A Literature Review of Impacts of Climate Change and Urbanization on Water Resource Management; an Asian Perspective

Amos Simwela[*], Mercy Hanna Kintu [**], Sam Morie [**], Shilongo Sem Mekondjo

[*] Tongji University, College of Environmental Science and Engineering, P.R. China.
[**] Institute of Environment and Sustainable Development (IESD), P.R. China

DOI: 10.29322/IJSRP.8.5.2018.p7754
http://dx.doi.org/10.29322/IJSRP.8.5.2018.p7754

Abstract- Urbanisation and climate change are directly linked to each other. This is because urbanisation accelerates human activities that result in emission of greenhouse gases which are a major cause of climate change. Both climate change and urbanisation have catastrophic impacts on natural resources, especially water resources; whereby affecting the management of the same. The impacts of climate change and urbanisation on water availability and water quality affect many sectors, including energy production, infrastructure, human health, agriculture, and ecosystems. The impacts of these two phenomena on water resources management are also similar; and or linked to each other.

Index Terms- Urbanisation, Climate Change, Water resources, Asia

I. INTRODUCTION

Urbanisation is defined as the increase in the proportion of people living in towns and cities. It can also be defined as the process whereby a society changes from a rural to an urban way of life. (MeSH, 2017). People move from rural areas to urban areas for various reasons such as escaping from poverty, seeking employment and desire to live a better and modern life. The reasons vary depending on the country and other factors. The urbanisation trends are changing the landscape of human settlement, with significant implications for living conditions, the environment and development in different parts of the world; it is clear that Urbanization and growth go hand in hand, and no one can deny that urbanization is essential for socioeconomic transformation, wealth generation, prosperity and development.

Climate change on the other hand is described as the change of weather conditions which is attributed directly or indirectly to human activity that alter the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. This is manifested in unpredictable weather conditions throughout the year; that may go to extremes.

Water is one of the most importance resource in the world. Human, animal and plant life depend on it. Not all the available water is useable, but only the freshwater which according to (USGS, 2016) is just 2.5% of the Earth's water. Human beings need freshwater for domestic, agricultural and industrial use. The availability of water therefore is vital to human, animal and plant survival. On the contrary, availability of too much water causes catastrophic impact on human, animal and plant life. Thus Water resources are important to both society and ecosystems. We depend on a reliable, clean supply of drinking water to sustain our health. We also need water for agriculture, energy production, navigation, recreation, and manufacturing. Many of these uses put pressure on water resources, stresses that are likely to be exacerbated by climate change and urbanisation. There is therefore need to have particular attention on all the world phenomena that contribute to availability of either too much or too little water resources.

Climate change and urbanisation affect each other in many ways and as well pose similar or related impacts on water resources management. This paper reviews the impact of climate change and urbanization on water resources management.

II. The Status and Trend of Urbanisation, Climate Change and Water Resource

A lot of research and reviews have been done and documented on the impact of Urbanisation and Climate change on water throughout the world. This is mostly because the two are threatening the availability and quality of one of the most important resource on earth, water. Both climate change and urbanisation are equally imposing mainly negative impact on water resources management. Climate change, water, poverty and livelihoods are intimately intertwined in the developing world where climate change is likely to be experienced primarily as increased variability in rainfall and availability of water.

Particularly vulnerable to these climatic changes are the rain fed agricultural systems on which the livelihoods of a large proportion of the region's population currently depend. As agricultural livelihoods become more precarious, the rate of rural–urban migration may be expected to grow, adding to the already significant urbanization trend (Serdeczny et. Al., 2017). It is no coincidence therefore that climate change has become a pressing international development agenda simultaneously with urbanization, offering many opportunities for climate change adaptation, mitigation and disaster risk reduction. Between 1950 and 2005, the level of urbanization increased from 29 per cent to 49 per cent, while global carbon emissions from fossil-fuel burning increased by almost 500 per cent (World Cities Report, 2016).

There are many ways in which urbanisation affect water and the Environment as a whole. Urban populations as a result of urbanisation, interact with their environment. Urban people change their environment through their consumption of food, energy, water, and land. And in turn, the polluted urban environment affects the health and quality of life of the urban population. (Torrey B., 2004). Urbanization, according to (Torrey B, 2004), also affects the broader regional environments. Regions downwind from large industrial complexes also see increases in the amount of precipitation, air pollution, and the number of days with thunderstorms; which in turn has a great impact on the water levels and quality.

Urbanisation is also to an extent an effect of increased population around the world. Across Africa, the United Nations is projecting a population increase from about 1 billion in 2011 to over 2 billion in 2050 and over 3 billion in 2100 (UN, 2011). With this increased population, one implication of the changing climate is that rising temperatures will not only increase food and water stressors but also increase broader population scale water insecurity. Again an increase in human population leads to a rise in human encroachment into flood plains; this coupled with and lack of flood response plans increase the damage potential. The observed increase in precipitation intensity and other observed climate changes, e.g., an increase in westerly weather patterns during winter over Europe, leading to very rainy low-pressure systems that often trigger floods (Kron and Berz, 2007), indicate that climate change might already have had an impact on the intensity and frequency of floods. Changes in rainfall variability over space means that although some areas will experience increases in rainfall, many will receive it in the form of intense precipitation events, especially in tropical and high-altitude regions (Bates et al., 2008).

III. Impacts of Climate change on Water Resources Management

Climate change affects water resources management in a sense that it leads to either too little or too much water. In many areas, climate change is likely to increase water demand while shrinking water supplies. This shifting balance would challenge water managers to simultaneously meet the needs of growing communities, sensitive ecosystems, farmers, ranchers, energy producers, and manufacturers. The impact of climate change on water resources management therefore include Drought, floods and reduced groundwater levels, water pollution and increased water demand.

Drought

Climate change has over the years led to extended dry spells in otherwise rain season. This leads to general shortage of water for Agricultural, industrial as well as household use. Since fresh water bodies are not evenly distributed world over, drought causes a major disturbance for communities that reside in areas far away from the major water bodies. Suh communities start scrambling for the little available water or they resort to migrating to other places where there is water. In the same line climate change increases the evaporation rate as a result of extended sunny days leading to loss of even more water. Increased evaporation rates are expected to reduce water supplies in many regions. The greatest deficits are expected to occur in the summer, leading to decreased soil moisture levels and more frequent and severe agricultural drought. More frequent and severe droughts arising from climate change will have serious management implications for water resource users. Drought can cause coastal water resources to become more saline as freshwater supplies from rivers are reduced. Water infrastructure in coastal cities, including sewer systems and wastewater treatment facilities, faces risks from rising sea levels and the damaging impacts of storm surges (CCSP 2008).

Draught leads to water shortage. The Indian water crisis in 2016 is a good example. 330 million people were affected in India in 2016 (BBC, 2016). India is heavily dependent on monsoon rains, which had been poor for two years in a row

Tankers and trains were used to deliver water to the communities to save their lives.

Floods

Due to climate change, surface temperatures are expected to increase the proportion of winter precipitation received as rain, with a declining proportion arriving in the form of snow.

A variety of climatic and non-climatic processes influence flood processes, resulting in river floods, flash floods, urban floods, sewer floods, and glacial lake outburst floods (GLOFs) and coastal floods. These flood-producing processes include intense and/or long-lasting precipitation, snowmelt, dam break, reduced conveyance due to ice jams or landslides, or by storm. Floods depend on precipitation intensity, volume, timing, phase (rain or snow), antecedent conditions of rivers and their drainage basins (e.g., presence of snow and ice, soil character and status (frozen or not, saturated or unsaturated), wetness, rate and timing of snow/ice melt, urbanisation, existence of dykes, dams and reservoirs).

Floods in both rural and urban areas cause destruction of human, animal and plant life. Floods among other things destroy water conservation structures such as dams, wells and pipes. This therefore shows that floods due climate change render the management of water resources very difficult.

Reduced groundwater levels

Due to extended dry spells in the rain season as a result of climate change, the ground water is not recharged for a period of a one year or more. This means that water table levels keep on decreasing; as such some existing wells will not be deep enough to get water and might run dry.

Additional effects of global climate change that have important implications for water resources include increased evaporation rates, a higher proportion of precipitation received as rain, rather than snow, earlier and shorter runoff seasons, increased water temperatures, and decreased water quality in both inland and coastal areas.

Reduced groundwater levels mean that the water becomes inaccessible for human, animals and plants; hence making survival difficult. Governments around the world it this situation thus find it difficult to supply water to their citizens, as a result of the depletion of the main source; groundwater. A good example is China; it is said that he most developed Chinese cities rely on groundwater, which is being overexploited by 22 billion cubic meters per year. (Batemane, 2014)

Water Pollution

Climate change also greatly compromises water quality. Water quality suffers in areas experiencing increases in rainfall. For example, in the Northeast and Midwest increases in heavy precipitation events could cause problems for the water infrastructure, as sewer systems and water treatment plants are overwhelmed by the increased volumes of water. (USGCRP, 2014). Heavy downpours increase the amount of runoff into rivers and lakes, washing sediment, nutrients, pollutants, trash, animal waste, and other materials into water supplies, making them unusable, unsafe, or in need of water treatment.

Increased Water Demand

Climate change also leads to increased temperatures. As temperatures rise, people and animals need more water to maintain their health and thrive. Many important economic activities, like producing energy at power plants, raising livestock, and growing food crops, also require water. The amount of water available for these activities may be reduced as Earth warms and if competition for water resources increases. This poses a huge challenge to water managers.

IV. Impacts of Urbanisation on Water Resource Management; a case of Shanghai City in China

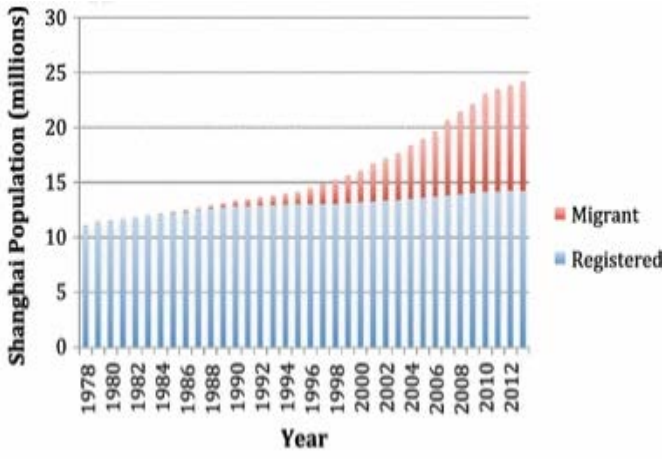
Just like Climate change, Urbanisation also has great impact on water resource management. The interesting part is that urbanisation also contributes to climate change in some way. The impact of urbanisation on water resources management thus include leading to water scarcity, water pollution, urban

waterlogging and waterway flushing. All these make it difficult to manage this precious resources, water.

Water resource Scarcity due to Increased Demand and Consumption

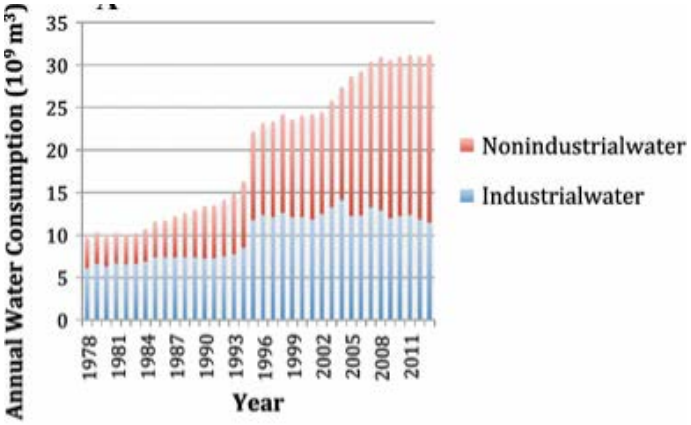
As earlier defined, Urbanisation simply means people moving from rural area to live in an urban area. Thus it result into having a much higher population in the urban areas; towns and cities than in rural areas. The tricky part is that when the people come in to live in the urban area, they do not bring with them such important resources as water; thus they increase the competition for the available resources. In so doing, they make it difficult for the authorities in the urban areas to provide water to all the people. This therefore puts pressure on the ground water resources as too much of it is used and hence depletion. For example a study by (Maotian et al., 2017) shows that in the past three decades, water consumption has greatly increased in Shanghai city as a result of continued urbanisation. This is showed in the two graphs below.

Graph A



A. A graph showing Shanghai population from 1978 to 2012. (Maotian et al., 2017)

Graph B



B. A graph Showing Shanghai annual water consumption from 1978 to 2011. (Maotin et al, 2017**.**

The two graphs show that as the population of Shanghai City has been increasing, the water demand and consequently consumption has also been increasing.

Water Pollution

An increase in the number of people living in one area; urban area means an increase in the amount of waste being released. This happens in both urban residential areas and in the streets. The too many people living in one area renders it difficult to do waste management, the waste that's end up in rivers and streams, making the water unsafe to use.

Again when rain water comes in contact with urban surfaces such as roofs, roads and footpaths, it becomes contaminated with oil, metals, litter and other pollutants. This consequently contaminate main water bodies such as lakes.

Water pollution also results from poor sewage facilities and disposal of industrial heavy metals into waterways. As a result of urbanisation, production industries boom, resulting into production of even more wastes than before. This puts factory owners under pressure to meet the increasing demands and then they end up neglecting waste management regulations. They thus resort to dumping the untreated wastes into water ways.

The wastes dumped in rivers, apart from making the water unusable, they also produce a foul odour. The good example in Shanghai is the Suzhou River where many people along it sold their land and relocated to other places because the smell was becoming unbearable. This clearly shows that polluted water is difficult to manage and pose a health risk to people living near or around the polluted rivers.

Urban Waterlogging and Floods

Urbanisation greatly contributes to the growth of the towns and cities; new buildings are constructed at a very high rate in an effort to providing necessary services to the ever increasing population but also to make the area modern. This makes the whole area almost covered by buildings leaving so

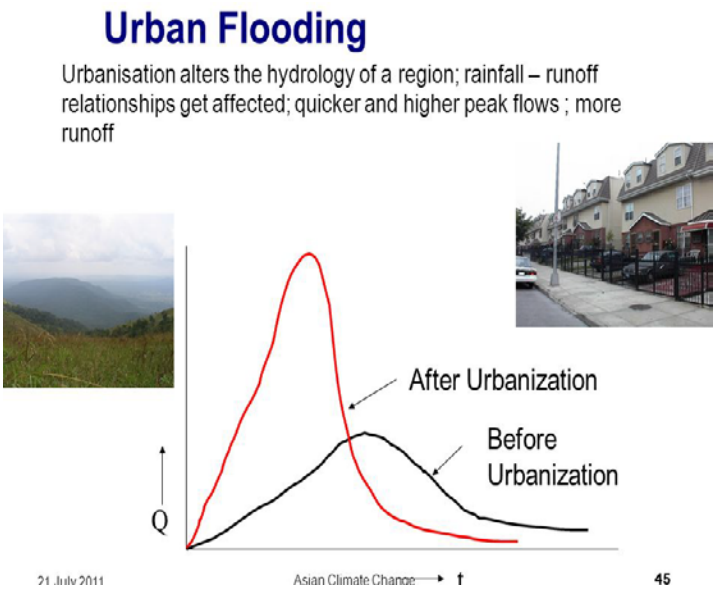
empty space for water infiltration. During heavy rainfall events, large volumes of stormwater collect on sealed surfaces and flow into the stormwater drainage network. Flooding can occur when the volume of stormwater exceeds the capacity of the stormwater drains. This can cause flooding in areas not necessarily close to waterways. Since urban areas are greatly constructed, they reduce the infiltration of water and lower the water tables; water does not infiltrate through impervious surfaces. As the urban area grows, there is also an increase in the proportion of the impervious surface (Wang et al., 2017). Table 1 bellow shows that as the City of Shanghai grows, there was an increase increased proportion of impervious surface from 2002 to 2013.

Table 1. Proportion of imperious surfaces in Shanghai from 2002 to 2013

	Downtown	**Pudong**	**Minhang**	**Baoshan**	**Jiadin**
2002	55.66%	17.98%	34.03 %	49.47%	18.89 %
2007	83.95%	43.69%	62.03 %	70.21%	47.08 %
2013	82.68%	45.02%	62.11 %	72.13%	47.21 %
	Jinshan	**Songjiang**	**Qingpu**	**Fengxian**	**Chongming**
2002	6.13%	10.60%	10.32 %	7.34%	15.01 %
2007	18.99%	27.39%	22.94 %	28.37	20.34 %
2013	19.26%	29.76%	23.02 %	28.64	21.80 %

Table 1. Reginal proportion of impervious surface from 2002 to 2013

The more the impervious surface increases in the urban areas, the less the water infiltrates into the soil and the more waterlogging occurs. This means that runoff occurs more rapidly with greater peak flows. Flood volumes increase, as do floods and water pollution downstream. Waterlogged urban areas does not only make it difficult for authorities to manage the water resources, it also prevents recharging of groundwater. As illustrated in the graph below; urban runoff and flooding increase and urbanisation increases.



(Mujumdar, 2011)

Waterway flushing

When it rains, the volume of stormwater entering the waterways in urban areas increases. Water that would usually soak into the ground floods into the stormwater drainage network, where it is transported directly to our waterways. This again poses a challenge to water resource managers as sometimes the waterways are destroyed.

V. Conclusion and Recommendations

Climate change and Urbanisation are some of the most popular phenomena in the current era of development. Almost all governments in the world are fighting to developing theirs countries. On the course of development comes urbanisation whose effects greatly contribute to climate change. Both Urbanisation and Climate change have a great impact on natural resources such as water, air, trees, soil, animals; etc. This paper has highlighted some of the impacts of Urbanisation and Climate Change on water resources management. The impacts among others include; water scarcity, floods, reduced groundwater levels, drought, pollution and urban waterlogging. All these pose a big challenge to managing on of the most precious resource world over, water. Water is one of the most important resources for human, animal and plant survival. There is a great need therefore to sustainably manage this resource which is already scarce and unevenly distributed.

There is need for strong rules and regulations to curb the effects of urbanisation and climate change; and above all there is need to establish measures that will prevent people from migrating to urban areas such as by establishing industries within the rural areas to create employment. The impacts of Both Climate Change and Urbanisation can be reduced by adoption of Green technology such as Sponge City concept of constructing the

urban structures as well as adoption of clean energy such as solar energy; but also controlling population.

Acknowledgment
This work did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors

REFERENCES

[1] Bateman, J. (2014). China's looming water crisis. The Ecologist. http://www.theecologist.org/News/news_analysis/2291208/chinas_looming_water_crisis.html

[2] CSP (2008). The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Backlund, P., A. Janetos, D. Schimel, J. Hatfield, K. Boote, P. Fay, L. Hahn, C. Izaurralde, B.A. Kimball, T. Mader, J. Morgan, D. Ort, W. Polley, A. Thomson, D. Wolfe, M. Ryan, S. Archer, R. Birdsey, C. Dahm, L. Heath, J. Hicke, D. Hollinger, T. Huxman, G. Okin, R. Oren, J. Randerson, W. Schlesinger, D. Lettenmaier, D. Major, L. Poff, S. Running, L. Hansen, D. Inouye, B.P. Kelly, L Meyerson, B. Peterson, and R. Shaw. U.S. Environmental Protection Agency, Washington, DC, USA.

[3] World Cities Report, 2016; Urbanisation and Development. Source http://wcr.unhabitat.org/wp-content/uploads/2017/02/WCR-2016-Full-Report.pdf

[4] MeSH, 2017. Urbanisation. Source;https://meshb.nlm.nih.gov/record/ui?name=Urbanization

[5] Torry B., 2004. Urbanization: An Environmental Force to Be Reckoned With. Source;http://www.prb.org/Publications/Articles/2004/UrbanizationAnEnvironmentalForcetoBeReckonedWith.aspx

[6] Richard M. Adams and Dannele E. Peck, 2008. Effects of Climate Change on Water Resources. http://www.choicesmagazine.org/2008-1/theme/2008-1-04.htm

[7] USGCRP (2014). Georgakakos, A., P. Fleming, M. Dettinger, C. Peters-Lidard, Terese (T.C.) Richmond, K. Reckhow, K. White, and D. Yates. *Ch. 3: Water Resources. Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 69-112.

[8] Haiting Wang , Yuanzhi Zhang, Jin Yeu Tsou and Yu Li, 2017. Surface Urban Heat Island Analysis of Shanghai (China) Based on the Change of Land Use and Land Cover. file:///C:/Users/Amos%20Lupi/Downloads/sustainability-09-01538.pdf

[9] Mujumdar, 2011. Hydrologic Impacts of Climate Change: Scale Issues and uncertainties. https://www.google.com.br/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=0ahUKEwiDh5D7v6nYAhXLRiYKHap5BHoQjRwIBw&url=http%3A%2F%2Fslideplayer.com%2Fslide%2F7724647%2F&psig=AOvVaw2h34MbtqIkF2Sg6cJKWCtG&ust=1514386127150434

[10] Serdeczny, O.; Adams, S.; Baarsch, F.; Coumou, D.; Robinson, A.; Hare, W.; Schaeffer, M.; Perrette, M.; Reinhardt, J., (2017) Climate change impacts in Sub-Saharan Africa: from physical changes to their social repercussions. *Regional Environmental Change* **2017,** *17* (6), 1585-1600.

AUTHORS

First Author – **AMOS SIMWELA**, Mater Degree Candidate, Tongji University, College of Environmental Science and Engineering, Institute of Environment and Sustainable Development (IESD), Shanghai, China.
Phone: +8613162729969.
E-mail: amossimwela@yahoo.com

Second Author – Mercy Hanna Kintu, Tongji University, College of Environmental Science and Engineering, Tongji University, Shanghai, China,
Phone: +8613162772551
E-mail: 1793409@tongji.edu.cn

Third Author – Morie Sam, College of Environmental Science and Engineering, Tongji University, Shanghai, China,
Phone:+8613120812375
E-mail: 1793418@tongji.edu.cn

Fourth Author- Shilongo Sem Mekondjo, College of Environmental Science and Engineering, Tongji University, Shanghai, China,
Phone:+8613127580065
E-mail: 1793173@tongji.edu.cn

Correspondence Author – **AMOS SIMWELA**, Mater Degree Student, Tongji University, College of Environmental Science and Engineering, Institute of Environment and Sustainable Development (IESD), Shanghai, China.
Phone: +8613162729969.
E-mail: amossimwela@yahoo.com/1793390@tongji.edu.cn