Free Clean Drinking Water for All based on the PCAST Report

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Content

Abstract

In this paper, our objectives rely on to free clean drinking water for all people based on the PCAST report. During the literature search, we examine three main influencing factors that prevent people from having clean water such as cost, increasing population and accessibility. In order to suggest for users to have sustainable clean drinking water, we came with up with several methods such as technology road mapping, quality function deployment (QFD), and Supply Chain to evaluate what are better options to get sustainability water through clear aligned policy, tax incentive, and technologies to resolve society problem.

1. Introduction

It is undeniable that water is necessary to human. Without water, we cannot survive. According to Mayo Clinic's statement, "Nearly all of the major systems in your body depend on water. There are eights important functions of water in the body such moistens tissues such as mouth, eyes, and nose; protects body organs and tissues; regulates body temperature; lubricates joints; helps prevent constipation; helps dissolve minerals and other nutrients to make them accessible to the body, lessens the burden on the kidneys and liver by flushing out waste products, and carries nutrients and oxygen to cells" [1]. Water play huge role in our bodies and organs. According to free drinking water website, "Blood is about 92% water and it carries nutrients and oxygen throughout body"[2]. Doctors recommend their patients to drink at least eight 8-ounce glasses or 2 liters of water per day to fulfill our body need. Moreover, drinking enough water, eight glasses of water daily, can decrease the risk of colon cancer by 45%, bladder cancer by 50% and it can potentially even reduce the risk of breast cancer [2]. However, the kind of water that we drink or inject into our body is an important factor. There are many types of waters such as drinking water, wastewater, stormwater, and so on. In this study, we focus on drinking water which is safe clean water that people can drink and use for food preparation without risk of health problem. The big issue around the world including the United States is "Does everyone have access to clean drinking water?" Moreover, climate change is a reason of water problems. For example, couple years ago, California had to deal with drought, so all people in California needed to reduce the use of public water. The states of California recommended to cut back their public water use. If they did not follow the policy and the regulation of the states, they had to pay a huge fine. Farmers wanted water for their farm so they needed to buy water from outside of the states. The cost of water and water delivery was too expensive. Normally, a pack of water contains 12 or 24 bottles which cost between $6 to $12 depending on states. For individual bottle, it costs $1.50 or more. Population growth in the U.S. can lead to higher cost of drinking water because of increasing demand. Therefore, this is a big problem around the world including the U.S. In this study, we analyse PCAST report by President Obama and try to improve and compare with a new policy by President Trump in term of drinking water. The PCAST report is done by a group of committees to remind the president what they did during his/her term. Normally, once president Obama finishes his term, his committee will make this report to nominate his progress work in environment, technologies and other field. Furthermore, we try to extend literature in our studies to answer the questions as follow: What the government can do to solve the problem? What policies can be done to help people to access clean drinking water? What are the barriers from accessing clean water? How can technology solve the problem by government agencies?

2. Literature Review

As the need for clean water sustainability for all continues to evolve, this review examines the literature on the subject to understand the regulations, technologies, and developing potential solutions needed today, some of the issues related to the increased population and cost, as well as key factors that may influence the best accessibility points for clean water. Searching for these key factors helps guide the technologies and policies to use for developing a suggested roadmap for this social problem.

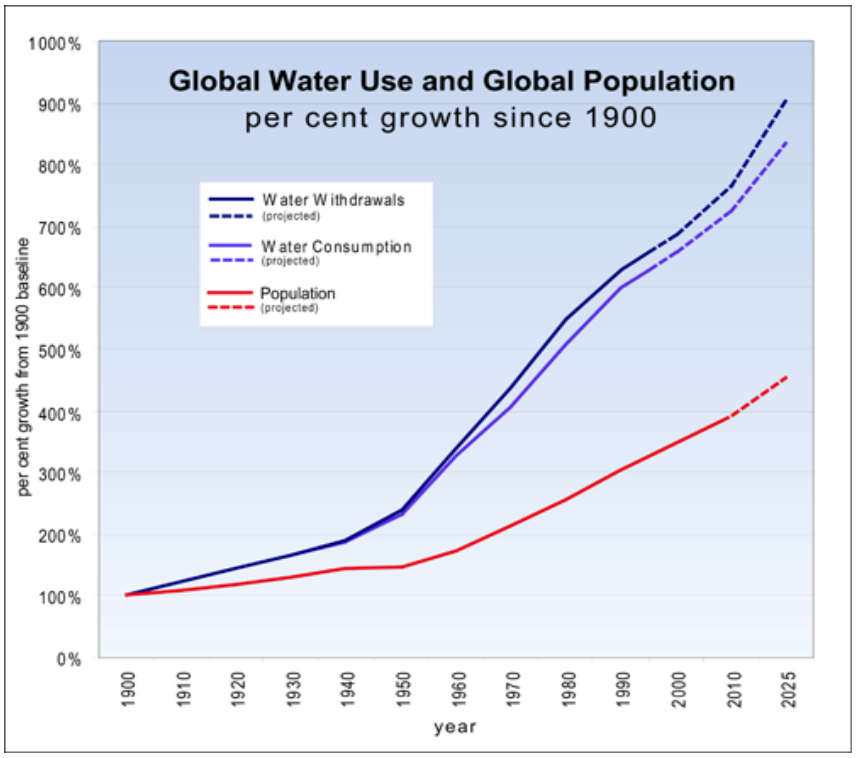

Figure 1: Global Water Use and Global Population percent growth since 1900 [3]

a) Increasing population

Fresh water is a fundamental need for people's daily activities and routine. Indeed, water is integral to all ecological and societal activities, including food and energy production, transportation, waste disposal, industrial development, and human health. It makes sense that water has a relationship with conflict, it is very important to know the where and when conflicts are most likely to occur. According to Lee and Schwab, "the rapidly growing populations and migration to urban areas in many countries have resulted in a vital need for the establishment of centralized water systems to disseminate potable water to residents" [4]. Because of the growing population, the U.S. can anticipate new interpretations of the maxim that drinking water should be

obtained from the best-quality source available. Reclaimed water and water reuse, for instance, can enhance both groundwater and surface water supplies [5]. In fact, Water reuse plans are already being investigated in several states, including Arizona, California, Florida, Texas, Utah, and Virginia [5].

b) Cost

Because there is a lack of easy reaching to clean water in poor areas, new methods are being developed to meet the demands of growing populations with requiring major new construction or new large-scale water transfers from one region to another. Indeed, Lee and Schwab claimed "the water quality is important for all people so they are seeking to have clean water, water treatment is crucial but polluted water sources are more costly to treat than less polluted sources, and increasing reliance on degraded water resources is likely to increase the costs of supply" [4]. This will create the cost problem of freshwater availability. On the other hand, many regions have a fixed price for water supply is charged to all customers, resulting in a disproportionate percentage of income paid for the service by the poor. According to Lee and Schwab's statements, "Since impoverished residents are less able to afford this service, this may encourage the use of illegal connections. This is a major emerging problem in many urban cities" [4].

Table 2 compares the average water use per capital and price per cubic meter among selected Organisation for Economic Cooperation and Development (OECD) countries [5]. In fact, other countries have a higher price for water compared to the U.S. The substantial opportunity for water conservation is more likely to exist in the U.S.

Table 2. Water use and rates in selected Organisation for Economic Cooperation and Development countries.

Country	Estimated per capita water use in 1997 (L/day)	Average household tariff ($/m^3)[a]
Germany	129	1.69
United Kingdom	153	3.11
France	156[b]	3.11
Sweden[b]	191	2.60
Greece	200	1.14
Italy	213	0.84
Spain	237[b]	1.07
Australia	268	1.64
Japan	278	2.10
Canada	326	0.70
United States	382[c]	1.25

[a]Estimates for 1996, 1997, or 1998. [b]Data for 1995. [c]U.S. Geological Survey 2000 (*119*).
Reprinted from Herrington et al. (*25*), unless otherwise noted (*21*), with permission of the Organisation for Economic Cooperation and Development.

Table 2: Water use and rates in select organisation for OECD countries [5]

c) Accessibility

By looking at the most favorable areas to live in the city where people are able to

easily access to clean water, many people have either prefer to move to seaside areas or move from villages to urban areas. Also, people will move from one area to another due to the weather climate change. It is more likely for some areas that have a high temperature for the weather to move to other places where there is more seashore water available and more groundwater, so the soil is not dry. On the other hand, in 1997, there were about 54,000 permanent community water supplies in the U.S. (Table 1), only 1,500 more than 10 years earlier (27,28). Over 90% of these systems serve fewer than 10,000 customers and together account for less than 20% of the U.S. population. By comparison, "the United Kingdom has fewer than 30 public water systems" [5].

Table 1. Profile and characteristics of U.S. public drinking water systems.[a]

System size	No. of systems (% total)	Millions of people served (% total)	No. of systems (% total)	Millions of people served (% total)
	Groundwater		Surface water	
25–500	28,829 (53%)	4.5 (2%)	3,075 (6%)	0.6 (<1%)
501–3,300	10,414 (19%)	14.1 (6%)	3,626 (7%)	5.7 (2%)
3,301–10,000	2,512 (5%)	14.4 (6%)	1,844 (3%)	11.0 (4%)
10,001–100,000	1,372 (3%)	34.5 (14%)	1,904 (4%)	56.6 (22%)
>100,000	68 (<1%)	18.9 (7%)	279 (<1%)	93.6 (37%)
Total	43,195 (80%)	86.4 (34%)	10,728 (20%)	167.4 (66%)
	Publicly owned		Privately owned	
25–500	7,353 (14%)	1.8 (<1%)	23,023 (44%)	3.2 (1%)
501–3,300	9,892 (19%)	14.6 (6%)	3,761 (7%)	4.7 (2%)
3,301–10,000	3,671 (7%)	21.5 (9%)	598 (1%)	3.4 (1%)
10,001–100,000	2,804 (5%)	77.3 (31%)	421 (1%)	12.5 (5%)
>100,000	284 (<1%)	92.8 (37%)	56 (<1%)	16.8 (7%)
Total[b]	24,004 (46%)	207.9 (84%)	27,859 (54%)	40.6 (16%)

[a]Under the Safe Drinking Water Act (*3*), "public water systems" are defined as those regularly serving at least 25 people or 15 service connections. [b]2,060 systems serving 5.3 million people had unspecified ownership.
Reproduced from the U.S. EPA Safe Drinking Water Information System, 2000.

Table 1: Profile and Characteristics of U.S public drinking water system [5].

d) EPA Program

Environmental Protection Agency (EPA) is finding by President Richard Nixon on December 2, 1970[6]. EPA is basically government agency. EPA have ten regional office around the United States. A mission of EPA is to "protect human health and the environment"[7]. According to Dowdey's statement, "EPA creates and enforces regulations that enact environmental legislation. So while Congress sets environmental laws like the Clean Air Act, it's up to the EPA to determine how the United States will reach the goals laid out by the legislation" [8]. In this case, EPA has the power to regulate anything didn't fit under environment regulation.

3. Methodology

In order to ensure that all people can access to clean water, we have chosen supply chain and technology roadmap to be the method to describe the process of getting clean water for all people.

a) Supply Chain

In order to understand how supply chain of cleaning water work, we have to define what the supply chain is. According to Rouse, "A supply chain is the network of all the individuals, organizations, resources, activities, and technologies involved in the creation and sale of a product, from the delivery of source materials from the supplier to the manufacturer, through to its eventual delivery to the end user"[9]. The figure 2 showing how the network of water supply chain works. It starts out with regulation as an initial input element, then it goes from water collection source element to water treatment facility element to distribution element and finally the output is sustainability in every element of water supply chain for clean drinking water. This process was driven by many agencies in each element. Difference agencies regulate different regulations and policies in the supply chain might lead to some conflict in each section. Therefore, to reach the goal in the next 20 years, we need to evaluate and analyze those regulations.

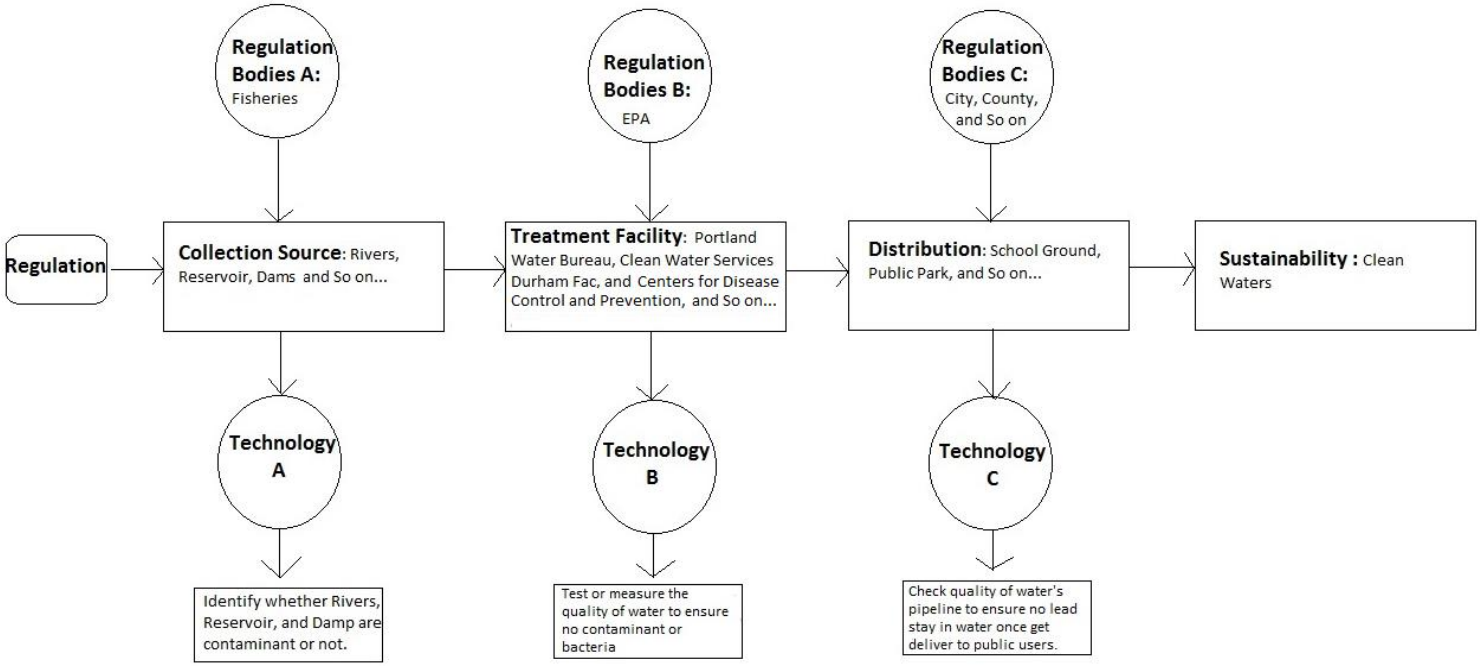

Figure 2: Supply Chain Model for Clean Drinking Water

b) Technology Roadmap Methods

Benefit of Roadmap

According to Winebrake, Willyard, and McClees, " Technology Roadmap is future based strategic planning device that outlines the goals, the barriers and the strategies that are necessary for achieving a given vision [10]. According to R&D Today's website "The main benefit of technology roadmapping is that it provides information to make better technology investment decisions by identifying critical technologies and technology gaps and identifying ways to leverage R&D investments" [11]. Indeed, Kostoff and Schaller indicated, "techniques and methods vary based on the roadmap objective"[12]

Objective of Roadmap

In general, any roadmap can have one of these three possible objectives: Energy Security, Economic and Social Benefits, and Environmental Sustainability. As drinking water being an essential need for the human life in the entire world, we are addressing the problems associated with clean water accessibility for every individual. The objective for the roadmap is environmental sustainability for clean water availability.

Method of Roadmap

We are building Technology Roadmap for access to clean water based on supply chain model, we use QFD to evaluate which elements are important to the roadmap. We pick five main factors for drinking water such as society problem, policy, technologies, resources, and regulation. Each factor has a single element that served as 5-year plan in a term. We project four terms for 20-year plan for each factor.

Roadmap Barriers and Challenge

Future based strategic planning device that outlines the goals, barriers, and strategies necessary for achieving a given vision. In fact, so many challenges appeared in water availability problem. While the demand for clean water accessibility increasing in the United States, government associations and the federal agencies are working in creating agencies that can sustain the availability of clean water to every U.S. citizen. Based on (REPORT TO THE PRESIDENT, Technology and the Future of Cities, 2016) report, water was listed as one of the important factors of happiness and comfort in modern or urban cities. The concepts of integrated water systems design and management, local recycling, water efficiency via smart metering, re-use in buildings and districts were all listed together for new cities infrastructure in the U.S. The objectives were Active ecosystem integration, Smart integration of water, sanitation, flood control, agriculture, and the environment as a system, and Increased resilience. Moreover, roadmap barriers were ranked on the basis of their impact on the roadmap targets.

c) Quality Function Deployment Method

To define the most important part of people requirement about water problems, the one method that we used is Quality Function Deployment (QFD) method [13]. It contains both the uses' voice identified by consumers' requirement and marketing drivers. This makes the links between consumer's request and the technical characteristics to determine the optimal accomplishment object. After applying the QFD to identify all elements, we valued the degree of achievement and improvement direction of each characteristic by the number from 0 to 4. As the meaning, 4 means the most important, 2 means medium important, 1 means low important, and 0 means no important. Then, we calculate by multiply each relationship between consumer's requirement and the technical characteristics to find the most important consumer's requirement.

4. Results and Discussion Analysis

a) Supply Chain

From figure 2, we analyze regulations and policies in each step in the supply chain as a method that leads us to sustainability on clean drinking water for all people. As the results, we found that there are many regulations and agencies who respond those water problems such as EPA, state regulations, city regulations and fish and wildlife regulations [14]. Such regulations involve with each step differently as follows.

1. Collection Source Network

There are many rivers, reservoirs, and dams in the U.S. which have different regulations based on the environment in regions, rural areas, cities, and states. Hence, it is complicated for people or companies to follow. For example, the Columbia River has its own regulation which might be different from the EPA or city regulations. However, the EPA and Centers for Disease Control and Prevention (CDCP) try to collaborate to identify whether rivers, reservoirs, and dams have contaminant or not base on assisted technologies. To reduce regulations, every agency should polish of conflicts and customize regulations to be a success and easy common model for people and companies to follow. Moreover, it can reduce the cost of the water treatment step if they keep water sources clean. However, they need to concern about recreation activities because of people happiness. Hence, they should collaborate to balance and accomplish the suitable regulations.

2. Treatment Facility Network

There are many water treatment facilities in the U.S. such as Portland Water Bureau, Clean Water Service Durham Far, Milwaukee Water Council, Clean Water Act, and so on. Each treatment facility has a different way of using technology to treat water. The method that they use will be different but the common goal is to have clean water

and keep it sustainable. Most of the water treatment processes are in high cost. The challenge for treatment facility is reducing water treatment cost and attract users to cut back their water use. For example, the government should offer intensive tax to companies or people who have save the water systems. Additionally, this process should collaborate with the first process to figure out the optimal regulation to reduce the cost of water treatment step. Also, each agency should delete overlap work to delete cost. Furthermore, Treatment Facility Network needs to test or measure the quality of water regularly to ensure water is clean to drink before transfer to any distribution network.

3. Distribution Network

Water distribution systems consist of an interconnected series of components, pipes, storage facilities, and components that convey drinking water. There are variety ways to deliver water to users. It depends on the size of the community users. However, the government divides the capacity of drinking water system by the region such as region 10 consists of Alaska, Idaho, Oregon, and Washington in order to ensure that safe drinking water is provided [15]. This strategy is valuable because they have the general common regulation but provide small contact based on a specific area so it can provide the best distribution way and can solve problems if needed. Moreover, they focus on pipeline maintenance to ensure that pipelines are safe and clean without contamination. However, some areas have a lack of pipeline maintenance. For example, Flint, Michigan faced many water pipeline problems that contain contaminant or lead. The real problem is funding to maintain distribution network both water pipeline and public water storage tank. Therefore, the government should provide resources and funding to all regions to increase clean drinking water accessibility.

Finally, a strong act of water stability could address past over-use, and wasteful use, of water and protect drinking water and fish from over-use, poor oil and gas, logging or mining practices, and other threats [16].

b) Technology Roadmap

	2017 (limitation now)	2022	2027	2032	2037
Society problems(water)	Quality	Remove 60% of synthetics	Remove 80% of synthetics	Remove 100% of synthetics	Clean drinking water for all
		Develop indicator to see water clean or not	Provide the indicator to people (easy to use and cheap)	Easy indicator is available to public and all	
		Encourage to reuse and recycle on water (tax incentive)			
	Accessibility (Limited for rich people)	Keep water affordable 20% off cost of water	50% off cost of water	80% off cost of water	Free clean drinking water for all
		Maintenance Public Water Station	Build more Public Water Station (more incentive - tax)	Build more Public Water Station and Maintain stability of reclaimed waters over time	
Policy	Conflicts (in each process of creating clean drinking water)	Reducing lack of awareness in adoption policy	Meet the need of policy require knowledge transfer	Reduce unnecessary policy	Clearly aligned policy
Technologies	Technology Filtration such as membrane, nano-technology	Efficient and accuracy 60% benefit for all users on technology adoption	Efficient and accuracy 80% benefit for all users on technology adoption	Efficient and accuracy 100% benefit for all users on technology adoption	Green technologies and Green building
		Incentive tax about separated pipelines of different wastewater level in new buildings	Regulate separated pipelines of different wastewater level in new buildings	Every new building has separated pipelines of different wastewater level in new buildings	
Resources	Collaboration from multi-water resource centers	Create annual conference for all water resources	Scaling more water resources centers from federal to rural area.	Available resources in everywhere	Available water resource center for public or private to use and free consultant of water to public use.
		Have clear water management for every agencies			
		Knowledge public users			
Regulations	Too many (ex. EPA, City, country, Fish wildlife, etc.)	Lack of awareness in adoption regulation	Meet the need of regulation require knowledge transfer	Reduce unnecessary regulation	Few only necessary

Table 3: Technology Roadmap

As seen in table 3, we will accomplish the objective that the U.S. have clean drinking water for all by 20 years. In order to make a successful plan, we project each of five-year to be our timeline to adjust the implement and the change to the next level. For example, in 2017, we used society problem of water based on two criteria such as quality and accessibility. In order to move to the next level in the year 2022, we need to attract people's need by providing the benefits of getting quality and accessible water such remove 60% of synthetic, develop on the indicator to see water clean or not, and encourage people to reuse and recycle water based on the utilize tax incentives. From the year 2027, we did the same thing with the year 2022 by remove 80% of synthetic,

provide an indicator to people and also give the tax incentive to people who adopt this approach. In 2032, we try to remove 100% synthetic and allow easy indicator that is available to the public and all. By the year 2037, we are reaching the ultimate goal that is free clean for all water.

C) Quality Function Deployment

We use QFD to evaluate people's need and market driver. We divide into four parts such as Technologies, Policies/Regulation, Resources, and society problem. Each part has their own element and also depend on market drivers such as population growth, increasing prices of water bottles, the cost of water treatment, the cost of distribution, water storage, reduce contaminant, and sustainability. For example, we give all market drivers as 4 mean high for clean drinking water to be sustainable. Furthermore, we select nano-technologies and weigh 4 mean high related to correlation factor of market drivers such as the cost of water treatment, water storage, reduce contaminant, and sustainability. In order calculated priority factors for technology part, we take nano-technologies that we weight 4 multiply each factor and add up together:

Nano-Technologies = (4 x 4) + (4 x 4) + (4 x 4) + (4 x 4) = 64

Out of the four parts, we find out that priority factor for the societal problem of water is rating 112 which is higher compared to other parts on table 4.

d) Policy - New versus Old

Right now, the federal EPA is an open system that everybody has the power to access clean drinking water without strict policies or regulations in each state. Hence, the federal EPA needs to have a policy guidance book as a closed system, so it can address common issues for all states in the U.S. to follow based on their location. In fact, Federal EPA needs to send their advisor committee as a consultant to the states in order to help states solve the problem out of the state's ability and their range. Also, Federal EPA needs to give to the states the full power to make any decision on cleaning drinking water.

In this moment, states need to address all policies and locates access resource centers where people can have access to clean drinking water. However, states need to be aware about the regulation and setting up policies for cities, and other rural areas as a closed system. For example, the state can limit people to swim in public rivers such as prohibit alcohol or any chemical which can cause river pollution and contaminant. Moreover, the government should provide intensive tax which has the attention from people and companies to care more about clean and safe water. Also, they can regulate a new building policy which should have separated levels of wastewater to reduce the cost of water treatment.

		Market Drivers							Priority
		Population Growth	Increasing price of bottles	Cost of Water Treatment	Cost of Distribution	Water Storage	Reduce Contaminant	Sustainability	
Technologies	Nano technology			4		4	4	4	64
	Membrane			4		4	4	4	64
	Filtration technology			4		4	4	4	64
	Dasalination technology			4		4	4	4	64
Policies/ Regulations	Federal		2	4	4	4	4	4	88
	States		2	4	4	4	4	4	88
	City		2	4	4	4	4	4	88
Resources	Centers for Disease Control and Prevention	4	2	4	2	4	4	4	96
	Office of Water (EPA)	4	2	4	2	4	4	4	96
	Water Service Center	4	2	4	2	4	4	4	96
	Portland Water Bureau	4	2	4	2	4	4	4	96
Society Problems	Quality	4	4	4	4	4	4	4	112
	Accessibility	4	4	4	4	4	4	4	112

Table 4: QFD Priority Calculation

e) Technology Gap

As water-cooperation, there are “780 million people do not have access to clean water and almost 2.5 billion do not have access to adequate sanitation”[17]. Due to rich versus poor class, there is technology gap involving between two classes. Rich people can get in new technology adoption and well-trained knowledge of the technologies but the poor cannot access modern technologies or resources that we have right now. Therefore, this problem is a big global issue.

f) Impact of Social Problem

After we understand the influence of lack access to clean drinking water in different nations, we can finalize the impact of the social problem. Indeed, the unlimited increase in the nation population, the cost of providing fresh water, and the short access to clean water is the main social problems for clean water availability. However, enormous human suffering occurs because of the lack of satisfactory water for health and sanitation. Moreover, more poverty, shortened lives, and misery will be seen in the nations who do not have the clean water accessibility [18]. Also, a lot of conflicts internally inside on country and externally between the governments and the nations to raise their right of accessing clean water.

Conclusion

Overall, there are too many policies and regulations that need to be minimized if the states and federal share in common. We hope many water resources center should collaboration together to come up a better plan for future water use. In our of view, we think EPA and states should collaboration more. Public users need to know what is in water and make sure they have access to this information According to office of water, "States and US EPA must prepare annual summary reports of water system compliance with drinking water safety standards and make these reports available to the public"[19].

Due to climate change, EPA and other water resource center need educated public users to cut back or reduce water use if the situation is unnecessary because the population growth will be huge issues that lead to a shortage of waters. Indeed, clean drinking water is depending strongly on population growth, accessibility, and cost so EPA and other water resource center should come up with a better plan for distribution.

Recommendation

After we went over our project and our literature search, we come up with a recommendation for that all multi-water resource centers should collaboration together and come up National Strategic plan which assists water infrastructure on each state to keep up an update, restore and expanding change. For example, Local Government Agency Center who with EPA say that current Safe Drinking Water Act is old and need to an update: "The current Safe Drinking Water Act does not authorize the EPA to regulate private wells. The EPA should work with states to achieve the same levels of drinking water protection from contamination for the approximately 15 million U.S. households who rely on private water wells for drinking water and develop standards for these wells" [20].

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