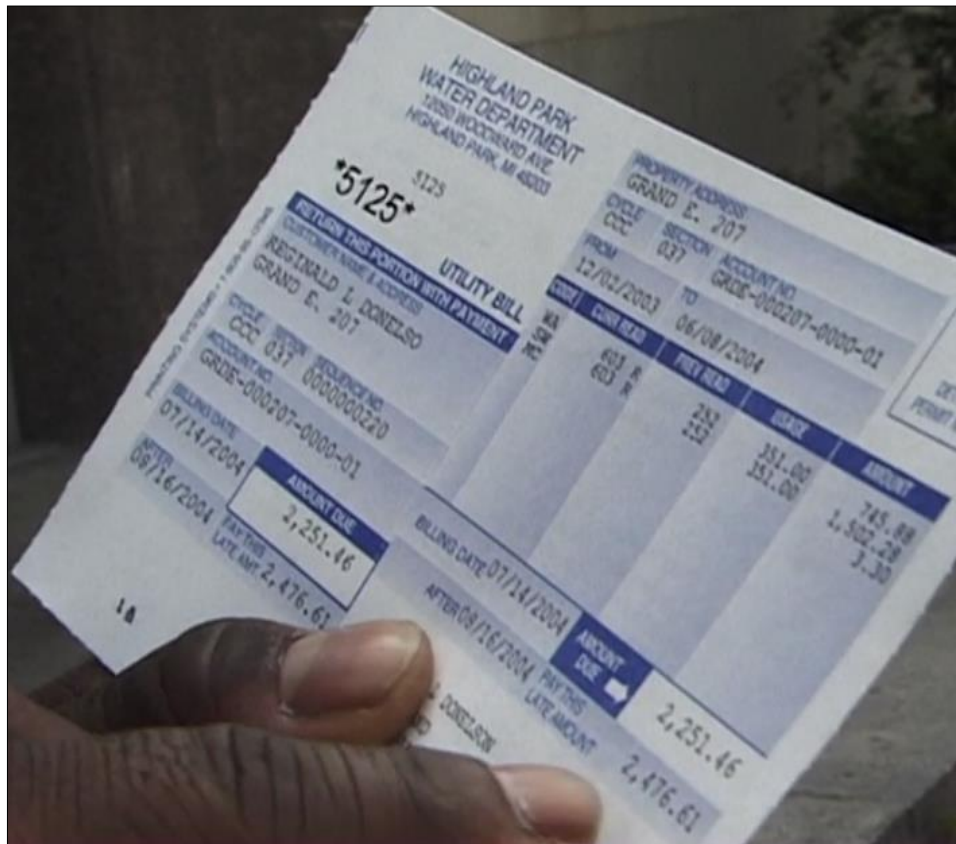


Figure 1 Water Utility bill in Highland Park over a 6 -month period (Miller, 2007).

United Nations Suggested Plan:

Since the human right to water is a really a non- binding political statement, the United Nations has developed a optional protocol to help governments incorporate the human right to water into their laws. Though this guide it is geared more towards developing countries in the sufficient, safe, acceptable, physically accessible categories of the human right to water, the recommendations on how to make water affordable can apply to the Detroit government. The following outline of the plan consists of summarizing statements taken directly from the Human Development Report (2006).

General framework for action (2006):

1. National Planning: All countries should have national water and sanitation plans that have poverty reduction strategies integrated into them. They should:

- Establish social minimum provision: People should be provided access to at least 20 liters per day.
- Revise Millennium Development Goal benchmarks for inequality
- Strengthen the treatment of inequality in Poverty Reduction Strategy Papers: All plans should include goals for narrowing extreme inequalities of water provision based on wealth, location, and gender.

- Adopt pro-poor regulation and contracting: All water providers should be bound by equity performance targets.
2. System financing: The national plans should establish financing estimates - where all financing ultimately comes from government budgets.
 3. Expansion of access to the unserved populations through:
 - Lifeline tariffs: provisions of free water up to a certain limit as implemented in South Africa.
 - Cross-subsidies: transferences of resources from higher income to lower income households through utility pricing.
 - Sustainable and equitable cost-recovery measures: No household should be spending more than 3% of its income on water and sanitation.
 - Strategies for supporting demand for water and sanitation among the poorest households
 4. Scale-up of initiatives from below: Governments should work in partnership with the community.
 5. Regulation for human development: There should be a regulative body in place that prevents the abuse of monopolistic power and pressures providers to allow for public participation in decision making.

Benefits of this solution:

It is a nice thought that with some added effort, the Detroit government could ensure that all of their constituents have economic opportunities to survive and thrive upon the basic resources needed for human survival. A large part of their operations that would have to change would be to incorporate more public participation in their governance. Historically the listening to public opinion has been lacking. For example, when the governor of Michigan initially imposed an emergency manager, “Detroiters overwhelmingly voted in a referendum against ‘emergency manager’ law”. The governor responded by “passing a new [law] overnight – with a provision rendering referendums meaningless” (Lukas, 2014). Additionally, when the emergency managers were considering handing over management of the Highland Park water treatment and distribution infrastructure to a private firm, community activists drafted a alternate plan of action that they were told would be reviewed by the government, but it never was (Miller, 2007).

Issues with this solution:

The major problem with this solution is that government funds of some kind must be available in order to enforce utility subsidies. In a city so far in debt, finding these funds may be very difficult. At the city scale, it seems virtually no funds are available for subsidizing pricing. In the initiation of the water shutoffs, the Community Action Agency for the city, Wayne Metro, was offering payment plans for people who couldn't pay their bills, but after “support[ing] 904 customers over 10 months,” the funds were exhausted. According to an employee of Wayne Metro, they “still get hundreds of calls a day from residents, but have no way of helping them, and nowhere to refer them” (Clark, 2014). Unfortunately, the City runs up against the same wall with the federal government. Kevyn Orr, a former emergency manager, was told by Administration officials in March of 2013 that “there is no political way a bailout would get votes from Congress it would need because every other major city in America would want also want a bailout” (Isidore, 2013).

Another issue with enforcing the human right to water would be that providing free or highly discounted items to people could instill a culture of dependence that could be harmful to the people when provision systems fail. Detroit is actually a case study of this itself, but there are others cases as well. For example, in South Africa, free water up to a certain limit is provided to each household on a monthly basis. Because people were generally not paying for the water above the free threshold, the government installed prepaid water meters that would give the allotted free water, but would then require payment for any water above that threshold. Because people were unaccustomed to not being able to receive water for free or at least on credit, there were instances of meters not being paid enough to put out deadly shack fires (Danchin, 2010). Another example of when discounted water could be harmful is in the case of California. When water is highly subsidized it leads overuse, which has been a cause of the large drought Californians are experiencing. With population increase and global climate change, it might be smart to start planning for more frequent events of water shortage in some areas. Unfortunately for social welfare, highly subsidized water is not a good motivation for conservation.

Because the amount of water humans' need and the amount that should be given to the poor are highly subjective, it is hard to define the level of subsidy needed. In the case of South Africa, the amount of free monthly water has subject to contestation and has already been brought to court to raise it from 20 kilolitres a month to 67 kilolitres a month (Danchin, 2010).

The kind of centralized funding and management required for "fair" pricing of water is difficult for any government to uphold and for a government in economic crisis it is particularly hard. An establishment of this fair pricing may also conceivably set the expectation that a government will continue to provide the resources we deem vital to our survival as time goes on and our needs become more technological. If technologies are to be equitably distributed in society by governments, the question arises: what will be the state of patent laws and private property in the future?

2.2 Social Engineering as a Solution

To the Detroit utilities, a solution to non-payment of bills is to attempt to change the way in which people value water so that they make paying bills a priority. Other water providers around the country are attempting to social engineer people's value associated water as well, but for a different reason. Their goal is to inspire the conservation of water so that the supply of water doesn't become inadequate in the future. For the Detroit water providers, it is more important to instill within people a higher monetary value of water because the scarcity of funding for provision is a greater threat than the scarcity of the water itself.

2.2.1 Water-Diamond Paradox and Marginal Utility:

The economic principle behind the need for social engineering is the water-diamond paradox. The water-diamond paradox is the contradiction in the value a commodity has in its usefulness versus the value the commodity has on the market. The common example is that water is a very valuable commodity in terms of usefulness to human survival but the market value of water compared to a commodity like diamonds is much less, even though diamonds are relatively useless to our survival. The reasoning is that diamonds have such a higher market value because

they are scarce and because they provide more utility for every additional unit of diamond purchased.

Value of objects is formed by people's perception of the value. In stable economies, value of objects are diminished if they are not scarce and do not provide high marginal utility. If the economic environment were to change however, increasing the scarcity and marginal utility of goods that are traditionally low in those fields, people's perceptions of scarcity and marginal utility would change. People's values are slow to change, however, especially if the culture has the previous perceptions of the good's scarcity and marginal utility embedded within it. This is what it seems like Detroit has experienced. The economic climate has called for new ways of management of resources and government services, and without political transparency and with the maintenance of the American lifestyle, the new management is hard for people to accept.

For one, people are resistant to the fact that water is in actuality scarce. This is because scarcity can be defined as how readily available a good, skill, or service is (Study.com). The activists sometimes reference scarcity based upon water's availability as a resource (within the large bodies of the Great Lakes) instead of the scarcity of the service of water treatment in a near bankrupt city.

Secondly, in all surrounding areas of Detroit in the first class country of the US, water is affordable for citizens because of widespread use of subsidized utility rates. It might be engrained in our culture to expect water to be a very small proportion of our income. Additionally, the poor are given a helpful hand from the government in a lot of other cases that may provoke them to think that this is a necessary instance where the government should be helping.

It is stated in a description of the water-diamond paradox that the idea of water's marginal utility may only change "if one is dying of thirst" (Study.com). Since Detroit citizens still have the option of getting water, just at a higher price, the situation is perhaps not extreme enough to elicit a change in values. And the true existence of the scarcity is not objective enough in the minds of the residents.

2.2.2 Attempt at Paradox reversal in Detroit:

It seems that government officials view the situation as one that required some social engineering to reverse the water-diamond paradox and "coercively 'modify the behavioral patterns' of Detroit residents" (Gaist, 2014c). The water-diamond paradox and marginal utility seems to explain why government officials feel that nothing less than an aggressive action will change resident's value systems. When they further increased the aggression, and attached people's house deeds to their water bill, one of the consultants stated that it may have been a harsh act, but the number of people who paid their bills did increase dramatically after the policy was instated. (The Water Front, 2006).

Benefits of this solution:

This solution promotes the idea that the provision of water is an economic service with monetary value and is not just a service that comes free with the package of being human.

Issues with this solution:

This approach may be too aggressive in that it can stress the citizens to the point that their trust in government is lost and their compliance with laws becomes harder to enforce. Additionally, if governments aren't transparent with the uses of the collected funds, it will exacerbate the civil unrest.

3.0 Possible Technological Mitigations

Since the evaluation of the current ideas of solution leads to only a stagnant acceptance that each solution has its pros and cons, alternate solutions are proposed.

3.1 Alternative forms of funding

Due to advances in technology and the proliferation of Internet use, people are becoming more and more aware about social injustices around the world. Increased technology has also allowed funding grassroots projects to become easier. If someone just makes an attractive video like the ones made for developing countries, and post it on the Internet on websites like kickstarter, it is possible that people around the world would share their money if they felt it was a good cause. If funding by residents themselves for the following technologies is infeasible, the implementation might rely upon these types of funding more so than government funding.

It should also be noted that is also a possibility that generous people and organizations can directly fund people's water bills. Two Muslim organizations, The Michigan Muslim Community Council and Islamic Relief USA, have already donated \$100,000 to this cause (Hicks, 2015).

3.2 Alternative forms of water provision

While trying to strike this difficult balance between social welfare and economic health in a city, other types of water provision could be deployed by the community to mitigate the effects that shutoffs have on the poor. While these solutions get around the need for provision of water through the large engineered infrastructure, they still leave the issue of how to eventually recover the deteriorating infrastructure without a strong tax base. The technologies aiding alternative forms of water provision that are explored are rainwater collection, modern water treatment devices, and water bottle distribution.

3.2.1 Rainwater Collection:

In Detroit, where there is 31.33 inches per year of rain, rainwater collection may be an option for an alternative water provision system. Rainwater collection could either be used to collect water for irrigation or water for potable use. The type of use would depend upon the resident's needs and the level of treatment of the water that can be afforded. The calculations shown below were performed to assess the feasibility and significance of using rainwater collection in Detroit. It should be noted that much of the approximate data was collected from a rainwater collection manual created by the City of Bellingham in Washington.

Potential Rainwater Harvested vs. Water Demand

Water Collection Calculation:

$$\begin{aligned} \text{Water Collection} &= 31.33 \frac{\text{in}}{\text{yr}} \left(\frac{1\text{ft}}{12\text{in}} \right) \left(2,000 \frac{\text{ft}^2}{\text{house}} \right) (0.9) = 4,700 \frac{\text{ft}^3}{\text{yr} - \text{house}} \\ &= 4,700 \text{ft}^3 \left(\frac{7.4805 \text{gal}}{1\text{ft}^3} \right) = \underline{\underline{35,158 \frac{\text{gal}}{\text{yr} - \text{house}}}} \end{aligned}$$

Average rainfall in Detroit = 31.33 inches/ year

Approximate average square footage of rooftop = 2,000 sqft (City of Bellingham Staff, 2012).

Asphalt shingle roof runoff coefficient = 0.9 (City of Bellingham Staff, 2012).

Per Capita Water Demand:

$$101 \frac{\text{gal}}{\text{cap} - \text{day}} \left(\frac{365 \text{day}}{1\text{yr}} \right) = \underline{\underline{36,865 \frac{\text{gal}}{\text{cap} - \text{yr}}}}$$

Where the national average of water use is 101 gallons per person per day. (City of Bellingham Staff, 2012).

Total Houses in Detroit:

$$\text{Housing Density} = 2,703 \frac{\text{houses}}{\text{mi}^2}$$

Detroit square mileage = 138.75 mi²

$$\text{Houses} = 2,703 \frac{\text{houses}}{\text{mi}^2} (138.75 \text{mi}^2) = \underline{\underline{375,041 \text{ houses}}}$$

Total Amount of Water Harvested in Detroit:

$$375,041 \text{ houses} \left(35,154 \frac{\text{gal}}{\text{house} - \text{yr}} \right) = \underline{\underline{1.318 \times 10^{10} \frac{\text{gal}}{\text{yr}}}}$$

Detroit Potable Water Supplied by DSWR:

$$6.10 \times 10^6 \frac{\text{gal}}{\text{day}} \left(\frac{365 \text{day}}{1\text{yr}} \right) = \underline{\underline{2.23 \times 10^{11} \frac{\text{gal}}{\text{yr}}}}$$

(Detroit Water and Sewerage Department, 2014).

Percent of Supplemented Water out of Total DSWR Supply:

$$\frac{1.318 \times 10^{10} \text{ gal/yr}}{2.23 \times 10^{11} \text{ gal/yr}} \times 100 = \underline{\underline{6\%}}$$

Water Rates vs. Cost of Rainwater Harvesting

Costs of Rainwater Infrastructure:

Treatment: An at-home ultraviolet radiation treatment system costs as little as \$200 (Rain Brothers, 2015).

Tank for either irrigation or potable water: as low as \$70. Could cost as much as \$100,000 if you get a very large, high-quality tank.

Savings from Water Harvested:

$$\frac{\$97.85}{1,000\text{ft}^3} \left(\frac{1\text{ft}^3}{7.48\text{gal}} \right) \left(35,158 \frac{\text{gal}}{\text{yr - house}} \right) = \frac{\$450}{\text{yr - house}}$$

Where the reported DSWD Monthly rate is $\frac{\$97.85}{1,000\text{ft}^3}$ (Detroit Water and Sewerage Department, 2014).

Benefits of this solution:



It seems that rainwater harvesting could collect approximately the amount of water needed for one person in a year. That amount of water would cost \$450 from the Detroit water utility each year. If every house in Detroit harvested all rainwater, it would reduce the utility's water demand by about 6% per year. To collect the water, residents would need to buy a tank ranging from \$70 to thousands of dollars. To treat the water to be potable they would have to buy a treatment system that cost hundreds of dollars starting at around \$200. This would not cover the cost of installation or maintenance or quality monitoring.

City and Utility Opinion

Some utilities, which are not bankrupt, are offering incentives for rainwater installation. The following image shows the rebates offered in the city of Austin, Texas.

Local Incentives for Rainwater Collection Systems

Listed below are some of the local incentives to promote rainwater harvesting. These offers are available to residents of the respective cities or counties.

- City of Austin offers [rebates up to \\$5,000](#) for systems of all sizes, not to exceed 50% of the system cost
- City of Sunset Valley offers [rebates up to \\$3,500](#) for systems larger than 300 gallons
- All equipment used solely for rainwater collection in the State of Texas is [exempt from sales tax](#) 
- Hays County offers an [property tax reduction](#)  by your rainwater collection system construction costs

If you qualify for any of the rebates listed above, we will provide you with all of the necessary documentation for the rebate program.

Figure 2 Municipal Incentives for Rainwater Harvesting (Innovative Water Solutions)

In their rainwater collection guide, Bellingham utility says that they would benefit from the decreased water demand from people using rainwater collection methods because they sometimes cannot reach their peak demand and have to issue no landscaping water mandates (City of Bellingham Staff, 2012).

Rainwater collection may also be useful in its effects on the operation of the combined sewer system. Jeff Klein, a local landscape architect in Detroit has said that “[Rain water collection] projects are critical in Detroit, where an aging combined sewer system that collects storm and waste water in the same pipes can have its capacity exceeded during heavy storm events, resulting in the discharge of untreated waste water into the Detroit River and the Great Lakes water basin that threatens the ecosystem” (Lewis, 2013).

Social Engineering aspects

The level of effort it would take from the citizen to research, install, and maintain rainwater collection systems would possibly foster a real appreciation of the processes required to obtain safe water. Perhaps if the maintenance of the system takes up too much of people’s time, they would be willing to pay for the municipality water provision in exchange for their free time. This idea draws from the fact that people generally take services for granted until they see how many resources are required in the process and how many externalities the process can cause. For example, if people were exposed to the resource intensity of industrialized meat and then spent some time producing their own meat, they might be willing to gain their time back and pay more for the least resource and cruelty intensive meats on the market.

Issues with this solution:

While rainwater collection technologies have the potential to modify underlying value issues with water, it does not immediately solve Detroit’s economic problem. The water infrastructure will still be left deteriorating without the bill payments to renovate it. Additionally, the widespread use of unregulated rainwater that was individually harvested could contribute to an increase in disease vectors that would be hard to centrally control. The difficult aspect of rainwater collection for potable use is providing adequate treatment.

3.2.2 New types of individualized water treatment devices

Michael Prichard has invented water bottles that he has named “Lifesavers” with a sophisticated treatment mechanism attached that people could use to “make even the most revolting swamp water drinkable in seconds” (Walters, 2013). The treatment mechanism relies upon simple filtration and requires no use of chemicals. The filter is made from hollow fiber and has tiny 15 nanometer pores. It is claimed that filters can clean up to 6,000 liters of water in their lifetimes. The deployment of these bottles would provide one person’s requirement for drinking water intake for 2000 days. Or it could supply a family of four’s water for consumption for 500 days or 16 months. It is premised that “given the astronomical cost of shipping water to disaster areas, Pritchard’s Lifesaver bottle could turn traditional aid models on their heads” (Walters, 2013). This technology might also be a great way for Detroit citizens to provide clean water for themselves.

Benefits of this solution:

This could potentially bypass the need for infrastructure in the long term. For places where no infrastructure currently exists this is a great solution. For Detroit with an existent structure and culture around easily collecting water by turning on a faucet, it could have profound implications on culture and the economy if it were to be widely adopted.

Issues with this solution:

Trusting only one barrier of treatment could be risky. It is known that nanofiltration cannot treat all different types of quality issues in water. For example nanofiltration cannot remove all salts and heavy metals as Figure 3 shows.

Table-3 Rejection performance of nanofiltration with reverse osmosis and ultrafiltration

Substance	Degree of removal (%)			
	Ultrafiltration	Nanofiltration	Low- pressure Reverse Osmosis	Reverse Osmosis
NaCl	0	0-50	70-95	99
Na ₂ SO ₄	0	99	80-95	99
CaCl ₂	0	0-60	80-95	99
MgSO ₄	0	>99	95-98	>99
H ₂ SO ₄	0	0	80-90	99
HCl	0	0	70-85	99
Viruses	99	99.99	99.99	99.99
Bacteria	99.99	99.99	99.99	99.99

Figure 3 Nanofiltration Treatment (Abhang et al, 2013)

3.2.3 Use of water bottles

Buying bottled water is a common alternative to municipal water in developed and developing countries alike. In developing countries, water is bought from bottles out of necessity because water is not provided at all or at insufficient quality. In Detroit, people are buying water bottles after their water has been shut off (whether or not they could truly avoid this is up for debate). Additionally, some of the charity efforts are focused on delivering free water bottles to people in Detroit who have been shut off. The following image is a graph showing the prices of different kinds of delivered water sources. It shows that if infrastructure is paid for, public utilities

generally offer the cheapest water as opposed to other water vendors. This is attributed to the economies of scale that a utility enjoys versus the marginal costs of transportation of bottled water (Human Development Report, 2006).

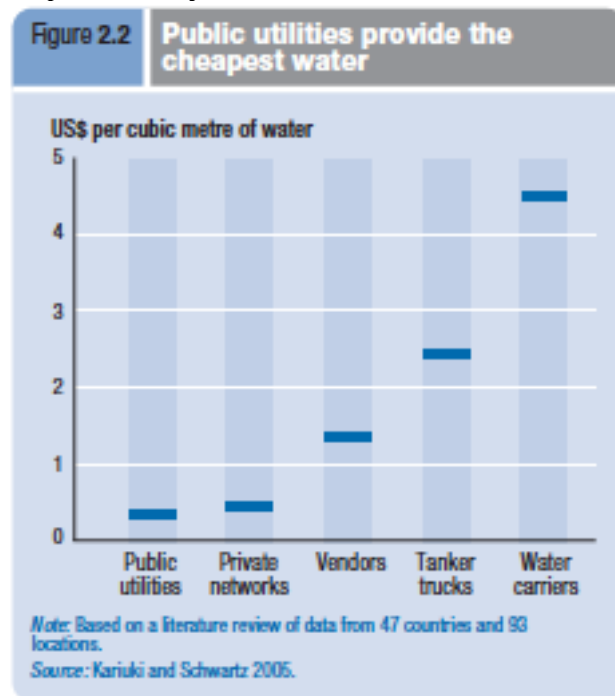


Figure 4 Costs of water sources (Beyond Scarcity, 2006)

A testimony to the costs of bottled water in a developed country is found in the Human Right to Water Bill in California: “Purchasing bottled water is a short-term and costly alternative for many California households without access to clean water. In some communities with contaminated water, up to 95 percent of residents purchase bottled or purified water. In the Central Valley, some households devote approximately 20 percent of their annual median income of \$14,000 to pay for water and sanitation services and to purchase bottled water” (International Human Rights Law Clinic, 2013).

Benefits of this solution:

The benefits of distributing bottled water are that there is little risk involved and there is already a general cultural acceptance of this form of water provision established in the US.

Issues with this solution:

It is an expensive form of water and though it could be the easiest and fastest way to provide water for people, it would not necessarily be the most efficient.

4.0 Adaptive Management Plan

From all different possible solutions I have explored, I will make a suggestion for a realistic adaptive management plan that members of the community of Detroit could follow to mitigate the effects of the complicated economic issues in their city without relying on the government to provide any services. It is suggested that monitoring programs be put in place to determine

whether or not the effects of technological mitigations point to any solutions to the root problems with the value of water.

4.1 Short- term mitigation

1. I suggest that members of the community, and any outsiders willing to help, put the Detroiters’ case on websites, like kickstarter, to ask for funding or technological donations. The funding could be spent on any of the alternative water provision technologies or for paying water bills. This step would serve the purpose of minimizing the decreases in social welfare the city is experiencing without asking the government for help.

4.2 Long-term problem solving

2. A research group (perhaps one of the community welfare organizations would suffice) should monitor the effects over time with the implementation of technological mitigations. Data could be collected in a similar format to the one shown in Table 1 below.

Table 1 Mitigation Technology's effect on root problem

Mitigation Technology	Change to problem monitoring			
	How well does it meet resident's needs?	Change in people's monetary value of water	Effect on the Utility	Emergent Effects
Rainwater Harvesting				
Water bottle delivery				
Modern water treatment devices				

To collect this data, interviews and surveys could be administered to both citizens who have adopted an alternative water provision technology and to utility managers.

It has been my prediction that all alternative water provision devices will increase the value people give to water through the labor that will be associated, and that rainwater collection would decrease water loads causing overflows in the sewers. This type research will monitor these possible types of effects, along with any emergent effects of the technologies (whether they are good or bad).

3. If the effects of technology adoption are mostly positive, perhaps the city could move towards supporting individual infrastructures in the long run instead of the centralized infrastructure system that is currently failing.

5.0 Conclusions and Sustainability

The United Nations is the organization that has officially defined both universal human rights and sustainability. Human rights were defined in The Universal Declaration of Human Rights as “rights based on the principle of respect for the individual” (1948), and sustainable development

was defined in *Our Common Future* as “meet[ing] the needs of the present without compromising the ability of future generations to meet their own needs” and as making sure that “the poor get their fair share of resources” (1987). Human rights were formulated based on influences like the US Constitution and Bill of Rights where it is stated that human’s inherent needs are liberty and private property. The definition of sustainability, however, has explicit social equity goals that if pursued might negate the original human rights as set out by western tradition. A simplified mapping of the United Nation’s definitions of sustainability and human rights is shown in Figure 5 below.

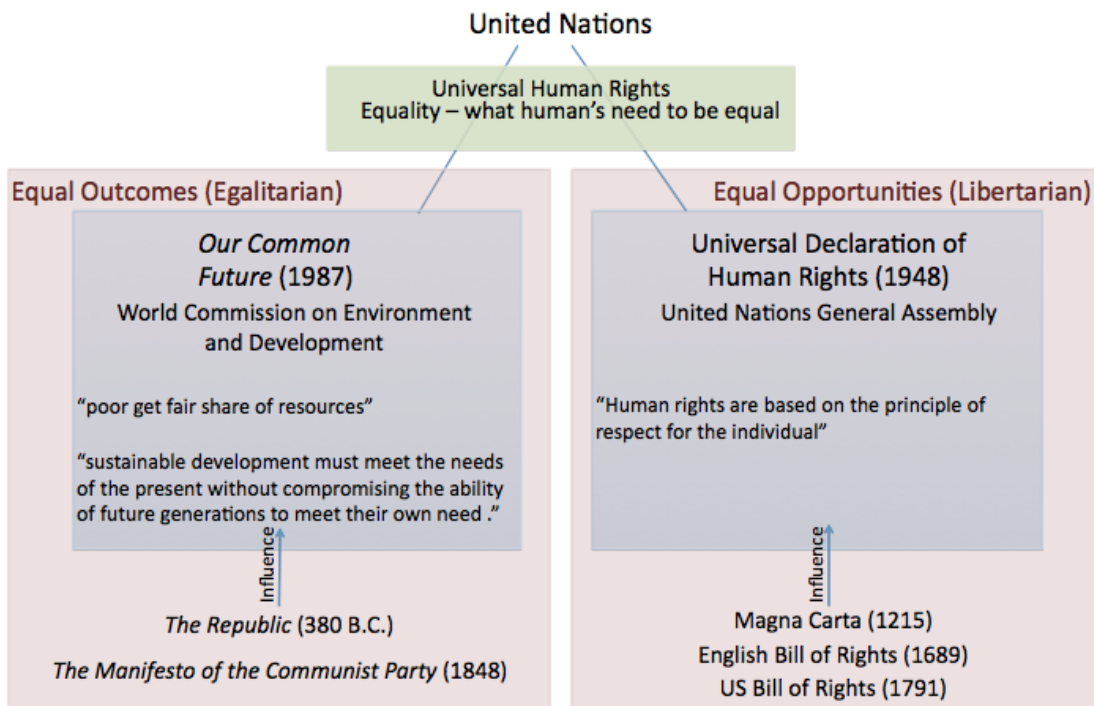


Figure 5 United Nations- Human Rights and Sustainability

The following list shows the progression of the assertion of rights in the western culture that influence the traditional definition of human rights:

- Cyrus Cylinder (539 B.C.)** – freedom from slavery, freedom of religion, racial equality
- Natural law**- observation of unwritten ethical structures in Rome
- Magna Carta (1215)**- Charter in England concerning relationship between monarchs and barons that declared protection of church rights, protection for the barons from illegal imprisonment, access to swift justice, and limitations on feudal payments to the Crown.
- Petition of Right (1628)** - stated objectives of the English legal reform movement that led to the civil war. Objectives were restrictions on non-Parliamentary taxation, forced billeting of soldiers, imprisonment without cause, and the use of martial law.
- English Bill of Rights (1689)**- sets out the rights of parliament to things like freedom of speech,

and freedom from cruel and unusual punishment.

United States Declaration of Independence (1776)- asserted the right of the United States to rebel against Britain by listing grievances and by asserting the famous rights to life, liberty, and pursuit of happiness

French Declaration of the Rights of Man and of the Citizen (1789)- asserted rights like liberty, property, safety, and resistance against oppression

US Bill of Rights (1791)- asserts specific protections of individual liberty like freedom of religion, speech, assembly, etc. and freedom from unwarranted searches, cruel and unusual punishment, etc.

While these traditional human rights are based upon minimizing government intervention in the lives of individuals, the human rights to commodities, such as water, have taken on the sentiment for equity found in the definition of sustainability because it requires the provision of services and funding. In the case of the human right to water, the conditions for provision of the right are stated in terms that make it sound like the goal of the right is to provide equal opportunity of life chances rather than equity of outcomes. In the Human Development Report of 2006, it is stated that the lack of access to water “reinforces the obscene inequalities in life chances that divide people within countries on the basis of wealth, gender, and other markers for disadvantage.” The caveat as explored in this report is that to ensure equal opportunity of access to commodities, resources must be distributed in an egalitarian way.

In some cases, like in Detroit, it might just be too hard to enforce equity in the face of the capitalist market. The noble goal of sustainability is to make this easier through integration of equity into the market dynamics. Since the protocol for doing this has not been clearly formed yet, an adaptive management of the situation in Detroit was made using the incorporation of mitigation technologies, which might or might not also have a positive effect on the root of the wicked problems.

Monitoring in changes in the system plays an important role in determining whether the employed technological solutions are only serving as temporary relief to a hopeless situation, or whether they have the potential to make truly positive impacts for solving the difficult situation in Detroit.

6.0 References

Abhang, R.M., Wani, K.S., Patil, V.S., Pangarkar, B.L, Parjane, S.B. (2013). Nanofiltration for Recovery of Heavy Metal Ions from Waste Water – A Review. *International Journal of Research in Environmental Science and Technology*

Badger, E. (2014). The UN says water is a fundamental right in Detroit. *The Washington Post*. Accessed from <http://www.washingtonpost.com/blogs/wonkblog/wp/2014/10/23/the-u-n-says-water-is-a-fundamental-human-right-in-detroit/>

Caruso, C. (n.d.) *A Case Study on Organizing: The Struggle for Water in Postindustrial Detroit*.

Centers for Disease Control and Prevention (CDC) (2011). Morbidity and Mortality Weekly Report. http://www.cdc.gov/mmwr/preview/mmwrhtml/ss6012a4.htm?s_cid=ss6012a4_w

City and County of San Francisco. (2008). Memorandum of Understanding Between: San Francisco Public Utilities Commission (SFPUC) & San Francisco Department of Building Inspection (DBI) & San Francisco Department of Public Health (DPH) For: Permitting Requirements for Rainwater Harvesting Systems Located Within the City and County of San Francisco. San Francisco.

City of Bellingham Staff. (2012). Rainwater Harvesting. A Guide to a Sustainable Water Future.

Clark, A. (2014). Going Without Water in Detroit. The New York Times. Accessed from http://www.nytimes.com/2014/07/04/opinion/going-without-water-in-detroit.html?_r=0

Coase, R. H. (1970). The Theory of Public Utility Pricing and Its Applications. The Bell Journal of Economics and Management Science, Vol. 1, No. 1. Pp. 113-128

Danchin, P. (2010). A Human Right to Water? The South African Constitutional Court's Decision in the Mazibuko Case. Available at available at <http://www.ejiltalk.org/a-human-right-to-water-the-south-african-constitutional-court%E2%80%99s-decision-in-themazibuko-case/>

Detroit Water and Sewerage Department. (2014). Fact Sheet.

Environmental Protection Agency (EPA) (2013). Rainwater Harvesting: Conservation, Credit, Codes, and Cost Literature Review and Case Studies. <http://water.epa.gov/polwaste/nps/upload/rainharvesting.pdf>

Gaist, T. (2014a). Detroit Water Departments Preparing Mass Utility Shut Offs. World Socialist Website: <http://www.npr.org/2014/08/01/337145827/a-right-or-a-privilege-detroit-residents-split-over-water-shut-offs>

Gaist, T. (2014b). Energy companies continue utility shut offs as bitter cold hits Detroit. World Socialist Website. Accessed from <http://www.wsws.org/en/articles/2014/01/28/dtes-j28.html>

Gaist, T. (2014c). The Detroit News endorses mass water shutoffs. World Socialist Web Site. Accessed from <http://www.wsws.org/en/articles/2014/03/27/shut-m27.html>.

Hicks, M. (2015). 2 Muslim Group's donations to help pay for water bills. The Detroit News. Accessed from <http://www.detroitnews.com/story/news/local/wayne-county/2015/01/07/muslim-donations-help-pay-water-b>

Highland Park, Michigan. (n.d.). City- Data.com. Accessed from <http://www.city-data.com/city/Highland-Park-Michigan.html#b>

Hill, A. (n.d.). Diamond-Water Paradox in Economics: Definition and Examples. Retrieved April 14, 2015 from <http://study.com/academy/lesson/diamond-water-paradox-in-economics-definition-examples.html>

Human Development Report.(2006). Beyond scarcity: Power, poverty, and the global water crisis. Published for the United Nations Development Programme.

International Human Rights Law Clinic. (2013). The Human Right to Water Bill in California: An Implementation Framework for State Agencies. University of California, Berkeley, School of Law.

Isidore, C. (2013). Detroit to get \$30 million dollars in federal help. CNN Money. Accessed from <http://money.cnn.com/2013/09/27/news/economy/detroit-federal-help/>

Klinefelter, Q. (2014). A Right or a Privilege? Detroit Residents Split Over Water Shut-Offs. NPR: <http://www.npr.org/2014/08/01/337145827/a-right-or-a-privilege-detroit-residents-split-over-water-shut-offs>

Lewis, M. (2013). Rainwater man of Southwest Detroit. Model D. Accessed from <http://www.modeldmedia.com/features/erbjeffklein513.aspx>

Locate Water Tanks Locally (n.d.). Locate water tanks locally in Highland Park MI Michigan. Accessed from <http://locatewater tankslocally.com/locate-water-tanks-locally-in-highland-park-mi-find-water-tanks-in-michigan/>

Lukas, M. (2014). Detroit's Water War: a tap shut-off that could impact 300,000 people. Environment True North. Accessed from <http://www.theguardian.com/environment/true-north/2014/jun/25/detroits-water-war-a-tap-shut-off-that-could-impact-300000-people>

Morrison, F.L. (2002). The Insolvency of Public Entities in the United States. The American Journal of Comparative Law, Vol. 50, Supplement: American Law in a Time of Global Interdependence: U.S. National Reports to the 16th International Congress of Comparative Law. pp. 567-579.

Rain Brothers. (2015). UV Filtration. Accessed from <http://store.rainbrothers.com/uv-filtration/>.

Rainwater Collection System Installation Services. (n.d.). Retrieved April 30, 2015, from <http://www.watercache.com/services/installation/rainwater/>

Renzetti, S. (1999). Municipal Water Supply and Sewage Treatment: Costs, Prices, and Distortions. The Canadian Journal of Economics, Vol. 32, No.3, pp. 688-704.

Miller, E. (Director). (2007). The Water Front [Motion picture]. United States: Red Lizard Media.

United Nations. (1948). The Universal Declaration of Human Rights. Accessed from <http://www.un.org/en/documents/udhr/>

Wilson, B. (2010). The Price of Water: A Comparison of Water Rates, Usage in 30 Cities. Circle of Blue. Accessed from <http://www.circleofblue.org/waternews/2010/world/the-price-of-water-a-comparison-of-water-rates-usage-in-30-u-s-cities/>

Walters, H. (2013). How to make sure everyone everywhere has clean water. Ideas.Ted.com. Accessed from <http://ideas.ted.com/since-the-ted-talk-michael-pritchard-on-how-hes-helping-end-water-poverty-in-malaysia/>

World Commission on Environment and Development. (1987). Our Common Future. Oxford ; New York : Oxford University Press, 1987