Water Quality in Emerging Cities

Sao Paulo, BR, Mumbai, IN, Shanghai, CN

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Problem Definition

A safe, clean, and useable public water supply is essential for a city to function without major

Figure 1: Shanghai City

social or economic strife. Water accounts for the major functions of life and society. Whether it be water for power, water for industry, or most importantly, water for drinking; keeping an adequate water supply ensures the longevity of the people of the city, as well as bridges the gap between "emerging" city and "developed" world.

Failing to maintain this water supply can result in widespread disease and public health issues, social unrest amongst the poor, a loss of economic and industrial ties, and potential exploitation of individuals and groups by powerful individuals. This is the case of water resources in many emerging cities around the world. With population growth and loose environmental standards, these cities are faced with increasingly poor water quality standards. In figure 1, Shanghai's *Huangpu River*, the major source of drinking water, 16,000 dead pigs have been fished out, the result of unregulated dumping. The question now becomes, is this water even remotely drinkable? Can society thrive under these conditions? Not having access to clean water harms the development of emerging cities, and society as a whole. Implementing measures of sustainability and water resource management in emerging water supplies is necessary for the sustained growth of many cities and people.

Introduction

The development of modern civilization and cities can be tied directly to the use of water throughout history. Water is a key resource for the development of life. When hunter-gatherer societies made the transition to agricultural societies, it was water from nearby lakes and rivers that sustained the stationary lifestyle. It was the location of a constant source of water that allowed populations to grow, cluster, advance, thrive, and now, crowd. In fact, most major cities in the world, developed or developing, can be found near some source of water. Shanghai, as mentioned above, is built on the banks of various rivers, and relies on these rivers (*Yangtze, Huangpu, etc…)* to sustain its massive population and growing heavy industry. Cities like New York, Chicago, Sao Paulo, Mumbai, Shanghai, etc… were all developed around a body of water.

However, as New York City found out in the mid-1800s, when the city grows, so do the problems. By 1850, New York's water supply was one of the most polluted in the world, riddled with chemicals from tanneries and human feces. Diseases such as cholera and dysentery spread like wildfire throughout the cramped slums, killing millions. In figure 2, a condemned river beneath the city shows the extent to which NYC water supplies were polluted. The water contained all forms of disease and chemicals, and was lightly regulated to serve special interests. Only by recognizing the plight of the dying masses, and proactively controlling the water supply, could New York City truly become livable for all. Yet there are many factors that contribute to the water concerns of a city.

Figure 2: Polluted River, Yonkers,

Growth

It is believed that 50% of the entire human race currently lives in cities. That number is believed to grow, especially in the "mega-cities" of the developing world. According to UN-Habitat, 95% of the population growth in the coming two decades will be absorbed by cities in the developing world; cities like Shanghai, Cairo, Mumbai, Jakarta, etc… will see unprecedented growth. In essence, an extra 2 billion people will soon crowd into already crowded and impoverished cities.

In Mumbai, one of India's largest and most industrial cities, it is believed that 350 new families enter each day. The city is supported by only six lakes that must support an industrial economy and a population of 20.5 million+ people. Citizens of Mumbai find themselves crowding around small wells that serve slums of hundreds of thousands, and must struggle to provide water for growing families. Population growth in developing cities has made water resource management a major issue. With more people using public water supplies, the supply begins to turn-in on itself. India faces the issue of citizens using the same river for drinking that is used as the local toilet. 80% of Urban Waste in India ends up in the countries' rivers.

Economic

A popular misconception about the developing world is that it is rural farm land with little economic value. However, as China, India, Egypt, and many other countries around the world will show, there is heavy economic development in these regions. In a post-Soviet world, Capitalism has taken hold of these developing nations. With little labor regulations, and high populations working for cheap, the developing world has become the major source of production for the world. New factories are being built each day, which has taken a toll on the water quality in developing cities. Industrial runoff is a major consequence of new economic prosperity, and is beginning to affect both the population and (potentially) economic growth. According to a UN report, "90 percent of wastewater discharged daily in developing countries is untreated, contributing to the deaths of some 2.2 million people a year from diarrheal diseases caused by unsafe drinking water and poor hygiene." The majority of this wastewater is attributed to industrial runoff.

Government and the People

The major issue for water resource management in developing nations lies in the lack of regulation, and lax attitude of the people. The Chinese government, for example, refuses to enact stricter labor regulations for fear of disrupting economic relations. At the same time, Palestinian "government" cannot stop its people from using the local rivers and ocean as a public bathroom. These issues faced by developing cities are both political and social, and stand at the heart of the issue. For many countries, these capitalist, democratic governments are new concepts. They have brought economic wealth, as well as Western luxuries, but they have yet to successfully tackle major issues of health and safety. India, for example, has one of the best cellular telephone systems in the world, but over 50% of the population lives below the water poverty line. It is the need to set priorities straight, and squeeze out corruption, which shall truly shape water resource management in these developing cities.

Case Study: Sao Paulo, Brazil

Project description & Rationale for selecting the case

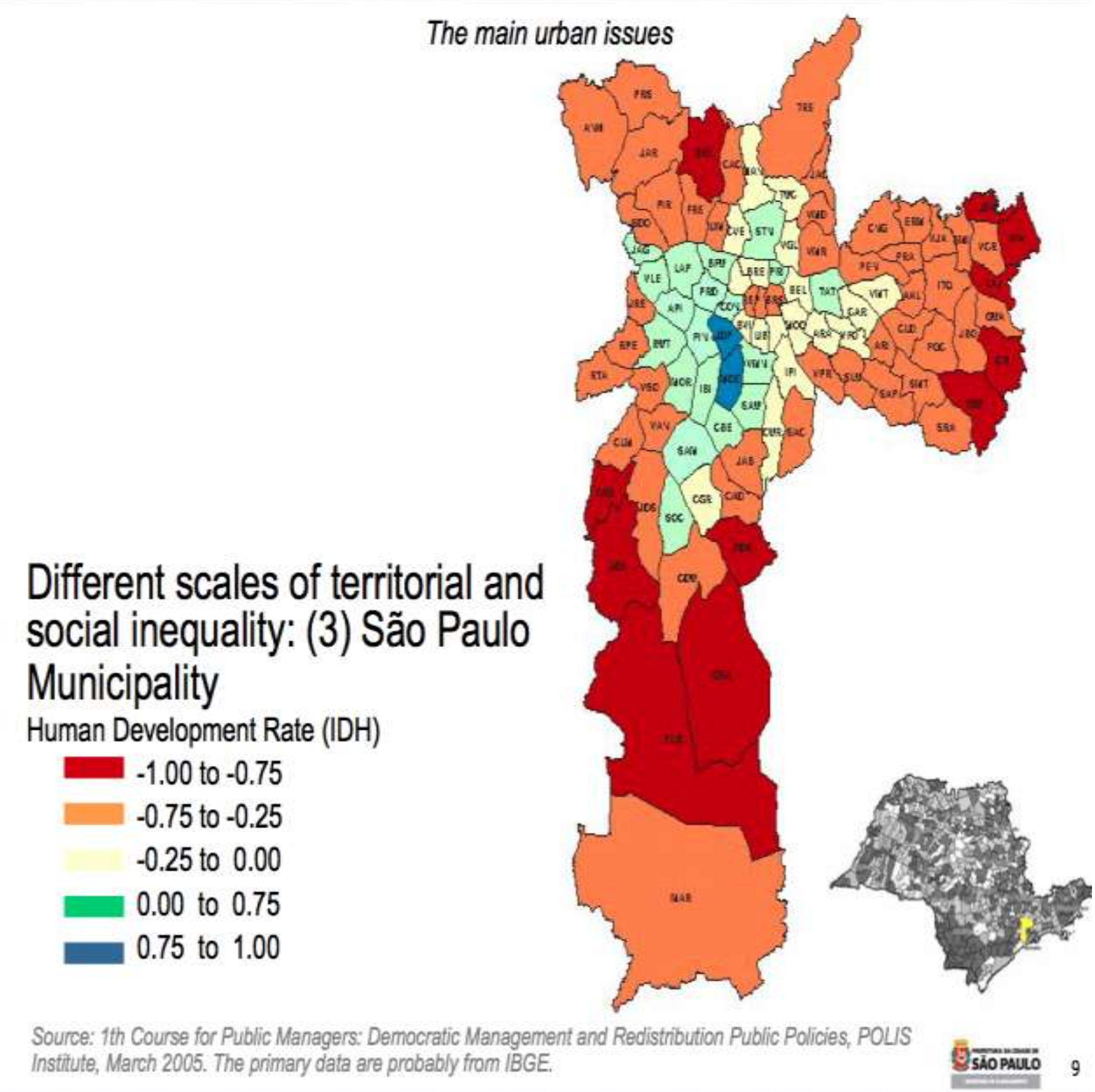
Sao Paulo, Brazil is the financial heart of the Latin American world, and is a rapidly growing city in the emerging world. Including the outer regions of the city, Sao Paulo boasts a population of 19 million people. In 2010, Sao Paulo was met with 11.7 million visitors, 56.1% to do business, and roughly 40% for leisure. The city has 24,000 shops and 77 shopping malls, and is connected by taxis, buses, subways, and private transportation. Economically, Sao Paulo contains one of the most robust economies in South America. 17 out of the 20 major Brazilian banks are headquartered in the city, as well as 63% of the major international corporations call Sao Paulo their home.

Sao Paulo operates through a system of state water companies that receive federal financing. It is supplied by groundwater resources, as well as the Guarapiranga Watershed Basin. Groundwater accounts for 35% of the business water supply, while the Guarapiranga Basin supplies water to over 3 million people in Southwestern Sao Paulo. The Guarapiranga Basin is currently threatened by heavy urban expansion. Another water source, the Billings Dam, has been ruled-out as a possible source due to massive pollution from the pumping of nearby Rio Tietê.

Urban Sustainability Issues involved

The greatest sustainability issue facing Sao Paulo is providing resources for the rapidly growing population, and bridging the gap between the few rich and the immense poor.

Figure 3: Sao Paulo Social Inequality Chart



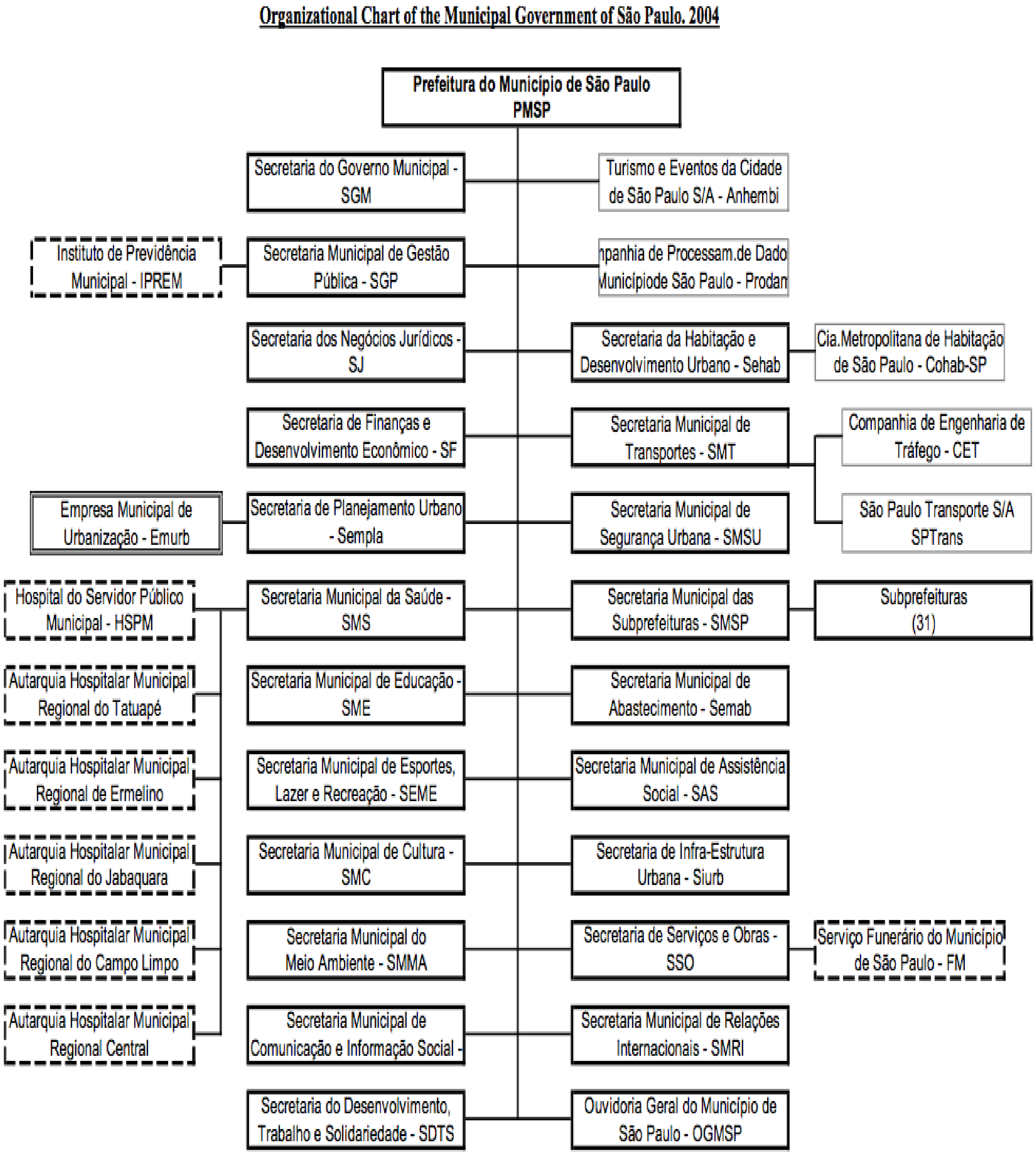
As the chart above shows, Sao Paulo faces an intense divide between those who can provide for themselves and live well, and those who can and do not. The blue shows the population that is developing well and healthily, while the red and orange show the portion of the population of Sao Paulo living in squalor. The squalor manifests itself in public health issues and economic poverty. Many of the citizens of Sao Paulo are faced with disease and poverty every day, stemming from overcrowded streets, and a lack of regulation that has led to polluted water and improper construction. Providing clean water for the citizens of Sao Paulo is a method by which the issues caused by overpopulation and poverty can be remediated.

Governance Challenges & Stakeholders Interests

Brazil, in issues of water quality and health, operates through a decentralized government. Ergo, the municipalities (Sao Paulo, Rio de Janeiro, Brasilia, etc…) are responsible for these public services, based on the 1988 Constitution. The municipality of Sao Paulo is, however, subject to the laws of the central government, and must in turn answer to both the state of Sao Paulo and the government of Brazil.

The 2001 bylaws of the city of Sao Paulo list three caveats to the master plan: 1) the city is the main urban planning stakeholder, 2) the master plan is a municipality law, and 3) the city must regulate both urban and rural territories. This both brings accountability for the maintenance of the city and its citizens onto the municipality, and empowers the municipality to take charge of the region as they see fit. An interesting point is the relationship put between urban and rural territories, addressing the sustainability issue of population and class distinction that tears the city apart. Another point to notice is that the main stakeholder in all development is the municipality itself. The municipality bears the brunt of any failed venture; however, in the face of the current poor health and water standards for the city of Sao Paulo, the load can only be lightened. In order to sustain the economic growth the city would like to see, the municipality must use its power from the master plan to design a sustainable water system.

Figure 2: Organizational Chart of the Sao Paulo Government (in Portuguese)



Source: University of Sao Paulo

Although in Portuguese, the following chart for the organizational structure of the municipal government shows the division of the government from the mayor to the various departments that oversee city life. For example, there is the department of transportation, the department of international relations, the justice department, the urban development department, and the economic development department, to name a few. All of these departments answer to the laws set down by the head of the municipality. The state-run water service answers to these laws, and is regulated directly by the municipality. The functions of the water service are to oversee sewage, drinking water distribution, drinking water quality, treatment, and communication.

However, the challenge for the government, and this department, is dealing with the poor and overpopulated city relative to the water supply. While the government has final say in matters of law, little social education exists on the matter of water quality. This has resulted in shantytowns being constructed along the banks of the many water basins, thus further polluting the rivers. The government can do little to stop the shanty towns besides help keep them well maintained because of their longevity and population density; moving a shantytown risks displacing a significant portion of the workforce. The government is in a difficult place as both the stakeholder in infrastructure and economic arm. On one end, providing optimal space for the people and industry is good economic business; however, this calls for the infrastructure which the government has a massive stake in to fall to pieces. Furthermore, this exacerbates the health and poverty situation even more in the long run. It is a matter of priorities that the government is not able to rap its head around beyond certain projects.

The greatest limitation is in mismanagement at the local government level. The Espirito Santo project, which sought to improve environmental quality for residents, water companies, and water sources, was most limited by the government level. After the project was instituted, it was suddenly dropped by the next, incoming government, and only revived years later. This wasted time only saw the issue grow. Many cancellations and re-planning were required to return the project to normalcy by the federal government of Brazil. Mismanagement of projects at the local government level results in little work being done on Sao Paulo's water quality issues for long periods of time. With a mismanaged local government, the federal government finds itself spread thin to help cities.

Environmental, economic and societal impacts

With the rapid industrialization of Sao Paulo following revolutions in the 60s, came a time of unregulated expansion by the Brazilian elite. A mixture of foreign powers, and local wealth began the process of turning Brazil into a modern country. However, this industrialization was believed to have caused massive water quality issues within the city due to toxic dumping.

However, through the exploration of Brazil's water quality, it was ascertained that water quality was directly linked to poverty. The poorest neighborhoods of the city often contained the worst water quality as far as wastewater was concerned. This contradicted previous beliefs that water quality was due solely to increased industrial activity. Thus, the issue of water resource management for Brazil becomes not only one of water quality, but of poverty/people management; a major limitation, then, is the sheer scale of the poverty in Sao Paulo and Brazil, an issue so large in certain areas, that a government cannot act.

Poverty is coupled with overcrowding and expansion of the city. As previously stated, the Guarapiranga Basin is threatened by urban expansion. An urban growth rate of 50% has resulted in the basin losing 15% of its vegetation. The basin is slowly disappearing due to the growth of the population. This growth has also rendered the Billings Dam useless due to pollution.

This has created a severe public health issue in Sao Paulo, as bacteria have spread from the polluted water resources, into the millions of Sao Paulo inhabitants.

Figure 4: Population Growth and Urbanization in Sao Paulo over time

	Population		Urbanized area	
Year	Million of inhabitants	Annual growth rate (%)	Related to the basin (%)	Increment (%)
1905	0.3	10.3	0.6	433
1930	1.1	8.7	3.2	172
1954	3.5	8.3	8.7	154
1973	9.3	4.1	22.1	63
1985	14.8	1.1	36.0	21
2004	18.0		43.8	

Source: Brazilian Journal of Microbiology

As Figure 4 shows, Sao Paolo has clearly seen massive growth in the population, particularly the urban population, since 1905. Reading further into the results, we can see that the growth rate has been a result of the basin, and the water it provides to the city.

Figure 5: Bacteria Populations in Basin Water Samples

Fecal Indicator	Community plastic tanks	Wells
Escherichia coli	5.6% (n=89)	39.5% (n=177)
Enteorococcus	23.5% (n=89)	80.2% (n=177)
Clostridium perfringens	12.5% (n=40)	87.5% (n=40)

Source: Brazilian Journal of Microbiology

Figure 5, from the same study as the population readings, shows a sample of current bacteria populations in basin-fed water. Water across 12 municipal water containers were tested, and the following bacteria quantities were found. The same water being used by citizens across Sao Paulo contains samples of *E. coli* and various other deadly, plague-like bacteria in dangerous quantities.

A correlation can be seen between the increase in population and the prevalence of the bacteria. As factory and human waste enters the Guarapiranga Basin, more bacteria festers. This poses a significant public health and environmental issue as these bacteria can harm the ecosystem and citizens who use the basin for their wells. Furthermore, crops showered with *E. coli* instantly become unusable, thus affecting the local agricultural economy. This stems from the unclean water quality systems within the city, and the overcrowding near the basin, which has destroyed the natural ecosystem.

The local government has taken an active role in environmental regulation within the region. The São Paulo Municipal Council on the Environment and Sustainable Development approved a plan to allow regulatory instruments of public policies. The plans were developed in a participatory manner by means of workshops and plenary meetings in the region, and also involved the production of maps and a databank with all the proposals presented by the population. This material was incorporated into a legislative bill that is currently being analyzed in the Council of Alderpersons in São Paulo.

Technology solutions

Since the 1990s, water quality remediation has been a concern for the Brazilian government and people in Sao Paulo. Over a decade, various improvement projects were enacted for the sake of directly improving water quality standards, as well as indirectly aiding the urban poor.

One solution to the water quality issue is a new system all together. The Cantareira system is a water system underway that will provide water for 50% of the population. The system supplies water to 9 million people. The system is designed within a

forest to maintain the natural ecosystem and purity of the process. Watershed reforestation is a method by which a watershed is given protected land. The land, usually forest land, allows the water shed to be protected from toxic fumes and human waste that might otherwise pollute the water.

Whereas Guarapiranga Basin is famous for illegal, unregulated shantytowns being built along its edges, the Cantareira system is located away from the city, and the municipal government has designated the land a national park. The benefit of this system is that no industries will pollute the watershed, and no human waste enters the shed. This allows for clean water to enter the homes of the citizens. While it is true Sao Paulo had a nearly 99.0% distribution rate, the issue lied in the quality of the distributed water. Finally, the urban poor can receive the same quality water as the urban wealthy, thus tackling the public health and disparity issues within the city.

Alternatives & Cost benefit Analysis

The proposed system for the reforestation program sees great benefits. The system allows for the water quality of the area to greatly improve.

Figure 6: Cost Estimates for Cantareira Reforestation Program

Restoration Techniques	FY09 – FY11			FY12 – FY13 (to Dec/2012)			Total Cachoeira Project		
	Area (ha)	Cost/ha (R$)	Total cost (R$)	Area (ha)	Cost/ha (R$)	Total cost (R$)	Area (ha)	Cost/ha (R$)	Total cost (R$)
Nucleation and assisted natural regeneration	60.36	3,190.00	192,548.40	-	-	0.00	60.36	3,190.00	192.548,40
Corridor	10.62	7,249.00	76,984.38	-	-	0.00	10.62	7,249.00	76.984,38
Biodiversity Island	5	9,242.00	46,210.00	-	-	0.00	5.00	9,242.00	46.210,00
Direct planting	10	3,966.00	39,660.00	-	-	0.00	10.00	3,966.00	39.660,00
Assisted natural regeneration	-	-	0.00	22.23	2,000.00	44,460.00	22.23	2,000.00	44.460,00
Forest thickening and assisted natural regeneration	-	-	0.00	56.18	5,000.00	280,900.00	56.18	5,000.00	280.900,00
Total planted area	32.81	7,249.00	237,839.69	74.63	7,249.00	540,992.87	107.44	7,249.00	778.832,56
TOTAL	**132.11**	-	**593,242.47**	**153.04**		**866,352.87**	**271.83**	-	**1.459.595,34**

Source: Sao Paulo Municipal Government

Based on the above chart, the US dollar cost of the project would be roughly $726,348.49. A negligible cost given the cost the public health issues are on the state-funded healthcare program. This cost for planting not only generates work jobs, but also alleviates state-funded costs in other programs. Combine this with the environmental benefit of national parks, and the social benefit of clean water, and the reforestation program seems much cheaper.

Another process for cleaning the water proposed by the city is greater treatment plants. Wastewater treatment is a method by which water is purified and filtered to return it to useable standards. This system calls for an increase in the number of plants, as well as the quality of the plants, so that the local resources may continue to be used. This process allows the Cantareira land to be used. However, when comparing this process against the reforestation process, the economic costs and ease is greatly different. The reforestation program, while showing a cost, does not involve the construction and training which the treatment program would cost. Now, should the funds exist, both systems in conjunction would be beneficial. However, to allow the Cantareira region to become as polluted as the original basin would be quite negligent on the part of the municipality.

Case Study: Mumbai, India

Project description and rationale for selecting the case

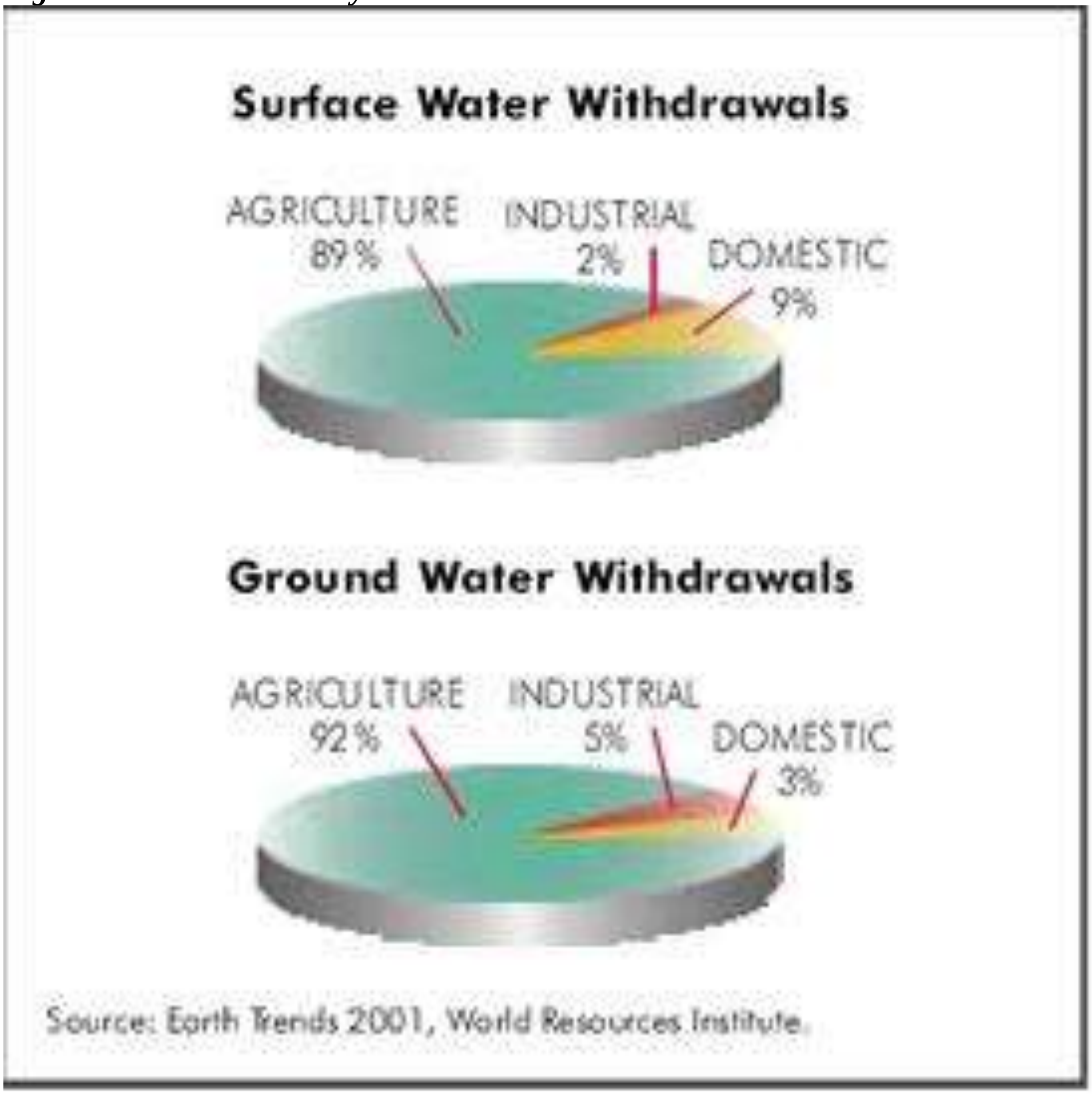
Rain is the source of all water. The monsoon is a time where it rains too much causing floods in several parts of India, in others it rains too little or not at all causing droughts. Most of the rainfall that they received is within 100 hours out of 8,760 hours in a year. According to a study, India, received 400 million hectares meters of rain outside of the country. This provides the country with river flows. With that being said, 67 million hectares is available as groundwater, and about 173 million hectares is lost as evaporated or becomes soil moisture. The key component is management of the water that India plans on working on, and it is just a matter of using the material that is locally available: stones, mud, bamboo, etc.

The people of Mumbai, India need access to clean drinking water. Due to the typical urban life, people living in cities tend to lead more water intensive lives. Population growth has been accelerating in Mumbai, India especially because more people are moving into cities from the country side. The rivers are too polluted to drink and they are turning to groundwater and the citizens are facing a crisis. Most people who live in these rural areas demand less water than those who are living in the cities, and the majority of their water demand comes from agricultural needs.

Urban Sustainable Issues Involved

Many of the urban sustainable issues have a lot to do with mismanagement, demand and usage, and supply of the water. Due to the water pollution in rivers, India draw 80% most of its irrigation water from groundwater. Water will eventually become this scarcity and draws a much bigger problem, especially in rural and farming areas where it will most likely hit the hardest. If this is not well maintained then India would have to end up being a net importer of food, which would have massive complications for the global price of grain.

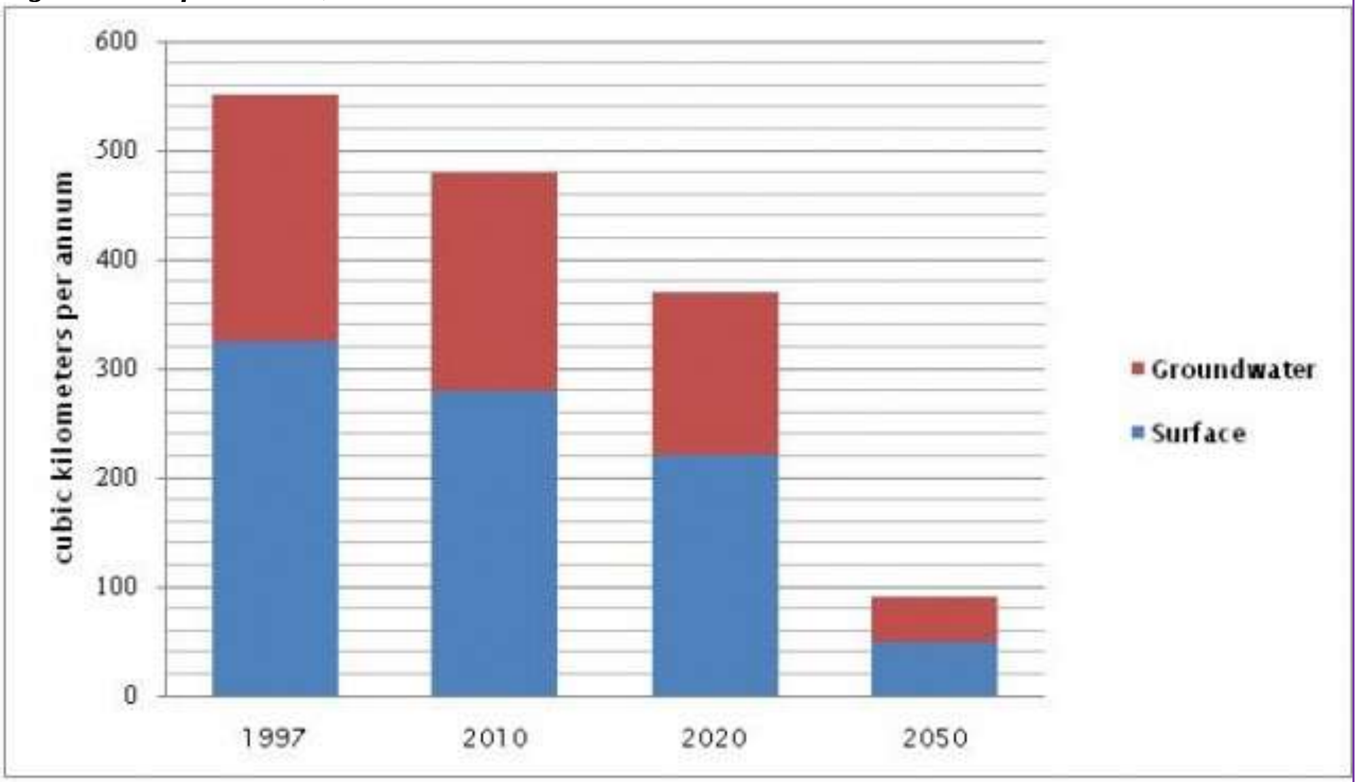
Figure 7: Water Demand by Sector



Source: Earth Trends 2001, World Resources Institute

Surface water and groundwater are the sources of India's water supply. Other sources, such as desalination, are negligible because they are not cost effective.

Figure 8: Surface Water, Groundwater Over Time



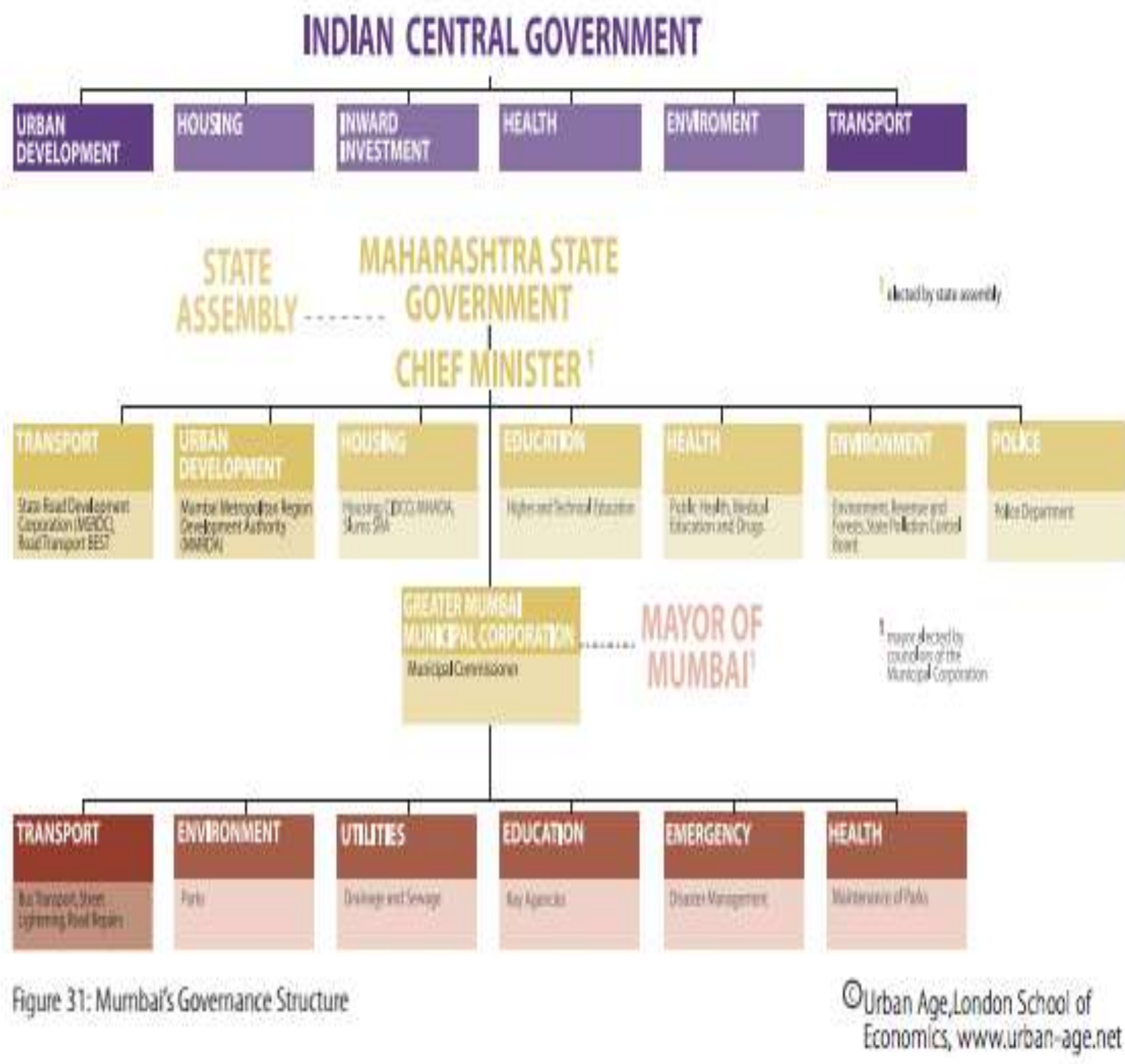
Source: World Bank Report on Water in India

Governance Challenges & Stakeholders Interests

Some of the government challenges and stakeholders interest would be trying to get the waste caused by this water supply crunch and rendered what water is available practically useless due to the huge quantity of pollution. In managing water resources, the Indian government must balance competing demands between urban and rural, rich and poor, the economy and the environment**.** However, because people have triggered this crisis, by changing their actions they have the power to prevent water scarcity from devastating India's population, agriculture, and economy. Basically to give an overview of the issues surrounding India's water scarcity: demand

and supply, management, pollution, impact of climate change, and solutions are being taken into consideration by the Indian government.

Figure 9: Indian Central Government



Source: Urban Age

Recent Projects Done:

Malvani Royal, Malad (W), Mumbai

Rainwater Harvesting Potential

Catchment are – 1,201 square meters (sq. m)

Average annual rainfall in Mumbia – 214.6 millimeter (mm)

Total water available from rainfall – 2,210 cubic meter (m^3) or 2,210,000 liters

Rainwater Harvesting System

The runoff collected form the campus is stored in a tank of capacity 2500 liters. The harvested water is used for secondary purpose. The overflow from the tanks is recharged by a recharge well having a recharge bore well. The cost of projects implantation was Rs. 1.0 lakhs. The project completed in 2006.

Environmental, economic and societal impacts

Some of the environmental, economic, and societal impacts would be climate change, pollution, getting to teach and create to inform the public and form opinions. Training the users in how to use the technology, and also having to provide a strict legislation

Technology

Rain-Water Harvesting

The Mumbai Municipal Corporation (MCGM) has promoted rain-water harvesting (RWH) since 2003 as a means of off-setting water issues. Rain-water harvesting is an indigenous practice to India since pre-colonial times, and is cheap and easy. Thus, the MCGM made rain-water harvesting mandatory for plots of land over 1000 square meters.

In Mumbai, India the level of fresh water is due to unnecessary drawing. The fresh water barrier limits sea water from coming into the land. Fresh water level is lower than the sea water level, and sea water rushes into the land. The sea water now comes in contact with the pile foundations which can threaten structures in future. By harvesting rain water we can maintain this barrier & prevent sea water ingression.

Rain water harvesting Methods:

Following techniques are used for urban rain water harvesting.

I. Storage in artificial above or underground tanks.

II. Recharging aquifer directly through existing dug up wells & bore wells.

III. Recharging aquifer by percolation / soakage into the ground.

IV. Pumping (putting under pressure) rainwater into the soil to prevent sea water access.

Other Measures

Mumbai has also considered systems such as waste-water treatment, and a "reuse, recycle" program to preserve the precious water resources that exist. All-in-all, barriers to entry for the programs have been the lax population. It is nearly impossible for the government to regulate every citizen given the immense slum population, and as such, the city finds regulation of buildings more effective.

Alternatives & Cost benefit Analysis

Rainwater harvesting methods is a component of a rainwater harvesting system. Basically one would be using pipe connections. Also, fixing up the slopes of roofs and location of rainwater outlets would be another thing to consider. Wells and tanks can be modified and used for water harvesting. This is where the cost varies widely depending on the availability of existing structure.

Installing the water harvesting system in a building would cost between Rs 2,000 to 30,000 for building of about 300 sq. m. Some of the basic rates of construction activities and materials may help in calculating the total cost of the structure. The figure below contains important rough estimated of the cost of the material.

Figure 10: Cost Estimation

Item	Unit	Rate (Rs.)
Excavation in soils	cu. m.	90.00
Excavation in rock	cu. m.	150.00
Brickwork with cement mortar (1:6)	cu. m.	1400.00
Plain cement concrete (1:3:6)	cu. m.	1500.00
Reinforced cement concrete (1:2:4) cu. m. 4700.00Including steel bars, shuttering etc.	cu. m.	4700.00
PVC piping for rainwater pipes - 110 mm diameter - 200 mm diameter	 Metre metre	 165.00 275.00
Making borehole in metre 165.00Soft soil (with 150 mm diameter PVC casing)	metre	180.00

Source: World Bank Report on Water in India

Case Study: Shanghai, China

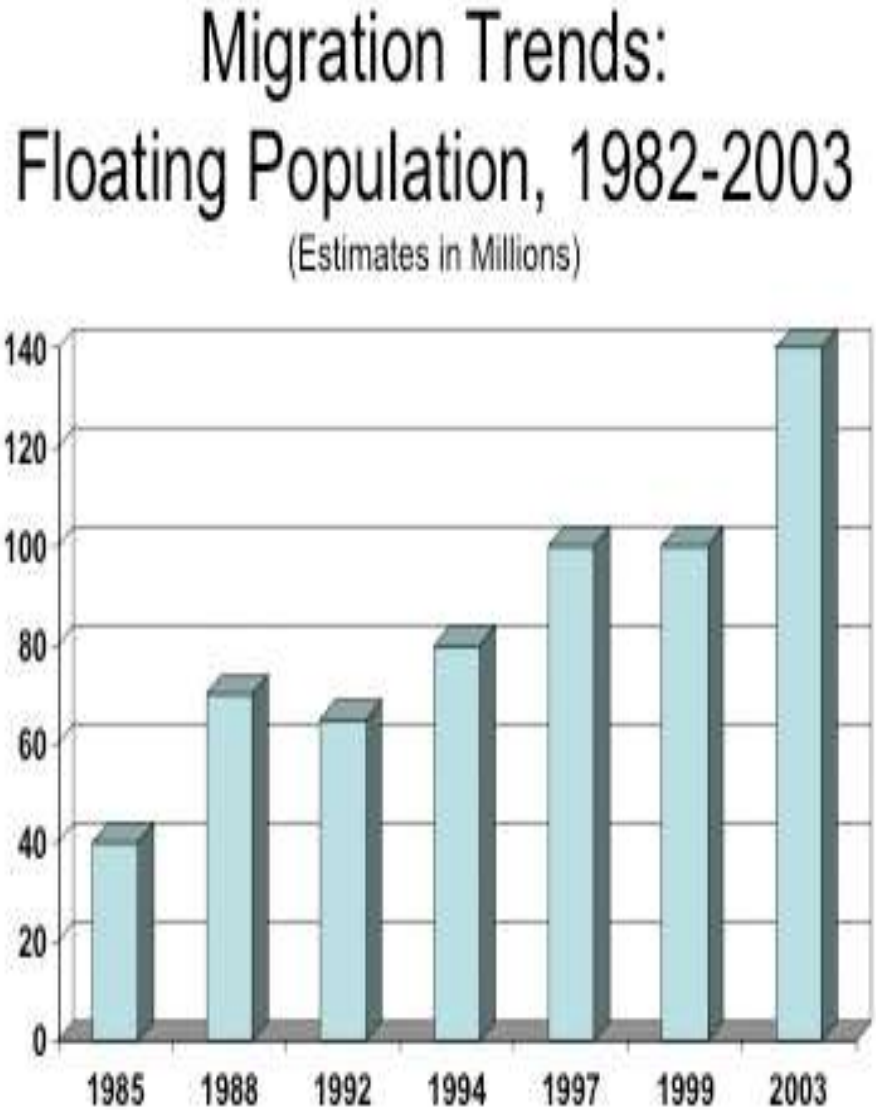
Project description & Rationale for selecting the case

The rationale for choosing Shanghai, China in this water quality paper is the abundance of information and data provided in this topic. Over 23 million people live in Shanghai and the rates of population increase are exponentially increasing each year. With populations so high Shanghai's infrastructure is beginning to how its capacity limits. This section will focus on the water management and quality of Shanghai's water infrastructure and network.

Urban Sustainability Issues Involved

The largest sustainability issues involved with the city of Shanghai is the inability for Shanghais infrastructure to support the increasing demand for capacity. In the past decade Shanghai has gone through economic growth and industrialization, these factors help to stimulate the rapid urbanization and population growth of the city. Population is broken up into two different categories, the residents and the floating population. Floating population is the group of people who live in the city for very short amounts of time, such as tourists, which may only live in the city for short periods of time. Urbanization is the rapid growth of urban areas through rural and even suburban areas into more concentrated cities. An increase has been identified in both the residential population and the floating population each year.

Figure 11: Population Trend



Source World Bank Report

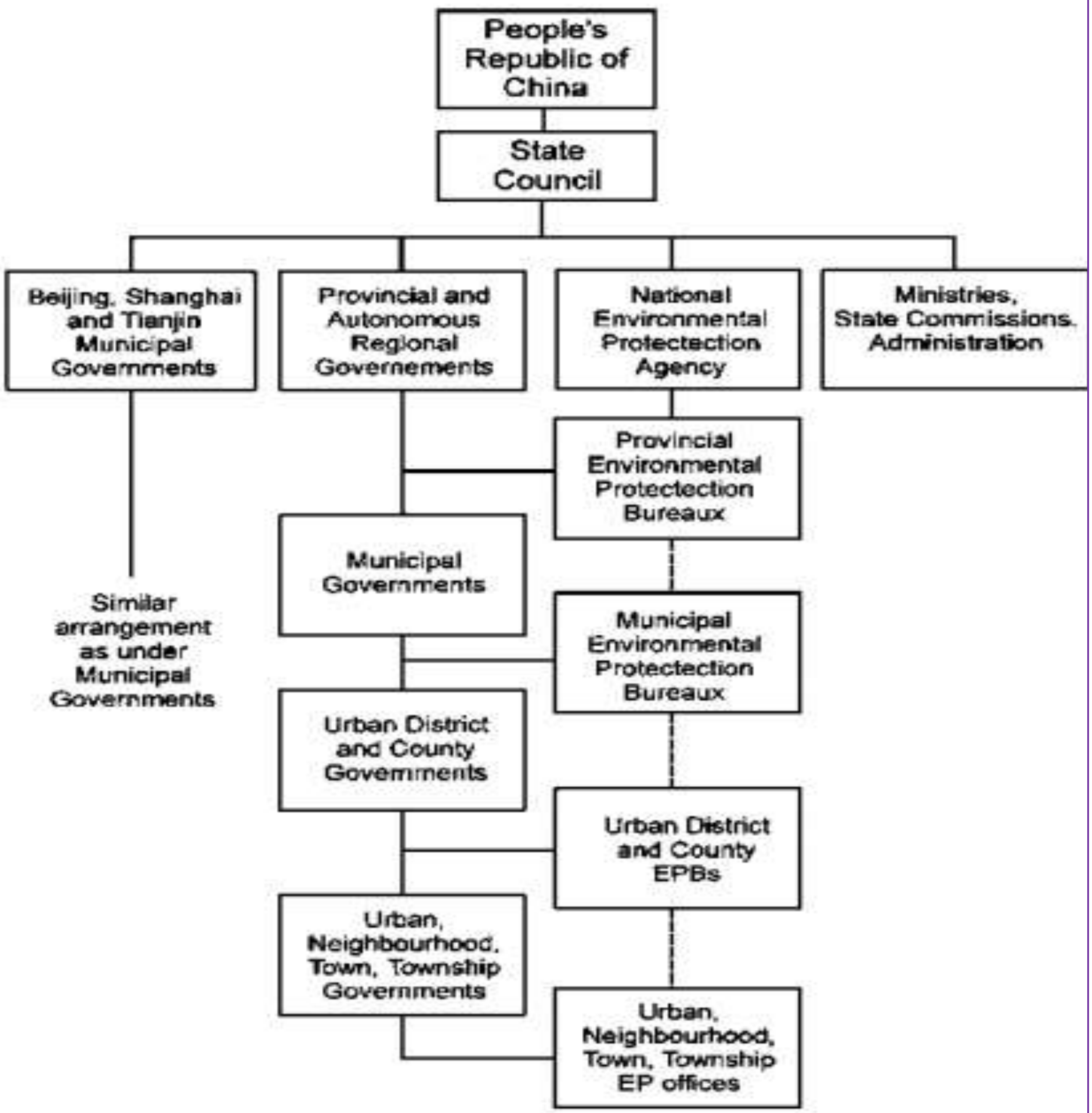
This graph shows the increase in floating population over a 21 year period, the quantity of floating population has made an increase of 40 million people between the years of 1999 and 2003 alone. Do to this concentration of population in the urban centers of Shanghai and other Chinese cities the amount of pollutants generated from these centers are very high.

Another sustainability issue that arises in Shanghai, is the water quality of drinking water within certain parts of the city. the northern supply of tap water from cities show no signs of abnormality, however in the southern neighborhoods of Shanghai there have been traces of potential mutagenic substances. Specifically the Huangpu River, has had some of the most polluted waters in all of China. In the mid-1980s, about 70% of the 5.5 million cubed meters of industrial wastewater and domestic sewage was untreated or partially treated (Zhang). Three different tests were conducted in order to determine the water quality of the areas in Shanghai, the Ames, Ara, and SOS/umu test.

Governance Challenges & Stakeholder Interests

One of China's laws that deal with the quality of water is the Environmental Protection Law of China. These laws protect the control of water, air, noise, solid waste pollution and radioactive substances. These laws are also followed by central, provincial, municipal, district, etc. The chart below shows the different divisions of China's federal government.

Figure 12: China's Government Structure



Source World Bank Report

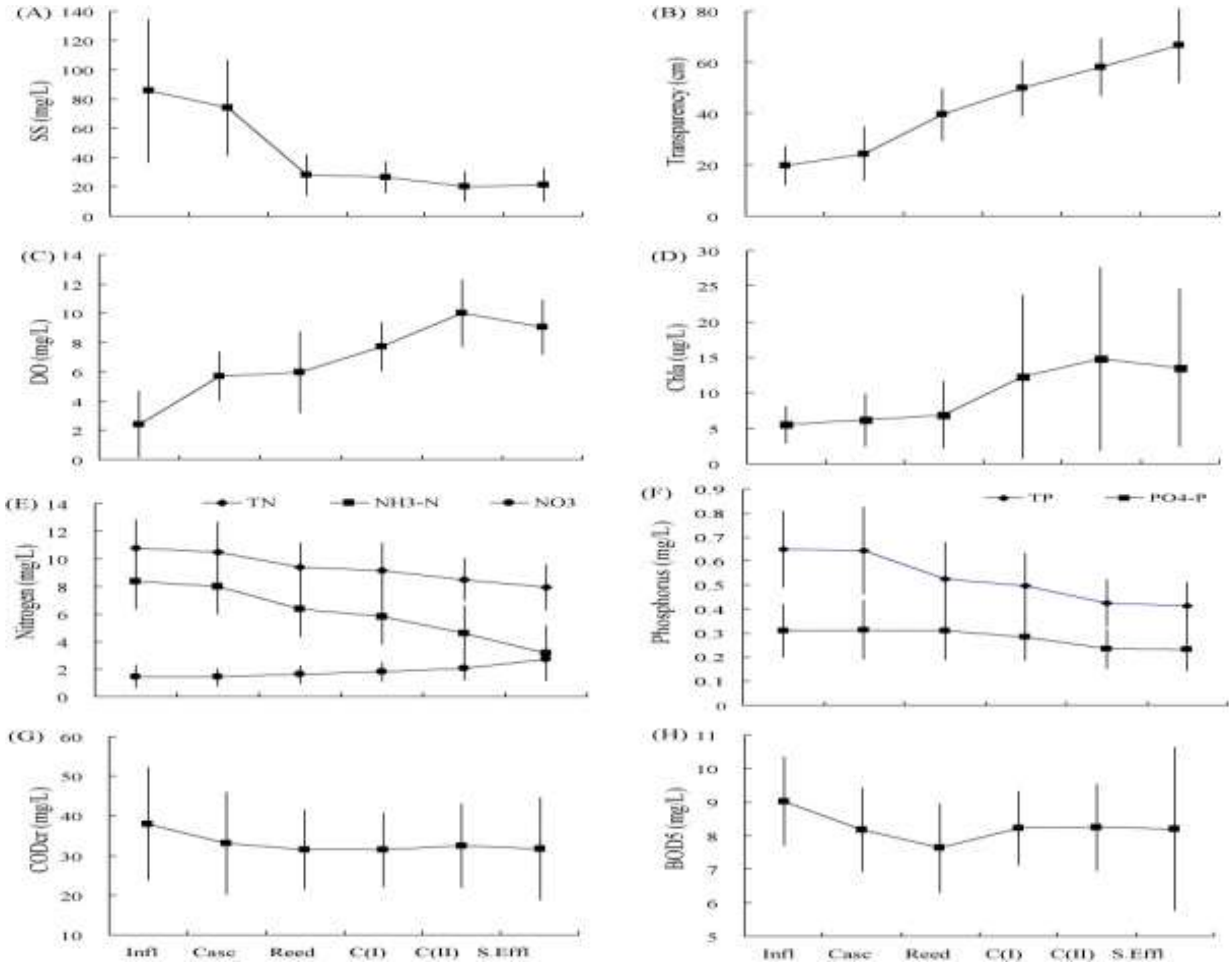
These different sections of governance all have a role in the way the water network system works, whether it directly affect it or indirectly affect it. The lowest branch of this tree the "Urban Neighborhood. Town, Township EP offices" are the organizations that have to most direct contact with water quality at a local scale.

Environmental, economic, and societal Impacts

The environmental impacts of water quality in shanghai has both immediate and future consequences in neighboring towns and cities. If the rivers that supply water to towns are polluted then the residences of these cities have to either drink polluted water or travel further and further to gain access to clean water. If this problem is not fixed then the future generations of people will be affected greatly. Also a huge economic impact of polluted rivers is the dependency on water from polluted rivers. this use of polluted water detrimentally affects the agriculture of the area, reducing crop output and quality of the agriculture being produced. this will linearly affect the economics of areas where agriculture is a major trading hub.

Technology Solutions

One small scale project that Shanghai has been working on is a water quality treatment (WQT) wetland system. This system as installed and implemented into a public park in Shanghai to: (1) serve as a demonstration of ecological engineering practices for the improvement of water quality in a degraded urban river, (2) demonstrate that such systems can provide new, variable aquatic habitat in these settings, and (3) to provide a recreational, aesthetic, and educational amenity for the neighborhood residents (Li, Manman, Anderson, 2009).



The graph shown above is the results from the WQT, the numbers are for my most part, linearly related to the time progression of the study.

Alternatives & Cost Benefit Analysis

Part of China's ability to reduce wastewater contamination is the discharge fees in Shanghai. The graph below shows the cost and contaminant particles:

Pollutant	GVOD (tonne.time)	Grade A (Yuan per tonne.time)	Grade B (Yuan per tonne.time)	Elementary Fee of Grade B (Yuan)
Total Hg	2,000	2.00	1.00	2,000
Total Cd	3,000	1.00	0.15	2,550
Total Cr	150,000	0.06	0.03	4,500
Cr^{+6}	150,000	0.09	0.02	10,500
Total As	150,000	0.09	0.02	10,500
Total Pb	150,000	0.08	0.03	7,500
Total Ni	150,000	0.08	0.03	7,500
Bap	3,000,000	0.06	0.03	90,000
pH	5,000	0.25	0.05	1,000
Colour	100,000	0.14	0.04	10,000
Suspended solids	800,000	0.03	0.01	16,000
BOD	30,000	0.18	0.05	3,900
COD	20,000	0.18	0.05	2,600
Petrols	25,000	0.20	0.06	3,500
Animal and plant material	25,000	0.12	0.04	2,000
Volatile phenols	250,000	0.06	0.03	7,500
Cyanide	250,000	0.07	0.04	7,500
Sulphide	250,000	0.05	0.02	7,500
NH_3-N	25,000	0.10	0.03	1,750
Fluoride	25,000	0.30	0.09	5,250
Phosphate (asp)	250,000	0.05	0.02	7,500
Methylaldehyde	200,000	0.12	0.06	12,000
Aniline	200,000	0.12	0.06	12,000
Nitrobenzene	200,000	0.10	0.04	12,000
Detergent (LAS)	25,000	0.30	0.09	5,250
Cu	250,000	0.04	0.02	5,000
Zn	100,000	0.06	0.02	4,000
Mn	100,000	0.06	0.02	4,000
Organophosphorus pesticides (as P)	250,000	0.07	0.04	7,500

Along with the contaminant fees, the pollution control fund is another important source of investment. In the 1980s the average amount of money collected was about 100 million Yuan. the combination of fees and pollution control plays a lot on the cost analysis of the economy.

Recommendations and Conclusions

In attempt to solve the specific problems within Better Water Resource Management, we believe that all these case studies, Sao Paulo, Mumbai, and Shanghai targets sustainability in water supplies for the sustained growth of many developing cities and people. In order to address this problem further, three cities: Sao Paulo, Mumbai, and Shanghai were used to compare their recent successful technologies to show their key perception and proposed projects in how they managed long term water resources and water treatment. The government has a big problem with water quality control in Sao Paulo, Mumbai, Shanghai. They are however taking active roles in reducing this pollution by using a combination of physical deterrents and economic deterrents. The increasing of population and the expansion of industry is creating more and more problems for Sao Paulo, Mumbai, and Shanghai to assess and fix their water quality problems. The challenge facing Sao Paulo was to deal with overpopulation and health problems by dealing with the water quality. To do this, the best course of action that can be undertaken. This requires the municipal government to exercise their legal authority, as laid out in the master plan, and tackle the issue of the poor shanty towns along the basins. By creating more reforestation zones near the water, the water quality can increase, and the bacteria levels will decrease. Thus, the growing population can be protected, as well as controlled.

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