Sustainability Innovation

Investigation On Sewage System In Wuxi

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Summary

As society is stepping forward to an unprecedented stride, humans' water consumption comes to a greater scale. Under normal circumstances, the sewage treatment plants can tackle it yet with high loads. However, in the flood season, sewage treatment plants are overloaded.

With the increasing population, the water consumption of both domestic and industrial sewage increases. By analyzing historical data and searching for information online, we learned that this is a problem with two facets. On the one hand, the problem is attributed to the treatment plants themselves. Their aging equipment cannot handle such a large volume of sewage. On the other hand, it is due to a lack of awareness among citizens, such as dumping sewage into the wrong pipelines or blocks pipelines with solid waste, leading to the increasing pressure of the water treatment plants. In the meantime, improper regulations and the lack of clarity in the government's responsibility prevent the sewage problem from being properly solved. We first proposed eight solutions based on the root causes of the current problems. By quantifying the proposed solutions based on self-defined criteria, we found the two best solutions, which are further combined together to form the "green credit system", which, we believe, can effectively improve the current problem.

Since the central part of the problem is that people are lack incentives to protect the environment, the green credit system would foster citizens and enterprises to perform sustainable activities. Incentives and punishment plans are designed for different groups of people, including normal citizens, government officials, and industry workers. Furthermore, based on the response from interviews and questionnaires, we evaluated the effectiveness of the proposed plan.

In the future, we may perform research and collect data in different regions in order to determine whether the green credit system could be generalized to the whole city. Our aim is to use the green credit system to address distinctive problems with the same central point, i.e., creating incentives for all parties involved to solve the problem.

In summary, this study uses an interdisciplinary approach, including policies, economics, and environmental science, to solve the problem of insufficient capacity of sewage treatment plants in our living community. If the proposed green credit system can be implemented, more people will pay attention to environmental

problems, which can further increase the awareness of the entire society and potentially promote more investment into water treatment.

Key words: overcapacity of treatment plants, incentives, green credit system

Choose the Topic

Identify the Challenges

During the flood season, people tend to wish the coolness from the rain in hot summer, but for our leader's father, this adds him another worry, because a great deal of rain means that he has entered the busiest time of the year. During that time, he worried about flood control during the flood season to prevent excessive sewage that could not be treated and discharged directly into the river to cause pollution. Just like the problem faced by our leader’ s father, the problem of sewage entering the river during the flood season is still prominent. Since currently in daily scenarios, most treatment plants would have great pressure in treating increasing volumes of domestic sewage and industrial sewage, as flood season would bring swamps of rainwater into tributaries, the total treatment water would be enlarged for the sewage treatment plants. Thus, facing the great volume of water, most treatment plants could not bear the capacity and that creates several problems like mixing rainwater and sewage water and backflow of sewage causing water pollution problems.

Identify a Root Cause

a. Historical problem

With the rapid development of the economy and population in South Jiangsu, the amount of water consumption has been increasing at an incredible pace, also leading to the increase of water contamination. According to Xishan District historical statistical Yearbook, the census in Xishan district from 2010 to 2020 indicates that the population increased by 17.4% from 414136 to 486499, which causes a large amount of water consumption，corresponding to a great leap of domestic sewage consumption from 228.0 to 561.5 million tons of water. Moreover, it is also reported in the Yearbook that the number of factories in Xishan district has nearly doubled during the same time period, which meanwhile, has brought nearly 10 million cubic meters of additional industrial water. However, the capacity of industrial sewage treatment is growing in a tardier way. Consequently, the growing consumption of both industrial and domestic sewage and the steady dealing capacity is out of proportion, resulting in the increasing pressure of sewage factories year by year.

b.Problem of insufficient capacity

The basic capacity of the sewage treatment plants is inclining so slowly that it is not able to reach the growing speed of the amount of sewage produced. According to the report, five out of seven sewage treatment plants maintained 70% of the workload on a long-term basis, one of the five plants may have reached 85% of the workload. The data reflects the dilemma of today’ s sewage treatment plants that the growing amount of polluted water hinders treatment plants from dealing with it in an environmental-friendly way. In addition, it is reported that the capacity of sewage treatment did not make any progress from 2013 to 2017 and grew slightly during the last ten years. Furthermore, what shows here are only the average bearing capacity within a year, corresponding to the time period that the chance of overcapacity is over 100%. Under extreme weather, three sewage treatment plants with a capacity of 22’ 000 tons per day need to treat 24’ 000 tons of sewage. Because of the overcapacity, in order to not damage the water processing equipment, the sewage treatment plants have to turn down or even close the opening of the sewage inlet valve port. In turn, the mixed rainwater and sewage water, which could not enter the sewage treatment plant, would directly back-flow to the tributary. As a result, when flood season is coming, the water quality will deteriorate, even though the quality meets the standard during the inspection.

c.Lack of separated sewer systems

Another serious problem of the sewage treatment is the mixed flow of the rain and the sewage. According to the research data of the outer pipes of the old communities, some of their rainwater and sewage pipelines are mixed together, which does not meet the standard of pipelines that we use today. Since residents usually put their washing machines in balconies, construction workers connected the sewage pipeline to the rainwater pipelines that connect to the rooves of the old communities, resulting in the mixing of domestic sewage and rainwater. Even till today, these mixed network accounts for 20% of the whole. In addition, from the yearbook, we learned that there was no sewage treatment plant until the first plant started to devote into operation in 2003. In other words, before 2003, there was no systematic design of sewage pipes. Things have changed until 2007 when the blue algae bloom broke out. The government started to pay close attention to the management of water quality and established special agencies to tackle various types of water pollution. However, some problems occurred in the process of construction. Since local governments at that time had no expertise to build sewage treatment systems, there were errors in project planning, design, and contracting. For instance, different types of pipes were not labeled with different colors, making it difficult for the maintenance men to distinguish the use of some pipes. What was worse, the design drawings of the first batch of sewage pipe networks have not been saved since 2007. As a result, maintenance men are likely to misconnect the sewage pipe to the rainwater pipe when reconnecting the pipes.

In addition, our citizens also make blunders that have caused the problem of mixing rainwater and sewage. Some people dump sewage into surrounding manhole covers, yet these manholes are used to drain rainwater. These behaviors have resulted in a significant problem with combined rain and sewage. These problems are especially prevalent in a township tea shops. For convenience, some vendors would dump their unsold tea into a nearby manhole. These citizens committed these errors because they were unaware of the genuine purpose of the manhole.

It is also a very serious problem that some enterprises discharge untreated sewage directly to sewage treatment plants without permission during rainy days. This behavior put undue strain on the sewage treatment facility and increasing energy usage.

III. Problems of government management

a. Regulation problem

In the context of the law and regulation, there are also some root causes that would directly lead to the problems of sewage disposal companies fail to treat so many volumes of sewage. We conducted research about the local regulation for water, and we find that some regulations will hinder new sewage treatment plants from construction and old plants from expanding.

In this region, there are two kinds of sewage disposal companies: one is a domestic sewage treatment plant, which could only treat the domestic sewage; the other is urban sewage treatment plant, which could not only treat domestic sewage but also 30% of all industrial sewage. We reviewed a released regulation form written by the government of Jiangsu Province. It says that for water function areas if the current pollutant flow into the river cannot meet the standard of pollutant discharge restrictions, the government would only approve the construction of urban domestic sewage treatment facilities. From the government's perspective, they think that if one sewage treatment plant is not capable of treating domestic sewage, it is less likely to be capable of treating industrial sewage. However, as we discussed before, more people, as well as industries, have come to the region in recent years, which means that both domestic and industrial sewage volumes are growing. Theoretically, the government should increase the number of sewage treatment plants, or encourage sewage treatment plants to expand their services or enlarge treatment volume, in order to meet the larger water treatment demand. However, under strict regulation, the existing sewage treatment plants do not have the capacity to treat all the sewage, and the sewage that could not be treated is released to nearby rivers, leading to river pollution.

Another regulatory problem is that government will only permit the construction and operation of sewage treatment plants if 18% of reclaimed water can be reused in applications such as industrial processes. In an interview with Fang, a professional environmentalist, he mentioned that the minimum requirement for the sewage plants to return reclaimed water is 18% of their total reclaimed water. It seems like a small number, but if we multiply it by the number of total volumes of reclaimed water produced, that is totally different. There are 783960.1 tons of reclaimed water that need to be reused by other companies. However, the problem is that since many processing companies can not use reclaimed water due to technical factors, it is not easy to find sufficient companies to consume the amount of reclaimed water. Therefore, the policy actually limits the construction of sewage treatment plants.

b.Pipeline treatment problem

Furthermore, it comes to the poor handling of the pipe network. We will turn it into two specific parts to discuss. Firstly, responsibility government regulators fail to properly treat and filter the sewage pipe network on a regular basis, causing the pipe network to clog and the sewage to not drain normally. This causes the constant rising of the sewage level in multiple septic tanks and sewer pipes in the area, leading sewage to overflow into the sewage wells many times. Additionally, our live shooting reflects problems of the aging of the pipe network and no regular maintenance. The sewage pipe leaked, and some dripped into the river, leading to the deterioration of the river water quality, which increased the pressure of the sewage treatment indirectly. We take the “Miao Qiao event” as an instance. As our District is located downstream of Wuxi, during the flood season, most of the

sewage in Jiangyin, Hui Shan District, and urban areas will flow into our district, which has a significant impact on the water quality of the whole district. The current pollution interception and drainage adopted in the Miao Qiao section and upstream are only temporary means, and the source control and pollution interception work are not carried out in-depth.

c.Responsibility division problem

The administrative division is not clear, resulting in some pipeline problems remaining unresolved in the long term. The primary and secondary pipeline network, which covers from district to towns and from towns to villages, is planned, constructed, and managed by the Department of Housing, Buildings, and Construction (DHBC). The third and fourth network, which manage farmers, households, enterprises, and village communities, is planned, constructed, and managed by town government. Therefore, in order to clarify the responsibilities, the DHBC and the town government take charge of the maintenance of pipe networks that were constructed by themselves respectively, which creates the problem of insufficient communication and lack of supporting facilities in third and fourth networks. Although DHBC proposed in the three-year plan to carry out the integrated design of pipe network construction and to guide the town government to promote the annual planning tasks of the pipeline network projects, in the relevant documents at the county and district levels, the number of investigations and maintenance tasks for the third and fourth-level pipeline network has never been clarified. In infrastructure construction, the task of investigating and maintaining township pipeline networks is often neglected. In the ideology, since there is no assessment from the higher-level government, the town government prefers not to invest a lot in pipeline maintenance.

d.Assessment and investment problem

In the government's assessment system, economic development accounts for a much larger percentage than environmental protection. And environmental protection does not bring significant economic benefits. Therefore, most departments are more inclined to invest in projects that bring economic benefits rather than environmental protection. For example, in most regions in Wuxi, what officials consider most is economic development. According to the two copies of the examination indicator standard, the economic development weighing accounts for at least 50% of the total examination score. With the addition of the 10 percent weighing of land demolition, which is correlated to economic development, the total weighing can be about 60 percent. In contrast, environmental protection only accounts for 20percent. But the assessment percentage is not the same as the proportion of funds invested. In the funding distribution decision making, suppose there are 500 million Yuan to be allocated, considering the assessment percentage, 50 million should be allocated to environmental protection. However, an investment report shows that only 5 million goes to environmental protection. In sum,

environmental protection is not a priority development project in terms of assessment and investment percentage.

e. Ambivalence of accountability system

The current society generally believes that all ecological and environmental problems should be the overall responsibility of the Environmental Protection Agency. In fact, the EPA is mainly responsible for environmental monitoring, and environmental protection involves all aspects of the government' s work. For example, air pollution caused by unqualified emissions from transportation vehicles should be the responsibility of the transportation department; water pollution caused by pesticides and fertilizers should be the responsibility of the agriculture sector. However, currently, even if the environmental pollution is managed or caused by other departments, EPA is always to be held accountable for its ineffective supervision of environmental issues and poor pressure transmission. This has created an imbalance of pressure among the departments. In addition, the complex division of work is also the cause of the ambivalence of the accountability system. For example, in an interview with the EPA, the staff reported that there was one time that sewage overflowed into the river due to the mixed flow of rain and sewage in the pipe network. Initially, EPA staff thought that some factories might discharge sewage without permission. However, with months of data, the EPA confirmed that it was due to a wrong connection of rainwater and sewage pipelines. Thus, the responsibility should fall on the Department of Housing, Buildings, and Construction (DHBC). But what is interesting is that the sewage pipes are under the control of the DHBC, whereas the rainwater pipelines are managed by the Department of Urban Management. This posed a big dilemma for the division of accountability.

- 管网堵塞
- population and water consumption change in the past ten years
- sewage leakage
- devotion to the indicator of examination and finance
- regulation for water
- ecerpt for regulation of water
- capacity of wastewater treatment plant

Generate Solutions

Solution 1: Implementing more severe punishment to illegal drainage
The government has now paid a lot of attention to the problem of releasing wastewater and waste gas, as well as dumping toxic waste at will in the past decade or so. Due to the government's neglect of management in the early stage of the development of enterprises that ignore environmental protection, many enterprises took the opportunity to release wastewater and caused an irreversible impact on the environment. Therefore, in my opinion, the first solution is to severely punish these enterprises by increasing the fines and closing these enterprises for rectification. Many cities have issued relevant laws in this respect. When the Hunan provincial government found that many enterprises released illegal sewage, it issued the “order to stop illegal sewage discharge", where the leaders in the involved enterprises will be under administrative detention and other penalties. When faced with the same problem, Shenzhen took corrective measures to suspend the responsible enterprises, fined them 200,000 yuan, and punished the responsible people with administrative detention. Therefore, I think our city should also implement relevant punishment policies in response to the same problem.

Solution 2: Separating the rainwater pipeline from the sewage pipeline
Because the plant is already running at full capacity, when it rains, the water goes directly into the tanks used to store sewage. However, due to the different processes used to treat sewage and rainwater and the overloaded status of the treatment plant, rainy days will have a huge impact on the treatment plant. Therefore, I think the second solution to solve the fundamental problem mentioned above is to separate the rainwater from the sewage, i.e., separating the pipes to treat them and purify them, to indirectly relieve the pressure.

Solution 3: Constructing emergency reservoir
Because the weather of our city is rainy throughout the year, our city will encounter a long period of flood season in a year. As mentioned previously, when the rainwater enters the sewage reservoir, it will cause a great workload to the entire system. Therefore, the emergency reservoir for the flood season will be essential. When the annual flood season arrives, the sewage treatment plant should open the emergency pool to prevent the sudden increase of rainwater, which leads to great pressure on the treatment plant. The emergency pool will play an important role in the flood season, storing large amounts of rainwater temporarily until the operating load of the treatment plant is gradually reduced. The stored rainwater can be purified by then.

Solution 4: Improving management of pipe network
Fourth, in order to reduce the pressure of sewage treatment during the special period of the rainy season, we should carry out better management of the pipe network and improve the basic design and work quality, which can effectively help improve the work efficiency and ensure the residential water use during the special period. The pipe network is the most important part of urban sewage treatment. Repairing pipe networks can prevent pipe explosion and avoid loss. In addition, the system needs to be equipped with a solid fence with regular cleaning in front of the whole regional network. Through this method, the solid waste or particles can be filtered out before entering the sewage, and this can greatly reduce the huge pressure of the central treatment plant and improve the overall efficiency even in the special period. Furthermore, sewage treatment companies can also perform timely and high-quality sewage treatment to protect the residential water.

Solution 5: Population migration
Fifth, due to the rapid development of our country and the rapid urbanization process, many people have flooded to some of the most developed cities to live and work. As a result, the population distribution in some cities is very dense, even exceeding the maximum capacity of urban infrastructure in cities such as Beijing and Guangzhou. This is also a direct cause of the greater pressure on sewage treatment in some cities. Due to the rapid increase of urban population, sewage treatment companies must adapt to the rapid increase of sewage treatment volume, resulting in the overload during some special periods of time. In order to solve this problem, I think we can imitate the way of Beijing, which migrates this can greatly alleviate the pressure of the sewage treatment in cities and reduce the amount of sewage treatment. The workload of sewage treatment can be evenly distributed to surrounding areas, increasing the standard of water supply.

Solution 6: Increasing investment in sewage treatment plants
Sixth, the lack of advanced technology and equipment is one of the fundamental causes of the high pressure experienced by the city sewage treatment. Since the number of sewage treatment ponds is not sufficient, sometimes the sewage treatment plant will have a very limited treatment capacity. Through the investigation, we also learned from the staff that not only the public sewage treatment plant has to face the excessive amount of sewage treatment, but also their subsidy funds are not enough. In my opinion, the government can allocate more funds for public sewage treatment plants, so that better equipment can be employed and more competent people can be attracted to the sewage treatment companies to ensure the sewage treatment and water supply of residents.

Solution 7: Raising the awareness of citizens
We should accentuate upon raising the public consciousness of the importance of

sewage treatment. To be specific, detection equipment should be installed in every sewage pipe of the street. Once an excessive amount of sewage emerges, the detection equipment can play the role of alarming and then identifying the root of the problem. The accountability needs to be traced down into specific units such as individuals or companies. In the meanwhile, imposing a fine on the relevant people or company can also be used to increase the awareness of citizens. Considering the awe toward certain policies and examples of punishment, the public can strengthen the awareness of sewage treatment and also learn more about the water environment.

Solution 8: Improving regulation system with the flexible ordinance
The refinement of certain policy and law systems should also be taken place. The current policy can be improved in a more tolerant way. Enterprises that are up to standard should be assisted in their further construction and development. Then, the water reuse system needs to be established after the arrival of enterprises that require water reuse. By such coordination, enterprises are rendered much more opportunity for self-developing. In addition, certain dilemmas between government and enterprises can be mitigated by implementing more flexible policies. For example, in particular, in regions where sewage treatment plants could have the capability to construct but could not find companies that can use the reclaimed water they produce, the government should allow the sewage plants to construct first. Later, they will find corresponding industries to which they can sell reused water. Second, while special sewage treatment plants should be equipped with a consistent, high standard for chemical, printing, and dyeing, and electronic factories, the rest of the sewage treatment plants could have more flexible regulation standards. For example, mixed treatment of domestic sewage and industrial sewage should be encouraged. The current policy system can also be refined to optimize the environment protection assessment system. Every department should be assigned definitive responsibilities in order to avoid over-classify common issues as emergencies. By allocating responsibility to the corresponding department, the accountability of each department can also be determined. According to our research, the fuzzy division of responsibilities leads to no rectification of problems even if people identified the problem. Thus, a clear and mighty responsibility equivalence mechanism is crucial in solving problems pertaining to the aforementioned problems.

Sewage fence before the pipelines
greater environmental punishment
Hua, R. (Trans.). (2017, December 16). [Warning] The Ministry of Environmental Protection raided the night, and two packaging and printing factories in Shenzhen were fined more than 200,000 each!

Identify the Criteria

a. Cost-benefit analysis (weight: 20%)
For each solution, a cost-benefit analysis needs to be performed. Is it worth the cost to add new equipment or redesign the treatment processes? Will the enterprise encounter a potential financial crisis because of this spending? To avoid such problems, the cost and benefit from the proposed solution need to be seriously evaluated, taking into account the potential changes in the future.

b. Long-term effectiveness (weight: 30%)
Could the solution be effective in the long run? Would the problem be solved instantly but happen again without constant intervention by people? Or, could the solution be used throughout the years, or could it only be used and effective for a specific period of time?

c.Time Constraint (weight: 20%)
For the redesign of the pipeline network, one needs to consider whether the rerouting of parts of the pipeline would result in a significant reduction in the load of the plant for a long period of time. Would the plant be able to solve the load problem for that period? Could the profit gained by adding new equipment cover the corresponding loss? These factors need to be quantitatively studied.

d.Operational possibilities (weight: 20%)
Before implementing the solutions that we offer, we also need to consider whether it is necessary to conduct improvement at the site. For example, many parts of the pipeline network equipped with solid contaminants need to be investigated whether it is feasible. Moreover, adding a fence to the pipe network in all areas would need huge operation cost, and would be equivalent to laying the network again. Therefore, before the implementation, current conditions of the local pipe network needs to be carefully investigated.

e.Residents’ acceptance (weight: 10%)
Public acceptance is one of the criteria that we care about in the consideration of solutions. The goal of our solutions is to satisfy residents in improving affiliated water conditions and the environment. Therefore, the residents’ suggestions are essential in the process of designing solutions. Furthermore, the solution would be refined after adopting residents’ feedback. We hope that each solution would be well recognized by residents.

Evaluate the Solutions

The following are the criteria for measuring the feasibility of solutions. The maximum score for each criterion for 10. If one solution can directly get a score of 9 or above, then we will use it directly in the action plan; if not, we will adopt the two highest-scoring solutions and plan with their comparative advantages.

Solution1: Implementing more severe punishment for illegal drainage

Cost (score 8): It incurs no cost to the society as it charges from the companies that conduct illegal drainage. But it is based on the premise of the toll of the environment as the environment has been polluted beforehand.

Long run effectiveness (score 4): Even though the companies that conduct illegal drainage would be economically punished for their misbehavior, it does not guarantee that the companies would stop their misbehavior as people did not eliminate the root cause such as lack of the capability to treat the sewage. It fails to consider the risk of repetitious problems of illegal drainage.

Time (score 9): Since illegal drainage can be easily identified nowadays, the punishment could be informed within a day, but on the extreme occasion it needs manually to check, so it takes a little time.

Operational possibilities (score 8): In general, it is easy to operate with greater punishment. However, as human beings need rest, it cannot be monitored for a total of 24 hours. So, even though with the power of automatic device censorship that can detect illegal drainage, it will have a lag for people to notice.

Residents' acceptance (score 10): The local residence is quite satisfied with the punishment to the companies for inappropriate releasement of sewage, as they perceive it will avert the chance of releasing the untreated sewage and improve the quality of water.

Solution 2: Separating the rainwater pipeline from the sewage pipeline

Cost (score 6): The environmental cost can be little, but in the economic means, it would cost a lot because that the total distance of these mixed old pipelines would be up to 300 kilometers, which means that it would be a cost of pipelines. In addition, most of these pipelines are buried underground, which also means that

people need to dig out and replace them. After replacing, they need to re-pave the road, resulting in additional cost.

Long run effectiveness (score 9): As the old pipelines are replaced, the pipeline would be divided into specific functions so that it can effectively tackle the overcapacity problem in flood season despite the repair work on occasion.

Time (score 6); Since replacing the pipelines needs to dig out the aboveground road first, so it needs about a week to do that; then actually goes into the pipe network laying and construction work, because of the long-distance, it needs about full month' s work to finish. Finally, it needs to repave the road, which will last one week. Furthermore, it still is on the consideration on the maximum efficiency regardless of the weather or other factors. As a result, the time consumption can be high.

Operational difficulties (score 6): Since it is correlated with several departments including the Department of Transportation, the Department of Housing, Buildings, and Construction, and the Department of Urban Management, with the addition of the tremendous work, it is difficult to carry out the whole construction work. But as it is the government' s responsibility of solving the hanging problem, operation difficulties could be addressed a little bit.

Residents' response (score 7): In general, the residents would be satisfied with the work in the long run. However, it would be hard in the short run as digging the road would interfere with people' s daily lives. And because of the huge noise of construction produced by trucks, the residents would also be annoyed by that.

Solution 3: Constructing emergency reservoir

Cost (score 8): The cost of the emergency reservoir can be medium as they need to own the land for constructing the emergency reservoir. But compared to the cost of replacing all old pipelines, the cost can be lower.

Long run effectiveness (score 5); Although it can alleviate the short-run problem of overcapacity management problem of sewage treatment companies during flood season, in the normal circumstance it cannot have any improvement to the sewage treatment plant itself such as enhancement of the ability to treat the sewage. Thus, it does not solve the root of the challenge.

Time (score 7): The time that needs to construct the emergency reservoir is about two to three weeks in total. It is a little bit longer, but it is not longer than replacing all the pipelines, so it can score a little bit higher.

Operational difficulties (score 6): From the operability’ s perspective, it is not a difficult problem. But from the space perspective, there will be some problems as some of the tributaries are near some building complexes, so it can be hard to construct enough emergency reservoirs to collect so much volume of sewage that cannot be immediately treated.

Residents’ acceptance (score 8): Overall, they are satisfied with the emergency reservoir as that mixed sewage will not be directly released into the water and cause pollution. However, the residents that would live close to the emergency reservoir are a little concerned about the bad scent of water since after all after storing for an amount of time the stagnant water in the emergency reservoir will have a stinky smell.

Solution 4: Improving management of pipe network

Cost (score 7): It would not incur the environmental costs, which is good. But it incurs the cost of additional labor to manage the work. In the long run management, it can incur a bigger cost as labor price is higher.

Long-run effectiveness (score 8): With a particular sector to regulate the network, in the long run, the system of the network would maintain great condition. But the premise is the sector always responsible for that.

Time (score 8): It needs to hire specialized labor to protect and clear, and it also needs to install the solid filter in all the entrances of the water, which in total would take about two or three days.

Operational difficulties (score 8): Generally, there are few problems except these specialized people need to have professional training in order to address all circumstances.

Residents’ acceptance (score 9): Residents are generally delighted about the solution as it can make the community cleaner and eliminate the risk of urban waterlogging as the pipeline is unblocked.

Solution 5: Population migration

Cost (score 4): First, the government needs to accumulate enough funds to reconstruct undeveloped rural areas to increase its capacity in order to hold these migrated people. The new place needs to build a completed infrastructure facility in order to attract people to come and reduce the pressure of local. Thus, the cost is huge.

Long-run effectiveness (score 4): In the short run, it can alleviate the pressure of

local treatment. However, the solution ignores the fact that it would not change the capability of the treatment plant and in a macro perspective, the total amount of sewage does not change. Therefore, if people don’ t upgrade the sewage treatment equipment, the new region will also face the same problem someday.

Time (score 4): It takes time to make the population shift as it is impractical to persuade most of the people to shift into a new area. In addition, it takes time to construct basic infrastructure facilities. Taking the example of Xiongan's new district, it needs at least one year to finish the basic construction.

Operational difficulties (score 5): Beijing, which is our solution example, is a global metropolis and a megacity. Thus, Beijing can have the work of population migration as the city has adequate money and space to perform the project. However, to Wuxi, since it is a second-tier city with less budget and space, it is difficult to carry out the project.

Residents’ acceptance(score 6): The residents are reluctant to migrate to the new region since their work locations generally are near their extent houses. Migrating to the new area means that they need to purchase a new housing asset in a new region again, and they need to adapt to the new environment.

Solution 6: Increasing investment in sewage treatment plants

Cost (score 6): In order to upgrade the facilities of the sewage treatment plants, including the pipelines and equipment, the plants need to spend at least about 3’ 000’ 000 RMB to perform. Considering the scale of the upgrade, the cost can be bigger in some places. As part of the fee is from government expenditure, the cost for the government can be tremendous.

Long-run effectiveness (score 8): Increasing the expenditure of sewage treatment plants would tackle the current situation as plants could stand more volume of water with upgradation. One small concern is whether the devotion to the sewage plants, which convert into equipment, could withstand the pace of increasing sewage in the region in the future.

Time (score 6): Since every year there is a limited budget, sewage treatment plants need to manage the budget distribution and accumulate the budget. It takes about a season to get enough money.

Operational difficulties (score 7): Since not all, sewage treatment plants are nationalized, some of the private treatment plants might not have the capabilities to upgrade as they need to pay for the equipment totally by themselves and the money is also managed by themselves. In order to achieve the projected goal, the

government had better buy back part of the plants and perform proper management and give more subsidies to the plants in order to achieve the goal.

Residents' acceptance (score 8): Residents accept the solution, but they know part of the fiscal fund would come from the water fee paid by residents.

Solution 7: Raising the awareness of citizens

Cost (score 9): It needs to have a platform to give lectures to citizens about the knowledge of the water treatment, which means that it creates the cost of promotion. But the cost is extremely small compared to some solutions mentioned before.

Long-run effectiveness (score 7): For a time, giving lectures to raise the citizen's attention to the water treatment problem can help citizens to cherish water use and properly treat the sewage in a short amount of time. However, if we lack continuous influence, citizens will gradually forget about the obstacles that we currently faced.

Time (score 8): It takes less time to carry out than most of those solutions. The central concern is about the time it takes to cover enough people and how long they will pay enough attention to the problem so that they will make an obvious change.

Operational difficulties (score 9): It encounters with few obstacles, but because of the current epidemic prevention requirement, some of the content needs to be covered online. However, it will not cover parts of people as some old people will not adapt to use electronic devices.

Residents' acceptance (score 10): Residents are satisfied with the solution as it will not only improve the environment around them but also influence residents' behavior into a great lifestyle without creating too much expense.

Solution 8: Improving regulation system with the flexible ordinance

Cost (score 10): It incurs no cost to society.

Long-run effectiveness (score 9): In general, it can solve the root of the problem as people can specify the responsibility to the department. The only concern is whether the department would always perform its duties immediately.

Time (score 8): It takes about one or two weeks to discuss and finally carry out the responsibility plan, which takes a relatively short time.

Operational possibilities (score 8): In all, the solution is good. The premise is that each of the responsible departments should get the task within their capability to solve.

Residents' acceptance (score 10): The residents are delighted to see government will take immediate responsibility and address the problem. In this way, it not only creates no cost but also creates more convenience for society.

Summary for the evaluation: Since no solution exceeds 9 or more, no solution should be directly taken. But based on the total score ranking, the seventh and eighth solution got the two highest score, which all exceeds eight. Thus, in the action plan, we combined two solutions with their comparative advantages to form the "green credit system".

evaluation of the solution

Make an Action Plan

a.Motivation
We plan to develop a green credit system, in which earning or deducting green credits could affect everyone’ s lives. This plan aims to motivate every citizen to participate in environmental protection. Additionally, we hope that this plan can alleviate or even address the responsibility inequality problems.

For ordinary citizens, since most of them have not developed a good awareness of protecting the environment, there should be more ways of rewarding the citizens than punishment. For example, citizens could get some green gifts made from sustainable resources after achieving a certain amount of green credits; when the citizens earn more green credits, they could even get the benefits of tax relief or green credit loans. Citizens could earn green credits by doing weekly environmental volunteer work in the community, monitoring and reporting environmentally unfriendly behavior, acquiring environmental knowledge, or even by proposing some novel ideas of environmental regulations and technologies. On the other hand, if citizens are caught by unsustainable behaviors, the system would deduct their credits.

For government coordinators, since it is their responsibility to regulate the environment, there should be more constraints and requirements on their behaviors. For example, besides routine check of credit-earning, if civilians report environmental issues and it is proven to be true, the relevant government coordinator’ s green credits would be deducted, and the person in charge would need to apologize and carry out a rectification plan on social media such as television.

For enterprises, if they could guarantee the water quality and do not conduct illegal drainage, they could earn a certain amount of green credit every month and vice versa. In addition, enterprises could be ranked by green credits at the end of the year. If the score of green credits is high, the enterprise could get priority in pollutant emissions trading and tax relief. Those enterprises with end up with low scores would have to pay additional fees to compensate for the cost of sewage treatment and green gifts as mentioned before. Furthermore, the green credit system of enterprises would correlate with the local big data system so that enterprises could pinpoint the recurring problems, and the responsible government would conduct more targeted reviews for the problematic enterprises. In this way, enterprises could be incentivized to generate green credits by good behaviors.

b.Community hub

The green credit system would provide a community hub for users to share their thoughts on environmental behavior. There are different columns that users can choose to comment on. For example, users could propose their eco-friendly strategies in their daily lives for consideration. After getting enough positive comments, such as 100 votes, the user could earn 1 credit. In addition, users could monitor and report on environmentally unfriendly phenomena with the aid of a GPS system, and mark the precise location and time period. If the report is confirmed to be true, the user will receive five green credits, and the relevant government will receive the messages and go to the corresponding problem site for rectification. Furthermore, the government could also establish a column for posting innovative regulation plans or satisfaction surveys for users to vote. If the voting rate achieves a certain amount, the government officer could get five green credit points.

c.Corporation—advertisement

In the opening of the system, we can display some advertisements for green products made by environmental companies. Users could get a certain number of green credits for buy green products and supporting green life. In addition, the companies and the green credit system could share their profit, part of which could devote to the construction and generation of the system.

d. Cooperation with other government departments

We will recommend the green credit system to the EPA and we will be together to track the trend of use of the green credit system. Additionally, we will cooperate with the professional environmentalists to hold live sessions and recorded ten-minute lectures to inform users about the environmental science concepts and how can we protect the environment by sustainable practices.

e. Funds

The “green credit system” would need funds to start, develop and operate. These funds would be primarily sponsored by the lowest 10% of green credit users. According to the statistical data of the system, each year it would screen out the lowest 10% of users. The system would charge extra funds from them for the operation of the system and the green gift funds. If the bottom 10% of users refuse to pay for the funds before the deadline, it would affect their credibility of honesty. To sum, the funds generally could be stable on both the demand and supply sides.

f. Maintaining

Since some of us have learned some CS, so we can have the ability to write the system’s code while doing routine maintenance. We will also employ our CS teacher and other professional app developers to cooperate to eliminate the bugs in the system.

g. Management

As the founder of the system, as soon as the users have some comments in the community hub, we will get first-hand information for improvement or modification. If the users have some potential requests regarding the content of the system, the manager will read them first and make a fair decision about whether it is rational. If it is rational, then we will try to achieve it in contact with the programmers.

h. Privacy concerns of users

Since the green credit system is associated with individual private information such as one’ s name and identity ID, users would have a concern about their private information security problem. Therefore, the system would develop a two-factor identification security system, which means once users enter their private information and successfully pass the confirmation when they need to edit or see their information, they need to confirm both on their personal face identification and the fingerprint which is difficult to duplicate so that they can see the precise information and edit it. In sum, it can guarantee the private information can always be secured.

Prototype and Test

Prototype Design

We would develop three sectors for three different groups of people: enterprises, citizens, and government. As users insert their basic information, they will automatically enter the according to the sector. For first-time users, when they enter the system, the system will display the green credit rules to inform all the users. The main theme is in white and light green to give a sense of relaxed and sustainable feeling. In addition, in the middle of the main theme, the system will display users' current green credit with a progress bar and a corresponding ranking color. The worst color is red, which gives users an alarming and urgent feeling to make a real difference in their lives in order to improve their score. The second theme is the area of a community hub with several columns to display several kinds of information such as green strategies, the latest advanced green products, etc. On the last page of the setting, there is a self-check page and product exchange site.

 green credit system design layout

Feedbacks learnt from users

Quantitative feedback
We released the questionnaires for surveying the feedback of the green credit system and eventually we receive 239 copies effective back. First, from the respondants data, we can see that the age range for the respondants are mostly young people who are aobut 18 to 25 years old, which means that some old people rarely engaged in the system work, so in the improvement we need to consider how to attracrt more old people to engage in the system in order to have a greener lifestyle. From the question of the frequency of the use of the system, the result is exilirating as about 57 percent of people will have a habit of checking the system at least once a week. From the questions according to recording environmental lectures and learning about laws to offset some negative points, most of the respondants support the act as more than 90 percent of the respondants will engage in. However, the problem is that still some people not pay much attention to the importance of environment as in the question of the frequency of how long do people keep track of the environmental news, about 7 percent of people just say that they rarely pay attention to those news. Additionally, about 31 percent will

track the system once a month or even longer time interval. So, how to raise the old people's attention as well as promote more people to use our system in greater frequency is our objective in our next improvement from quantitative feedback.
Qualitative feedback
We interviewed our AP environmental science teacher about her opinion of our system. She commented that from the public’ s perspective, it is hard to guarantee that citizens strictly follow the environmental behaviors in their real lives. Additionally, since we do not provide a specific definition of green behavior, it may be difficult for others to discover or define whether his or her behavior is consistent with green behavior.

In addition, the teacher suggested that we should not only focus on those large enterprises but also on some new enterprises that operate green products. Helping them to further develop is also supporting green society. Therefore, reducing the financial pressure of the small emerging enterprises will also be one of the tasks of our green credit plan.

quantitative feedback

Improvement for next iteration

A.Users of the system
According to our survey, the majority of the response is people from 18 to 25 years old and generally, it displayed a right-skewed shape of the users' age distribution. So, from the survey, we can conclude that some old people are not quite engaged in using the system. So, in order to attract more older users, we plan to develop a more simple mode for older people to use. In addition, for the individual part of judging the environmental behaviors, many users say that there is the ambiguity of scoring for some green behaviors. So, we will implement a rubric about the environmental behaviors for the users to check whether the scoring is reasonable.

B. Design for the system
In the iteration part, we would perfect the decoration of the system. In the background, we would set the light green as the symbol of a green lifestyle. In addition, we will develop more environmental correlated buttons to attract more people to use and identify the corresponding functions easily. In this way, we can have more means to attract more people to use our system and keep track of the local environmental act.

C. Regulation for the industry sector
We will add the tax reduction for some companies as some green factories are at a small scale in the very beginning. Implementing the tax reduction act could

effectively alleviate the financial pressure of these small companies and facilitate them to invent more green products to sell.

Reference list

The root cause of the problem:
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4. Department, E. (2019). The three-year projection for the Miao Qiao River management (thesis).
Solution:
5. The first in the province! The highest punishment in a single time is 10 million! Wuxi will be implemented tomorrow. WeChat platform. (2021, August 31). https://mp.weixin.qq.com/s/7f5ZV9JJ-PrGDg3vuvS8JA.
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7. Zhao, Y., & Hua, R. (2021, July 27). Why do floods often occur in our cities? We put a small robot in the pipe network and let it look at the situation inside. WeChat Micro-channel public platform. https://mp.weixin.qq.com/s/8yCtWv-Ds8VUzgmSb4ueDw.

8. Hua, R. (Trans.). (2017, December 16). [Warning] The Ministry of Environmental Protection raided the night, and two packaging and printing factories in Shenzhen were fined more than 200,000 each! Sohu. Retrieved August 5, 2021, from https://www.sohu.com/a/210973550_167159.
9. Hua, X. (Ed.). (2021). Four Years on, Xiong'an new area construction at Full Throttle. Xinhua. Retrieved August 5, 2021, from http://www.xinhuanet.com/english/2021-04/01/c_139852880.htm.

*Note: As some of the documents rely on the permission of the local responsibility departments, they only allow us to cite some crucial data but not for the full release of the whole document.

Team Credits

Rundong Hua is responsible to decide the overall topic, check up the progress of each team member every three days, summarize and adjust the structure of the whole thesis, conduct actual investigation and analysis with the charger of the local sewage treatment plants, analyze and write: Summary, Identify the challenge, Identify a Root Cause, Generate Solutions, Identify the Criteria, Make an action plan, and Prototype and test.

Xiwei Gu is responsible to summarize and adjust the whole thesis, conduct the actual investigation with the charger, modify: Identify the challenge, Identify a Root Cause; analyze and write: Summary, Evaluate the solution, Generate Solutions, Identify the Criteria, Make an action plan, and Prototype and test. In addition, he is in charge of designing the logo and drawing the layout of our system.

Yuda Hua is responsible to analyze and write: Identify the challenge, Identify a Root Cause and participate in the investigation to take notes and ask central questions we need to know.

Yiyang Shen is responsible to analyze and write: Identify the challenge, Identify a Root Cause, Identify the criteria and collect resources.

Zhe Zhang is responsible to write and summarizes the resources in: Generate the solution and identify the criteria and draw the layout of the system.

Tiancheng Qiu is responsible to write and summarize the resources in: Generate the solution and evaluate the solutions. He participates in the design of the system.

Jiaxi Zhao is responsible to write and summarize the resources in: Identify a Root Cause and generate the solutions. In addition, he participated in the releasement of the prototype and design survey and analyze the results.

Onsite Conference File

Reference list
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2. Jiangsu Provincial People's Congress. (R. Hua, Trans.), Regulations of Jiangsu Province on the Prevention and Control of Water Pollution in Lake Taihu308–309 (2018). Wuxi, Jiangsu; Environmental protection department. http://www.jsrd.gov.cn/zyfb/sjfg/201802/t20180205_490050.shtml
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SI Mock Presentation
SI mock presentation
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Judge Comments

" I applaud the team for picking a somewhat invisible (to most people) problem such as wastewater treatment. It’ s not an easy topic to identify meaningful solutions, especially ones that do not require significant capital investment by the government.
The team does an excellent job in the root cause section in identifying the various complexities in the system, including overlapping administrative responsibilities making responsibilities unclear, issues with uptake of reclaimed water as well as watershed level planning issues, especially with larger urban areas upstream. Kudos!
Another solution that is practical and somewhat less expensive/complex to implement is to look at ways to capture trash/sewage going from the streets/manholes to the wastewater system. There are many mechanical systems that are relatively cost affective that allow this. These could be overlaid with a software/ AI based identification system to target hotspots to intervene.
As the team continues to develop their understanding of water management, I recommend they focus on volume and frequency. For instance, how frequently do the wastewater plans exceed their capacity in a year (or in other words, how often does a rain event overwhelm capacity)? What is the proportion of stormwater run-off vs wastewater meant for treatment? I would also caution against infrastructure heavy ideas in water management – there is a good reason why water infrastructure and pipes do not change for 50-60 years.
Good luck continuing your education on this issue!
"