World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:16, No:3, 2022

Circular Economy: Relationship of the Natural Water Collection System, Afforestation and Country Park towards Environmental Sustainability

Kwok Tak Kit

***Abstracts*—**The government and community have raised their awareness of the benefits of water reuse. Deforestation has a significant effect to climate change as it causes the drying out of the tropical rainforest and hence increases the chance of natural threaten the storage and supply of clean water. This paper focuses on discussion of the relationship of the natural water collection system, afforestation and country parks towards environmental sustainability and circular economy, with a case study of water conservation policy and strategy in Hong Kong and Singapore for further research.

***Keywords*—**Afforestation, environmental sustainability, water conservation, circular economy, climate change.

I. Introduction

CONSERVATION of natural resources is the vital goal to combat global climate change. The United Nations' Sustainable Development Goal 6 (SDG 6) consists of a total of 17 goals targeted to address water related issues. According to [12], the global population using safely managed drinking water and sanitation services increased by 2 billion and 2.4 billion between 2000 and 2020. However, there are still 2 billion people lacking safely managed drinking-water services, 3.6 billion safely managed sanitation services and 2.3 billion basic hygiene services in 2020. In view of global populations continuing to expand and potable water supplies continuing to become uncertain and decreasing, the issue of water security and resilience is of concern to all governments, and highlights the need to implement urgent plans to start the conservation and imminent actions. It is the ultimate task for different government agents to form a clear roadmap to better and effectively utilize the existing water supplies to avoid underutilization and wastage, and create a more resilient future. The concept of a circular economy makes a revolution to the traditionally linear approach on water utilization and boosts the economy to the next regeneration for reuse and repurposing the rare and valuable water resources. The need for global adoption of advanced technology, knowledge and management of water treatment is increasingly urgent.

II. Sustainable Water

Sustainable water means a nation in which the efficient supply of water is self-sufficient and can ensure enough and consistent water through energy neutrality by coupling traditional water treatment technologies with renewable energies. It could also meet the needs from multiple sectors from agriculture to municipal and industrial, despite the impacts of climate change like lack of rainfall and drought. According to [10], it is revealed that catchment water was cheaper than recycled or desalinated water, and, desalination plants were mothballed or maintained at low processing rates [10].

III. Sustainable Development Goal 6: Clean Water and Sanitation

The United Nations' Sustainable Development Goal has 17 sustainable development goals at its core to stimulate partnership engagement in support of the achievement of sustainable development goals by 2030.

Under SDG 6– Clean Water and Sanitation, the target to achieve by 2030 included the major aspects shown in Fig. 2 [19].

Water Stress Indicator under SDG6

SDG 6 plans to ensure safe drinking water and sanitation for all and focuses on the sustainable management of water resources, wastewater and ecosystems. In the agenda for sustainable development, the countries participated in SDG 6 have committed to engage in systematic follow-up and review of progress towards the goals and targets. The water stress is one of the indicators which is adopted to measure the ratio of total freshwater withdrawal to total renewable freshwater resources, after taking into account environmental flow requirements. The inductors also reflect the effectiveness of natural water use and generation of renewable water. The data shown in Fig. 3 revealed that both South Korea and Singapore have significant and excessive withdrawal freshwater from natural sources compared to the freshwater available amongst major countries in Asia Pacific and around the World.

IV. Natural Water Sources and Collection

According to the United Nations' population estimates, the world population is projected to reach 9.7 billion by 2050 and 80% of the world's waste water flows back into the ecosystem without being treated or reused which may dramatically increase the future demand for clean water [8], [18]. Urgent action by all water users (environment, agriculture, domestic and industry) by promoting ecosystem management, resource

Kwok Tak Kit is with DLN Architects Limited, Hong Kong (e-mail: tkepisode@gmail.com).

efficiency, and governance and climate change adaptation is therefore becoming an increasing concern and important in water security. Lesson learnt from other countries, a framework system should also be developed and established to collect documents, procedures, processes, data and other activities and records that support the safe use of recycled water [1], [5], [10].

Fig. 1 The Sustainable Development Goals Established by United Nations [19]

Fig. 2 Major Aspects under SDG 6– Clean Water and Sanitation

In terms of water security due to population growth and climate change, different action plans are developed and implemented by different countries and cities now and in the coming future. The major concept and methodology of conservation of natural water can be classified as:

- Natural Water Collection System
- Afforestation
- Country Parks
- Education of Human Behavior on Use of Water
- Reusing, Recycling and Desalination

Natural Water Collection System

At the global and national level, the city water supply and water treatment are mainly operated by local governments in major countries and cities. The natural water is mainly captured and harvested by:

- Rainwater collection facilities by dams and reservoirs.
- Directly extracted from rivers sourced from mountains

In some cities, the water supply may have been sourced from other adjoining cities due to their geology or by recycling through desalination, as in Hong Kong and Singapore. Sustainability of water resources requires the adoption of an innovative and proactive approach to water management including heavy investment into its reservoir catchment system that directly leads to sustainable water supply.

Afforestation

Trees and forests not only play a significant role in affecting soil infiltration capacity and reducing erosion, they also enhance soil quality through litter fall and extensive root systems, and have been shown to act as natural water purifiers for clean water storage. Forests can achieve the function of more rainfall that tends to be partitioned through soil infiltration and to green water (used for food and fiber production), reducing its availability as blue water (available for human consumption) downstream [9]. Increasing surface runoff after

deforestation increases surface run-off and possible soil deterioration, leading to more "blue water," but water that is often polluted by soil erosion.

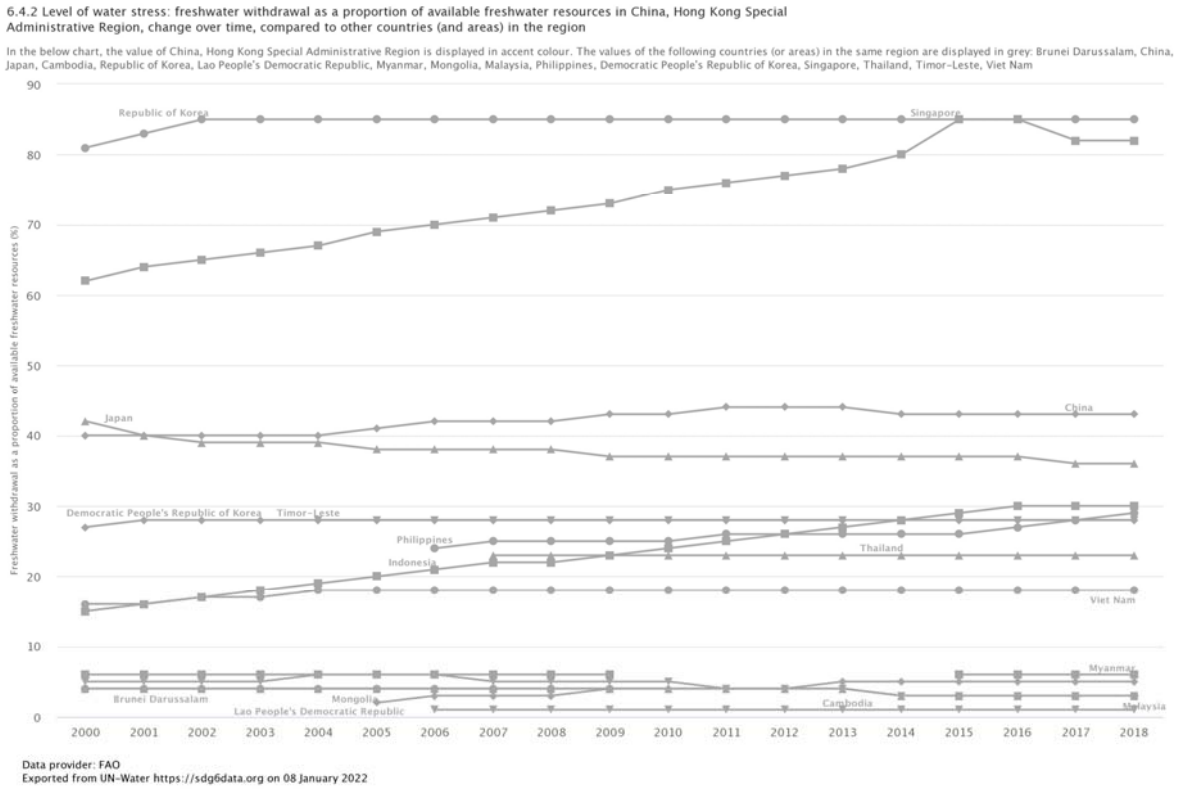

Fig. 3 Level of Water Stress: Freshwater Withdrawal as a Proportion of Available Freshwater Recourse in China, HKSAR, Change Over Time, Compared to Other Countries (and areas) in the Region [26]

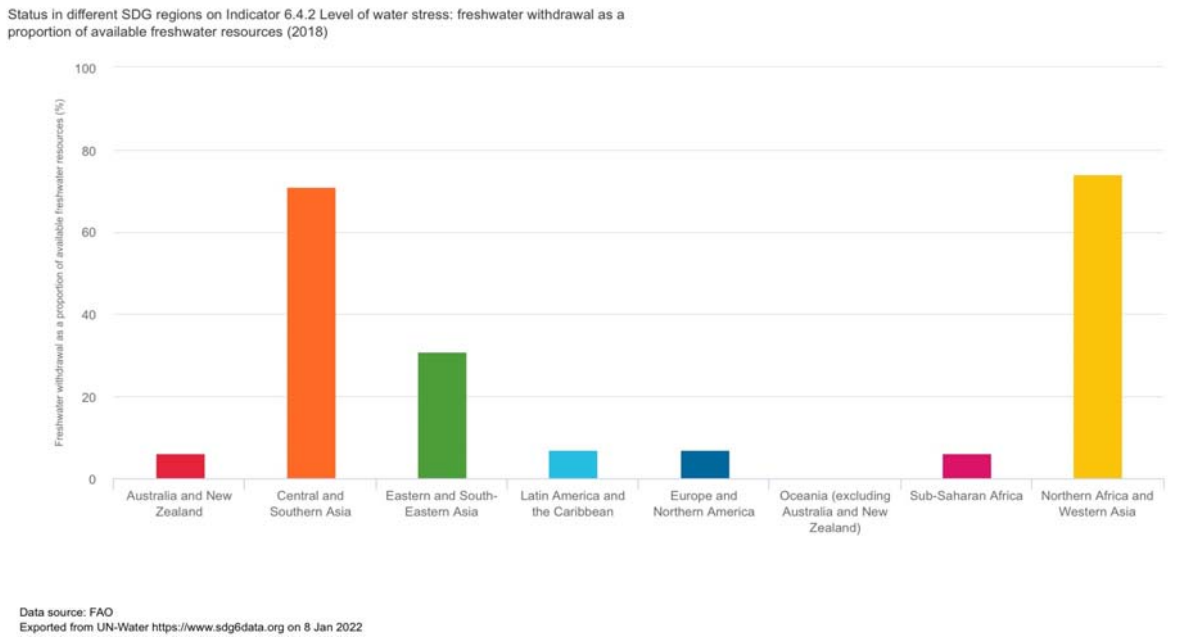

Fig. 4 Status on Different Regions on Level of Stress, Freshwater Withdrawal as a Proportion of Available Freshwater Resources (2018) [25]

According to [2], trees will hydraulically redistribute water during the dry season which means that the trees at night transport water from deeper soil layers to the top soil. Moreover, vegetative cover is to ensure maximum rainwater infiltration into the soil profile [3]. Forest served as a reservoir to ensure stable base flow in downstream river system and

increase water infiltration into soil for redischarge to shallow ground water sources.

Country Parks

Country parks are the main rainwater catchment areas and provide accommodation for trees in urban and rural areas. Afforestation can improve water quality by minimizing soil erosion, reducing sediment, and absorbing polluting chemicals; forests maintain and improve water quality. Country parks play a crucial role in the hydrological cycle, which influences the water available to regulate surface and groundwater flows as well as maintain and improve water quality. Rapid climate change adds to pressures on forests and risks leading to critical transitions or regime shifts in ecosystem structures and processes.

Forests serve as our natural water collection, storage, filtration, and delivery systems by collecting rain and snow and delivering it into streams, wet meadows, and aquifers throughout the year. Water flows from forests into rivers that supply our reservoirs, agricultural water, and drinking water.

Education of Human Behavior on Use of Water

Education of users is considered crucial to strengthen their awareness and attention on water conservation and use of recycled water. Government can provide funding for R&D and the development of pilot projects to identify innovation opportunities. Different measures can be implemented to achieve better use of water including roof-top rainwater water collection design, inclusion of catchment areas in building design and construction, installation of green roofs in new and existing construction, encouragement of water discharged from sewage treatment plants to be used in irrigation and flushing water. Other initiatives include promoting the use of effective water-saving devices, enhancing water leakage control installation and extending the potentiality of the use of seawater for toilet flushing.

Reusing, Recycling and Desalination

Sources of water for potential reuse can include municipal wastewater, industry process and cooling water, storm water, agriculture runoff and return flows, and produced water from natural resource extraction activities. Water recycling mainly refers to reusing wastewater such as from residential, industrial places, agricultural irrigation, etc., to implement something beneficial [22]. Water recycling provides great opportunities for the re-use of waste water to resolve the fresh water shortage. The principle of water recycling serves both water and money saving in different aspects and re-creates the functional propose of treated water. To ensure the satisfaction of recycled water supply to satisfy the demand, it is important and necessary that the waste water is adequately treated before use.

While in some nations lacking freshwater, desalination has provided an adequate water supply for many years. The development of sustainability of desalination can be further improved by the use and adoption and integration of renewable energy like solar power desalination to enhance its sustainability. Focus should be placed on the interaction and balance of economic growth, social equity and environmental sustainability for better and more sustainable development of cities. In case all possible means of water conservation had been adopted which still cannot meet the water demand, seawater desalination development is the ultimate option.

Environmental Impact and Sustainability Due to Deforestation

Due to rapid urbanization and industrial generation, the natural water sources are heavily contaminated and polluted in some developing countries and the supply of clean water becomes more rigorous with the continuing industrialization and lack of positive measures to alleviate and mitigate the pollution.

The cause of deforestation including conversion of forests for other land uses like roads and infrastructure, forest fires, illegal and unsustainable logging, fuelwood harvesting, over-harvesting for domestic use or for commercial trade in charcoal which significantly damages forests and accelerates the global climate change.

The United Nations Strategic Plan for Forests 2017-2030 (UNSPF) established a global framework for all levels to sustainably manage all types of forests and also trees outside forests which intended to halt deforestation and forest degradation [17], [24]. The forests provide the essential ecosystem element including timber, food, fuel, fodder, shelter, soil conservation, water conservation, and clean air which also prevent land degradation and desertification and significantly reducing the risk of floods, landslides and snow slide, droughts, dust and sand storms and other disasters.

V. Water in Circular Economy

The World Bank developed and established a new framework to help water practitioners ensure circular economy principles can be incorporated across policies, strategies and planning. The application of Water in the Circular Economy and Resilience Framework (WICER) could provide environmental, social, economic and financial benefits, according to the World Bank [6], [7], [21]. According to the WICER report, it highlights the role of the water sector towards the reduction of greenhouse gas emissions through a combination of energy efficient measures and renewable energy self-generation [4], [6], [11], [21].

VI. Sustainable Water Management

It is agreed that in order to achieve sustainable water management, it requires a multidisciplinary and holistic approach in which technical, environmental, economic, landscape aesthetic, societal and cultural issues are addressed.

The United Nations General Assembly recognition (Resolution 64/292) of “the right to safe and clean drinking water and sanitation as a human right that is essential for the full enjoyment of life and all human rights”. It is to ensure sustainable water to provide each person with access to the minimum 20 to 50 liters of daily water required to support their life [20]. The Resolution also formally asks the States and international organizations to provide financial resources, contribute capacity-building and technology transfer to help

countries, particularly for developing countries, to provide safe, clean, accessible and affordable drinking water and sanitation for all [20].

Water sustainability comprises effective and holistic management of water resources. According to the US Environmental Protection Agency (EPA), water utilities can be effectively planned such that water and wastewater systems can manage their operations and infrastructure as well as ensure the sustainability of the communities [13]. According to the International Water Association (IWA) [14], sustainable water systems should provide adequate and accepted water quantity and quality without compromising the future ability to provide this capacity and quality.

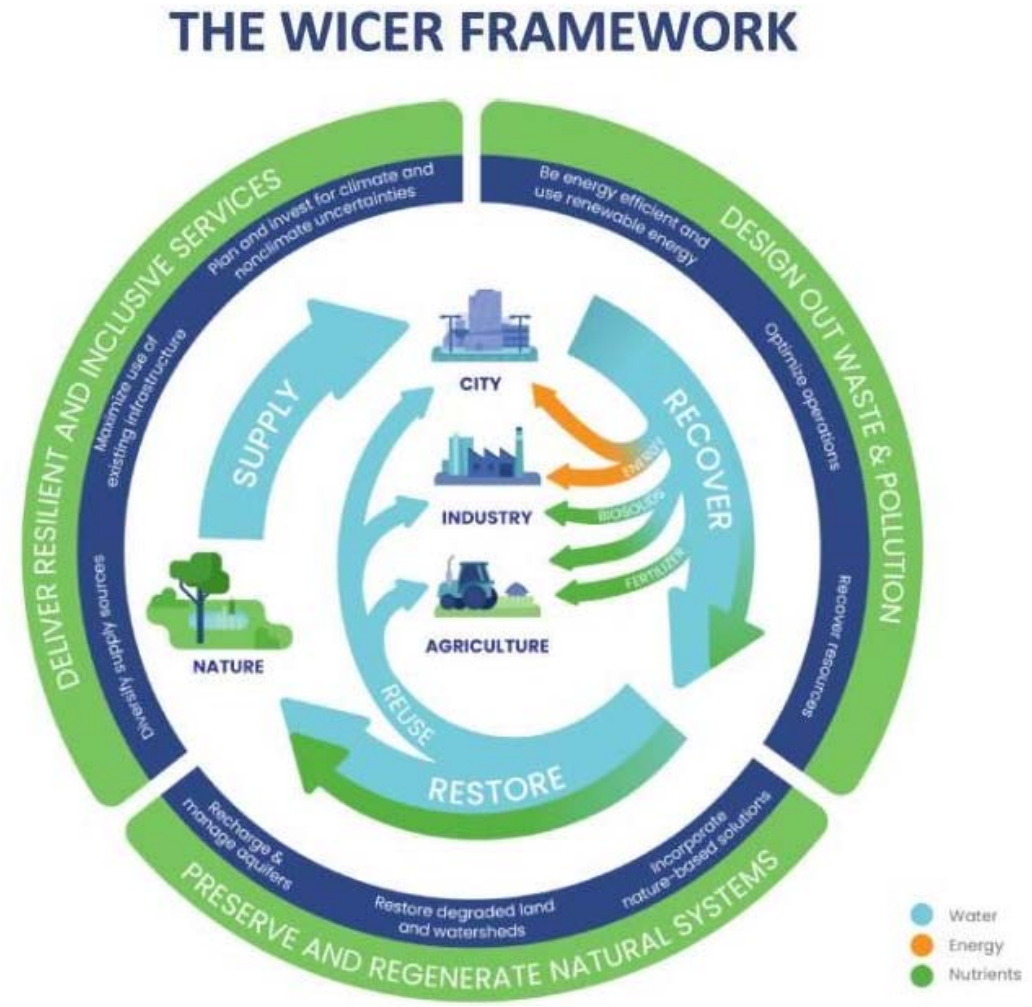

Fig. 5 The WICER Framework [27]

According to [21], water systems in the realm of sustainable development may not literally include the use of water, but include systems where the use of water has traditionally been required. Examples include water saving water tap, waterless toilets and waterless car washes which could help to alleviate water stress and secure a sustainable water supply [21].

VII. Case Study of Hybrid Adoption of Conventional Water Collection and Alternative Water Conservation Using Advanced Technologies

(A) Case Study of Water Supply Model in Hong Kong

Water Supply Sources Model

Although Hong Kong is one of the renowned small and dense cities with a total 1,108 square kilometers of land, about three-quarters is countryside with 17 impounding reservoirs as the natural catchments of rainwater. Hong Kong has two main sources of water, rainfall from natural catchments and Dongjiang water from Guangdong Province. The country parks in Hong Kong take up a total area of 44312 hectares including scenic hills, woodlands, reservoirs and coastline in all parts of Hong Kong and it also comprises reservoirs with total storage capacity of about 586 million cubic meters [13].

Since the average annual rainfall in Hong Kong is only about 2,398.5 millimeters which is insufficient to meet current demands, supply from Guangdong, Dongjiang is another of Hong Kong's major source of water. The alternative water supply system is designed to be capable of providing Hong Kong with 1.1 billion cubic meters per annum [13].

Alternative Water Sources - Adoption of Innovation and Latest Technologies for Energy Conservation and Water Recycling

Although there is no desalination plant in Hong Kong, the government has explored further water conservation through adoption of recycling. A pilot case called "T-Park", which is operated by the Environmental Protection Department, is a unique self-sustained facility for "waste-to-energy" sewage sludge treatment which can handle a maximum capacity of 2,000 tonnes of sludge per day to alleviate the overloading due to sludge disposal to landfilling [16]. The T-Park, using the advanced incineration technology through the high-tech thermal process, is adopted to ensure efficient and reliable treatment of sludge. The incinerator, turbine and condenser work together to recover heat energy and generate electricity to support the daily operation of the entire facility. The advanced desalination plant is deployed to purify seawater withdrawn from the nearby sea and to provide potable and processed water. Rainwater is collected for non-potable use. The facility achieves "zero effluent discharge" through the deployment of a compact wastewater treatment system which allows all wastewater being collected to be well treated and reused on-site for irrigation, flushing and cleansing purposes.

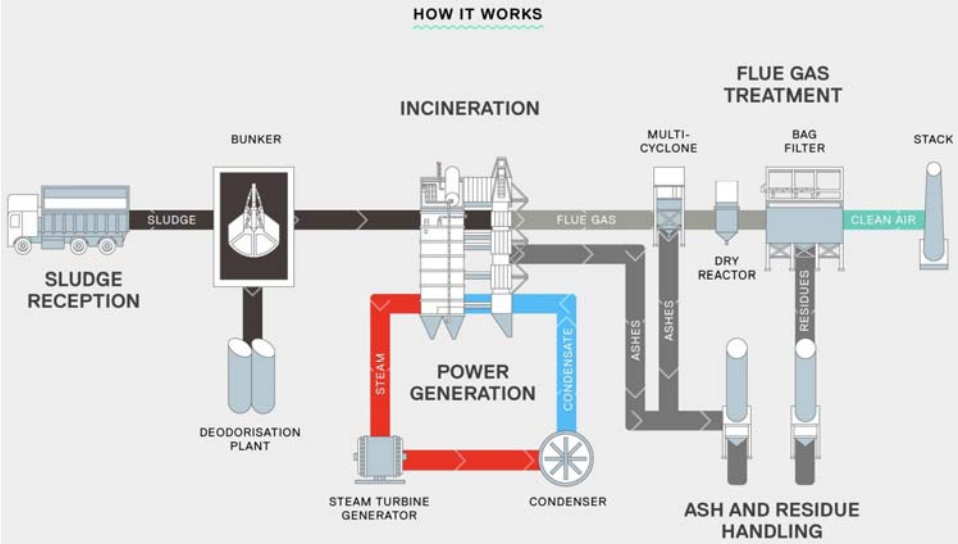

Fig. 6 Sludge Treatment Processing Diagram [28]

(B) Case Study of Water Supply Model in Singapore

Water Supply Sources Model

Singapore being a tiny island nation has little in the way of natural water sources through a network of rivers, canals and drains, rain that falls on two-thirds of Singapore's land area to 17 reservoirs with Natural Reserves [15]. Singapore is limited in space and therefore the main sources come from water from local catchments and imported water. Another water collection system for "used water" adopted in Singapore collects used water through underground sewers which lead to a water reclamation plant. Singapore has long relied on supplies from neighboring Malaysia and the government has started to explore alternative water sources based on the strategy of "collect every drop" and "reuse endlessly".

Alternative Water Sources - Adoption of Innovation and Latest Technologies for Energy Conservation and Water Recycling

The membrane technology has improved significantly and about 40% of water supply comes from recycled sewage in Singapore. [23] Currently, Singapore has built a robust and diversified supply from high-grade reclaimed water and desalinated water. The two compensatory sources of supply are: (1) NEWater and (2) Singapore's brand of reclaimed water, involving membrane and other cleaning technologies, and desalination of seawater. The first "NEWater plant" could be constructed. Three desalination plants were built which now supply the countries with 30% of water requirements. The technology of reverse osmosis treatment was used on wastewater at the Bedok NEWater plant in Singapore [15].

VIII. Conclusion

Based on investigation of different national organizations and government research on water security and their impact on their economy, sustainability development and global climate change, it was concluded that they are all aware of the need for conservation of natural resources including water as the vital goal to combat global climate change. The relationship of water conservation with afforestation and country parks is reviewed in this paper and it is considered necessary to take urgent action for water conservation to cope with continued future global population growth and water demand. Adoption of different methodology and global trends in water conservation, particularly in conservation of forests as one of the major natural water reservoirs is reviewed. The case study of two locations in Asia Pacific is reviewed in terms of their geology, water sources and supply model and the development of desalination as water recycling. The finding and review in this

paper is to present the updated concept and technology on water conservation for further research.

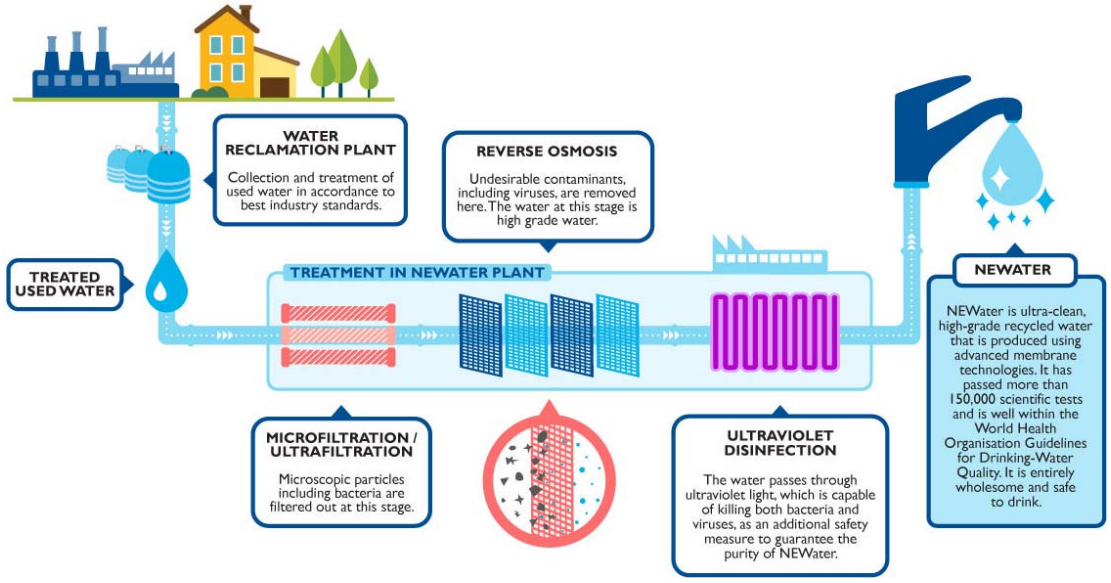

Fig. 7 NEWater Treatment Processing Diagram [29]

REFERENCES

[1] Asmalia Che Ahmad, Asniza Hamimi Abdul Tharim, Mohamad Haizam Mohamed Saraf1, Mohamad Quzami An-Nuur Ahmad Radzi, Meor Abdullah Zaidi Meor Razali, Zubir Ahmad Muhammad Ismail, Investigating the potential of water supply system for environmental sustainability, The 5th International Conference on Rebuilding Place, IOP Conf. Series: Earth and Environmental Science 881 (2021) 012040 doi:10.1088/1755-1315/881/1/012040

[2] Bayala J., van Noordwijk M., Lusiana B., Ni'matul K., Teklehaimanot Z., Ouedraogo S.J. (2008) Separating the Tree–Soil–Crop Interactions in Agroforestry Parkland Systems in Saponé (Burkina Faso) using WaNuLCAS. In: Jose S., Gordon A.M. (eds) Toward Agroforestry Design. Advances in Agroforestry, vol 4. Springer, Dordrecht

[3] Casenave, A. and Valentin, C., 1992. A runoff capability classification system based on surface features criteria in semi-arid areas of West Africa. J. Hydrol., 130: 231-249

[4] C. Oughton & M. Anda & B. Kurup & G. Ho, Water Circular Economy at the Kwinana Industrial Area, Western Australia—the Dimensions and Value of Industrial Symbiosis, Circular Economy and Sustainability https://doi.org/10.1007/s43615-021-00076-3

[5] Department of Primary Industries, Office of Water NSW Guidelines for Recycled Water Management Systems, ISBN 978-1-74256-764-8

[6] Delgado, Anna, Diego J. Rodriguez, Carlo A. Amadei and Midori Makino. 2021. "Water in Circular Economy and Resilience (WICER)." World Bank, Washington, DC

[7] Desbureaux, Sébastien, Richard Damania, Aude-Sophie Rodella, Jason Russ, and Esha Zaveri. 2019. "The Impact of Water Quality on GDP Growth: Evidence from around the World." World Bank, Washington, DC.

[8] Economic and Social Council, United Nations, High-level political forum on sustainable development, convened under the auspices of the Economic and Social Council, Agenda item 6, 2021 session, 23 July 2020–22 July 2021

[9] Farley, K.A., Jobbágy, E.G. and Jackson, R.B. (2005), Effects of afforestation on water yield: a global synthesis with implications for policy. Global Change Biology, 11: 1565-1576. https://doi.org/10.1111/j.1365-2486.2005.01011.x

[10] John C. Radcliffe, Declan Page, Water reuse and recycling in Australia-history, current situation and future perspectives, Water Cycle 1 (2020) 19–40

[11] Liu, Q., Yang, L., Yang, M. Digitalisation for Water Sustainability: Barriers to Implementing Circular Economy in Smart Water Management. Sustainability 2021,13,11868. https://doi.org/10.3390/su132111868

[12] M. Bazza, Wastewater recycling and reuse in the Near East Region: experience and issues, Water Science and Technology: Water Supply Vol 3 No 4 pp 33–50 © FAO 2003

[13] https://www.epa.gov

[14] https://iwa-network.org/

[15] https://www.pub.gov.sg/watersupply/fournationaltaps/localcatchmentwater

[16] https://www.tpark.hk/en/

[17] https://www.un.org/esa/forests/wp-content/uploads/2016/12/UNSPF_AdvUnedited.pdf

[18] https://www.un.org/en/global-issues/population

[19] https://www.un.org/sustainabledevelopment/sustainable-development-goals/

[20] https://www.un.org/waterforlifedecade/human_right_to_water.shtml

[21] https://www.worldbank.org/en/topic/water/publication/wicer

[22] Safieh Javadinejad, Rebwar Dara, Masoud Hussein Hamed, Mariwan Akram Hamah Saeed, Forough Jafary, Analysis of Gray Water Recycling by Reuse of Industrial Waste Water for Agricultural and Irrigation Purposes, Journal of Geographical Research | Volume 03 | Issue 02 | April 2020

[23] Shuo Liu, Lifen Hu, Weicai Zhang, Hongyang Ma, Cellulose Acetate Reverse Osmosis Membranes for Desalination: A Short Review, Non-Metallic Material Science | Volume 01 | Issue 02 | October 2019

[24] United Nations Strategic Plan for Forests 2030, United Nations Forum on Forests, www.un.org/esa/forests

[25] https://sdg6data.org/country-or-area/China,%20Hong%20Kong%20Special%20Administrative%20Region#anchor_6.4.2Hy

[26] https://sdg6data.org/country-or-area/China,%20Hong%20Kong%20Special%20Administrative%20Region#anchor_6.4.2

[27] https://www.worldbank.org/en/topic/water/publication/wicer

[28] https://www.tpark.hk/en/process/

[29] https://www.pub.gov.sg/watersupply/fournationaltaps/newater