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Climate Change Adaptation for Drinking Water Treatment Plant – A case study on Bangkhen Water Treatment Plant

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Summary

This report is prepared to show the effects of climate change on Bangkhen Water Treatment Plant in Bangkok, which is primary source of drinking water supply to Bangkok and its surrounding areas. The changing water quality of the raw water to the plant, limits the plant terms of production efficiency and increasing operational cost. Plant operators are finding it more difficult to provide safe drinking water to the users. With the changing raw water quality, the plant operators are facing three major challenges, i.e., Algae bloom, Salt Water Intrusion and increased Turbidity. Due to climate change the trends in water quality are also changing, but there is no fixed pattern and plants have to be prepared for these changes.

This report suggests possible measures in the treatment process or in the raw water management, which can be used to tackle these climate change related challenges.

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Acronyms and Abbreviations

BKWTP	Bangkhen Water Treatment Plant
BOD	Biochemical Oxygen Demand
DO	Dissolved Oxygen
MWA	Metropolitan Waterworks Authority
NTU	Nephelometric Turbidity Unit
PAC	Powdered Activated Carbon
PPP	Public Private Partnership
WTP	Water Treatment Plant

1. Introduction

1.1. Background

Climate change is now as imminent as it could be and it is going to affect human lives in ways that were unimaginable to mankind. Countries with tropical climate and long shorelines are more likely to get affected due to rising seawater levels. Moreover, climate change has affected the rain pattern, which is non-uniformly distributed over the year without a set pattern. Some countries are facing droughts and floods in the same year.

The changing rainfall patterns and rising sea levels have affected the drinking water supply in Thailand and has caused a loss of 1.5 billion Baht (WDR, 2011) in the year 1999. The growing industrial sector in the central parts of Thailand has led to an increase of 120 million cubic meters drinking water demand, from the year 2011 to 2015 (Metropolitan Waterworks Authority, 2015). The responsibility to provide safe drinking water in the capital city of the country resides with the Metropolitan Waterworks Authority (MWA). MWA has been dependent on the Chao Phraya River and Mae Klong River to meet the demands of water supply.

Due to climate change, MWA has been facing two major challenges in the dry season, i.e., algae bloom and saltwater intrusion. Algae bloom increases the filter backwashing rate and increases the cost of operations. While the increased salinity in water can cause harmful impacts on the health of the consumer. To keep a check on the water quality and increasing salinity, MWA has installed real-time water quality monitoring instruments, which feeds the data to an MWA monitoring station. The treatment plant is not equipped with the technology to reduce the increased salinity of the inlet water, which in turn reduces the water quality of the treated water. The reduced water quality in such a case typically lies out of the WHO standards, which is followed by MWA. In such a situation, the plant has to stop its operation and cease the pumping of raw water in the plant.

Similarly, wet season bring along flood in the Chao Phraya River Basin. This leads to a sudden increase in the turbidity of the river water, which is also aided by the water flowing from the flooded city into the river. Flood water also causes algae to bloom due to reduced dissolved oxygen (DO) and increased turbidity and biochemical oxygen demand (BOD).

1.2. Bangkhen Water Treatment Plant

Bangkhen Water Treatment Plant (BKWTP) is the most essential part of the water supply system of MWA, providing water to Bangkok, Nonthaburi and Samut Prakan. This treatment plant has 6 major operations – raw water selection, clarification, filtration, water storage, transmission and distribution, and sludge lagoon.

BKWTP depends on the Chao Phraya River for its water demand. Water is fed from Samlae Pumping Station, which is situated around 18 km away from the treatment plant located in Pathumthani district, next to Nam Omm natural canal.

Figure 1 Water Supply System of BKWTP

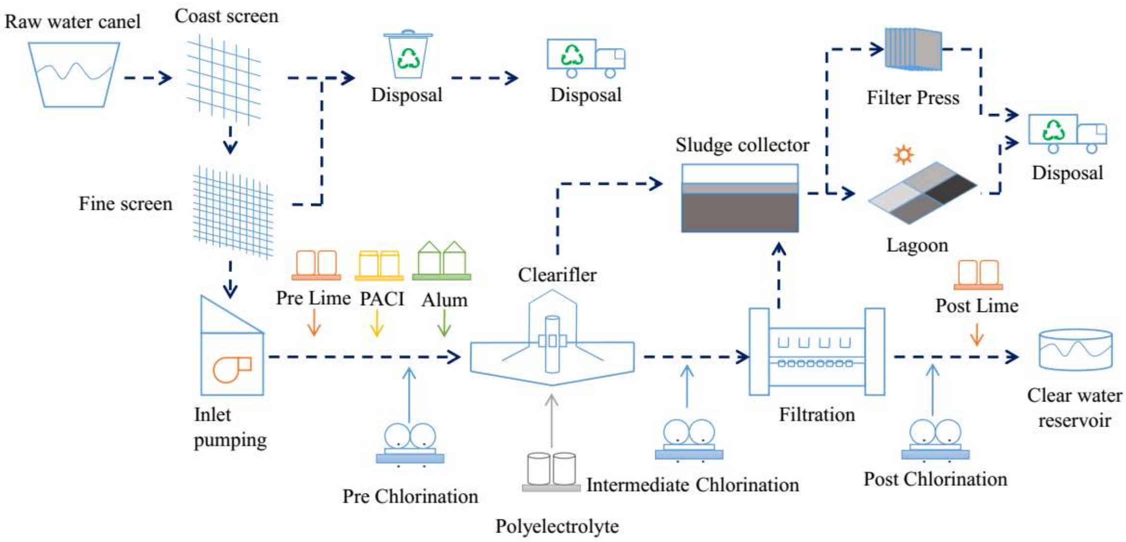


Figure 2 Bangkhen Water Treatment Plant - Treatment Process

This case study shows the impact of climate change on the Bangkhen Water Treatment Plant and the recommends the design guidelines for climate proofing of the water treatment plant. It includes a review of the existing complications faced by the treatment plant. Which are then utilized for design guideline recommendations.

2. Observations

As discussed earlier, BKWTP is the central part of the MWA water supply and thus it becomes important for the authorities to maintain a healthy supply of water.

2.1. Threshold Limits

The plant in its current specifications has certain thresholds, which if exceeded leads to subpar quality of treated water. Thresholds for BKWTP:

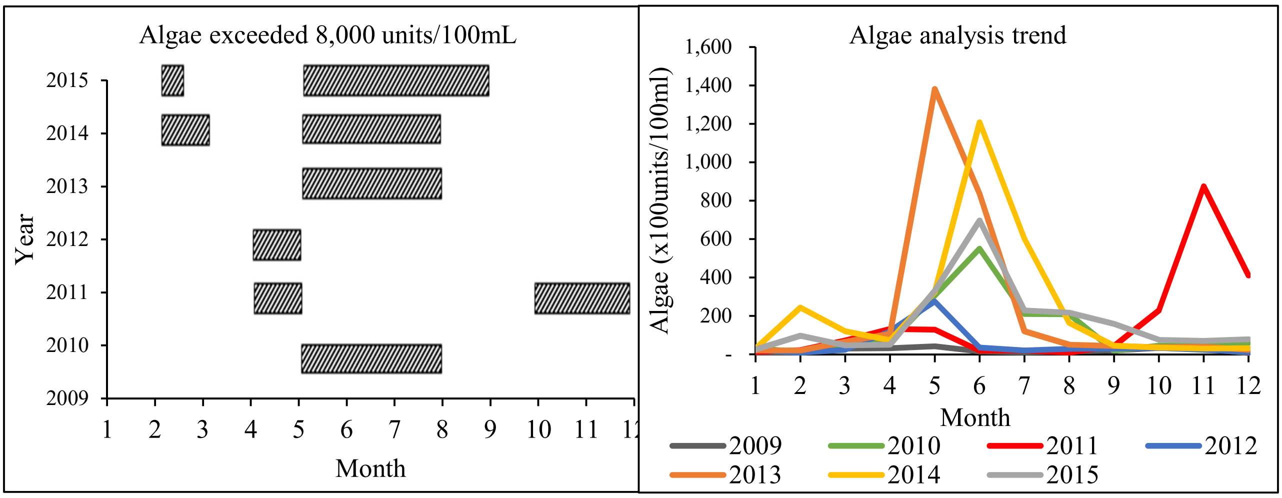
a) Algae Content - > 8,000 units/100 ml water, leads to filter clogging and increasing the backwashing cost by 4 times.
b) Salinity Level - > 0.65 g/L, at Samlae Station is kept as the limit for salinity for inlet water of the plant.
c) Turbidity Level - > 200 NTU, at Samlae Station is the limit for turbidity level beyond which the production of water is reduced.

2.2. Dry Season

Figure 3 Potassium permanganate and Copper Sulphate Treatment of Algae

Dry season brings two major issues with raw water supply:

a) Algae Bloom –



(a) (b)

Figure 4 (a) Duration of algae bloom from 2009-2015, (b) Trend and quantity of algae bloom from 2009-2015, (Mesomsup, 2017)

In figure 4, it can be seen that algae increases in the duration of dry or summer months. This trend has remained constant for past many year and has been on an upward trend. Algae does not interfere with the treated water quality, but it causes widespread hinderance with the treatment process. To get rid of algae bloom, the chemical dosages potassium permanganate (KMnO4) and copper (II) sulphate (CuSO4) is increased, which drastically increases the cost of chemical treatment. On the other hand, algae cause an increase in the filter backwashing frequency and duration. Typical backwashing duration remains between 48-70 hours, however during increased algae bloom the backwashing time reduces to mere 10 hours. Due to reduced backwashing time and higher frequency the amount of backwashing water also increases.

b) Increased Salinity –

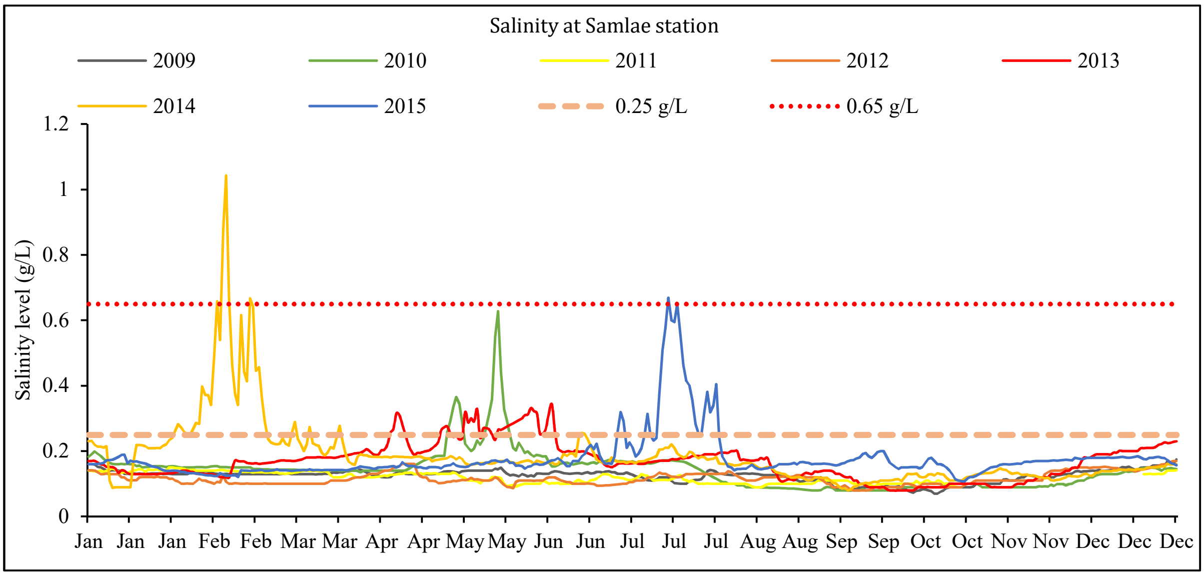


Figure 5 (a) Trend of salinity from 2009-2015, (b) Relationship between salinity at Samlae and Bangkhen inlet (Mesomsup, 2017)

In figure 5, it can be seen that the salinity of the water is increasing every year at Samlae station, which increases the salinity at Samlae-Bangkhen Inlet. Although, the Samlae station is located 96 km away from the Gulf of Thailand, the high tides in the sea causes an increase in the salinity of water because of the rising water level in the sea. Salt water intrusion in the inlet water reduces the quality of treated water and the plant operators have to warn the users about the increased salinity. To avoid such situation the plant operators typically operate plant in the duration of low tides.

c) Organic Contamination –

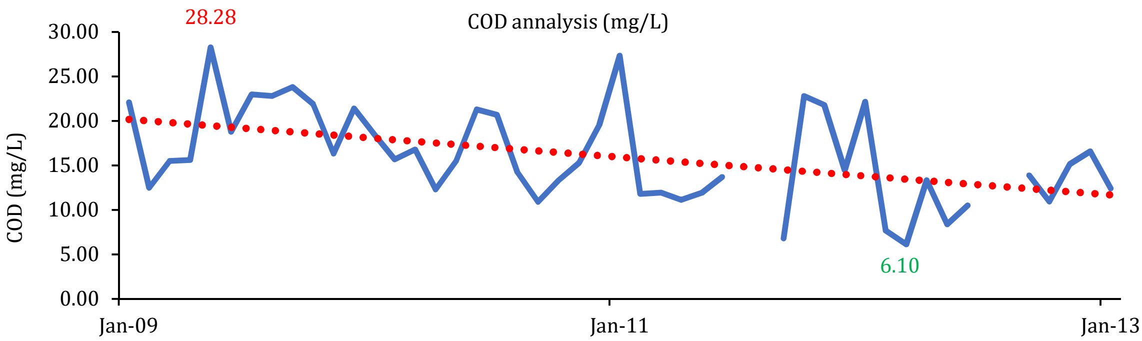


Figure 6 COD in raw water analysis, (Mesomsup, 2017)

Chao Phraya river is surrounded by residential buildings, industrial areas and agricultural fields, which leads to the percolation of organic material in to the river stream. This increases the concentration of organic content especially during the dry seasons. Although, there is downward trend in organic content as it can be seen from figure 6, the regulatory authorities have decided to change the measuring parameter from COD to Turbidity of water.

2.3. Wet Season

Thailand being a tropical country witness heavy rainfall especially during wet season. This leads to an increased turbidity in the water.

a) Turbidity –
In the wet season, the amount of foreign materials entering the Chao Phraya river increases drastically. This leads to increased turbidity at the inlet water from Samlae station. BKWTP is designed to operate at a maximum capacity of 200 NTU turbidity, however even if the turbidity remains within the treatment capacity of the plant it increases the operational cost. This also reduces the treatment capacity and reduced quality of treated water. s

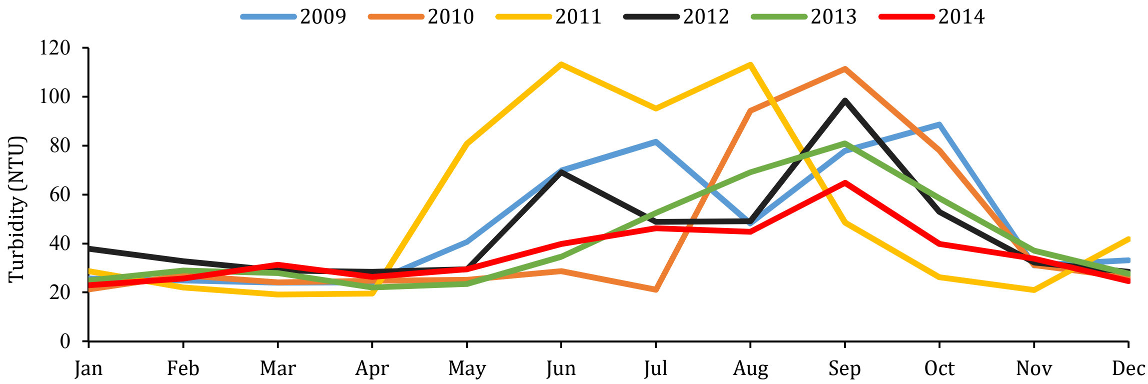


Figure 7 Raw water turbidity level at Sam Lae station from 2009 to 2015, (Mesomsup, 2017)

In figure 7, it can be seen that turbidity levels in the raw water has never exceeded the treatment capacity of BKWTP. However, there was an increase in the value in 2011 during the time of floods in summer, which was an exception. Turbidity increase in the inlet water increases the treatment cost and reduces the efficiency of the plant, as more coagulant is needed to cope up with the increased turbidity.

3. Recommendations for Climate Resilience

As, discussed earlier BKWTP is central part of water supply system for metropolitan Bangkok and its surrounding regions. Therefore, to make the plant climate resilient it becomes important to not only improve on technological fronts but also develop stronger policies. To ensure that the growing stress on the technological advancements on the plant remains limited, the development rate of policies should supersede with technological advancements. Figure 8, describes the position and possible methods for adaptation of climate proofing mechanisms, that are suggested in sections 3.1 and 3.2.

3.1. Policy Establishment

To keep the water supply intact and to maintain consistent water quality, it is important to develop various policies that can vary from simple techniques such as improvement in the supply system to creating water marketing and banking strategies. Table 1, summarises some of the suggested improvements in policy establishment to sure foot the advancements of water treatment policies for WTP.

Institutional improvements throughout the hierarchy of BKWTP will help the plant operators and officials to understand the impact of climate change on WTP. The training of plant officials will assist them in deciding the water demands and selecting regions based on the data. Meanwhile, they can work on their strategies to improve or maintain the water quality standards, irrespective of the changing climate or raw water quality.

As the legislations are made stronger for the use of water, the penalties or punishments impended with squandered usage of water will limit the wastage. Check on illegal activities will result in increased availability of treated water for those in actual need. Moreover, stronger legislation will formalize the water sector in the country and eliminate unwanted middlemen from the supply chain.

As discussed in table 1, the creation of PPPs will bring in better technology and expertise in the water sector. Private organizations are better at managing and completion projects in a limited period, due to narrower bureaucracy in the structure. Although the cost of projects could be higher, bringing in private organizations reduces the risk management expenditure from the governmental organizations.

Metropolitan cities like Bangkok have extremely limited green space, which reduces space for water percolation in the ground. There are only 3 m^2 of green area per capita in Bangkok, which is minuscule when compared to Singapore where 66 m^2 of green space is available per capita. This results in flash floods and increased stormwater supply in the wet season and dry spell during the dry season. Therefore, for a city like Bangkok, it becomes pivotal to increase its green space for better water banking. Moreover, water marketing from one area with sufficient supply to areas with limited water supply will help in addressing the problem of water shortage during dry seasons. This can be further facilitated with the addition of newer supply lines, which will reduce the leakages and provide better connectivity within the region.

Water treatment is an energy intensive process and with the use of membrane technologies, the energy demand is expected to further increase. In order, to reduce the dependence of treatment plants on conventional supply methods, Solar Cells or Wind Turbines can be utilised. This will keep the plants operational in the times of calamity. Moreover, the energy demands of increasing treatment capacity of plant can be easily satisfied by the new energy sources.

Table 1 Policy Improvements for Climate Proofing BKWTP

Policy	Description	Impact
Institutional improvements	1. Training of staff to attune them with the technical changes resulting from climate change improvements. 2. Optimized allocation of treated water. 3. Planning for water quality improvements.	1.Creates awareness among the plant operators and policy makers of imminent impacts of climate change
Strong legislation	1. Creation of stronger regulations for water theft and use. 2. Limitations on the use of treated and discharged water.	1.Reduce the misuse and water related crimes. 2.Treated water should be used more judicially.

Water marketing and banking	1. Increasing the green coverage in the city, to increase water banking in aquifers. 2. Limiting the rights of permanent water usage. 3. Construction of new facilities to bring water more efficiently to those in need from those in abundance.	1. Increase the storage capacity of underground aquifers. 2. Availability of water throughout the dry period of year. 3. Newer supply system will reduce the leakage of water.
Development of Public Private Partnership (PPP)	1. PPP will bring state-of-the-art technologies for WTP. 2. Can establish projects with Build-Operate-Transfer (DBT) or Design-Build-Operate (DBT). 3. Creating PPPs will share the risk of WTP operation and building between government and private partners.	1. Better technology availability and implementation. 2. Private ownership can develop with green economy. 3. The burden of financial and operational risks will be reduced from the government.
Adapting alternative energy sources	1. Changing the dependence on electricity or energy from conventional sources to solar or wind energy. 2. Reduced dependence on conventional supply system	1. Reduces the carbon footprint of the plant. 2. Increases the self-sufficiency in the time calamity.

2.2. Technological Improvements

According to table 2, the treatment measures can be divided in to 2 parts, i.e., measures in the raw water management and measures in the treatment process.

Table 2 Measures for Climate Proofing BKWTP

Raw Water Management Measures					
Alternative measures	Problems				Remarks
	Salinity	High turbidity	Low water quality	Algae	
Changing water source	✓	✓	✓	✓	Depend on new source conditions
Raw water reservoir	✓	✓	✓		Required large area
Treatment Process Measures					
Membrane	✓	✓	✓		
Membrane + Conventional	✓	✓	✓		
Tube settler + PAC+ Membrane	✓	✓	✓	✓	
PAC			✓	✓	Depend on the location where is added.
Tube settler		✓			

Tube settler + PAC		✓	✓	✓	
Adsorption			✓	✓	
Tube settler + Adsorption		✓	✓	✓	

Changing the raw water source can eliminate all the major challenges faced by BKWTP. But this remains dependent in the quality of water in the new water source. If the water quality in the new source is also affected due to climate change, it will create challenges which are similar to the current situation.

Another, method is to create a water reservoir which can withhold the raw water. This can put a check on all the challenges except algae bloom. However, with a regulated state if the reservoir algae bloom can be controlled very conveniently using chemicals and physical methods.

In terms of changes in treatment process, use of more advanced water treatment technologies such as membranes or tube settlers will lead to an effective prevention of the treatment plant and treated water from the effects of climate change. Using membranes in combination with Powdered Activated Carbon (PAC) and tube settlers will be able to control all the problems.

To control algae in the raw water both chemical and operational strategies can be adopted. BKWTP has not yet utilised PAC in their treatment process, which is a very flexible method to control the algae and can be done with the current process. However, using PAC will increase the operational cost of the treatment process. While, on the other hand using operational changes in the plant which limits to mechanical process of using a strainer before the canal or putting a cover on the canal, clarifier tanks and filtration tanks. This cover will reduce the light entering the tanks and will limit the photosynthesis, eliminating the algae growth.

The increased salinity can be reduced by using RO membranes in the treatment process. Although, costly in installation and operation RO can effectively reduce the salinity of the treated water. Moreover, RO eliminates the need of using any chemicals in the process.

The current design of the treatment plant is efficient enough to tackle the increased turbidity. However, to increase the efficiency and to keep the plant operational for future in case of any sudden increase in turbidity is observed, tube settlers can be installed. Tube settlers can increase the surface loading rates and in turn can increase the efficiency of the plant.

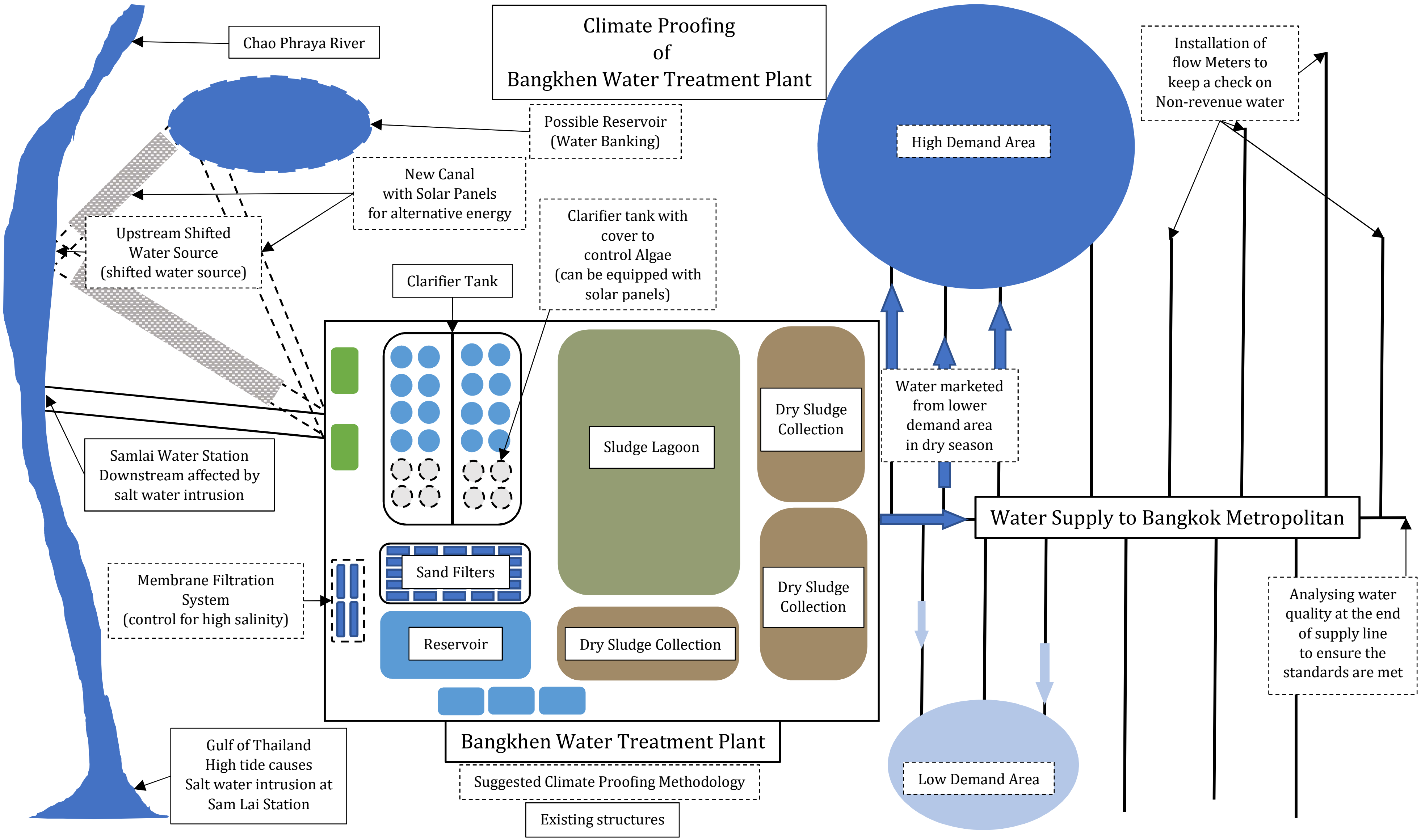


Figure 8 BKWTP Climate Proofing

4. Conclusion

Although, there are widespread efforts to reduce the effect of climate change, but the effects are now prominent and can be felt on the water quality. In order to provide safe drinking water to its citizens and to achieve SDG 6 of the UN, the governments and authorities around the world are compelled to modify their water treatment infrastructure. In countries like Thailand, where the effects of climate change can be more drastic compared to other countries, it becomes inevitable for the authorities to adopt themselves as soon as possible.

This case study on BKWTP is one such example, where authorities are trying to cope up and adopt according the changing conditions. Although, the plant is operational even with the changing water quality the authorities will have to adopt as soon as possible to keep the plant operational in future. The recommendations suggested in this case study report can be modified and implemented to climate proof other water treatment plants.

5. References

Mesomsup, T. (2017, July). Assessment of Climate Change Impacts on the Performance of Bang Khen Water Treatment Plant in Bangkok. *AIT Thesis*. Bangkok, Thailand: Asian Institute of Technology. Thesis Number UWEM-17-03

Metropolitan Waterworks Authority. (2015). *MWA Annual Report 2015.* Bangkok: MWA. Retrieved from http://www.mwa.co.th/download/pln0201/annual2015/annual report_2015_th.pdf

WDR. (2011). *World Development Report.* Washington, D.C., USA: The World Bank.