



Urban Drought Challenge To 2030 Sustainable Development Goals In India

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Abstract

Drought is recognized as one of the most complex natural hazards that have a large negative impact on society, economic sectors and the environment. Drought events affect freshwater resources and can become a great threat to urban water supply systems. According to climate change projections with an increase of air temperature and duration of dry periods, cities may experience a serious water shortage in the future that can limit sustainable urban development

In the first two decades of the 21st century, 79 global big cities have suffered extensively from drought disaster. Meanwhile, climate change has magnified urban drought in both frequency and severity, putting tremendous pressure on a city's water supply. Therefore, tackling the challenges of urban drought is an integral part of achieving the targets set in at least 5 different Sustainable Development Goals (SDGs). Yet, the current literatures on drought have not placed sufficient emphasis on urban drought challenge in achieving

the United Nations' 2030 Agenda for Sustainable Development.

This review is intended to fill this knowledge gap by identifying the key concepts behind urban drought, including the definition, occurrence, characteristics, formation, and impacts. Then, four sub-categories of urban drought are proposed, including precipitation-induced, runoff-induced, pollution-induced, and demand-induced urban droughts. These sub-categories can support city stakeholders in taking drought mitigation actions and advancing the following SDGs: **SDG 6** "Clean water and sanitation", **SDG 11** "Sustainable cities and communities", **SDG 12** "Responsible production and consumption", **SDG 13** "Climate actions", and **SDG 15** "Life on land".



Keyword: - Urban Drought, Urban

Development, Sustainable Development Goal.

Graphical Abstract

1. Introduction

While cities and urban areas cover 34% in 2019 (The World Bank). And approximately 31.16% of India's total population currently live in cities. This aggregated distribution of population magnifies the consequences of a wide-array of urban disasters. Among the is urban drought, which has far reached consequences that are often overlooked by the scientific department. Urban drought directly impacts the ecosystem of a city, from agricultural yields to industrial productivity, the health of city's inhabitants, and social stability. Such in the case in the recent urban droughts occurred in 21 cities of India among them Chennai, Bengaluru, New Delhi, Hyderabad (Composite Water Management Index, CWMI, by NITI Aayog) is noticeable. Actually, many of the existing urban communities are still far from drought resilience, which is defined as the ability of urban water supply to thrive under drought and to continue to deliver its essential water service to humanity.

It is estimated that in India there will be an additional 100 million urban residents in 2030 and climate change will significantly alter the pattern and distribution of the India's water supply. It is also predicted that more than 30%

of the India's major cities with a total population of 40 million will exhaust their current water resources by 2050 (India's water economy bracing for a turbulent future, 2006). These trends will continue magnifying the severity of urban drought and put cities under tremendous water crisis and drought risk. Therefore, strengthening urban resilience to drought is recognized as one of the important tasks in achieving the 2030 sustainable development goals (SDGs; Robert et al.,2005; Griggs et al., 2013).

The sustainable development goals (SDGs) are a collection of 17 global goals designed to be a "blueprint to achieve a better and more sustainable future for all".

The SDGs, set in 2015 by the United Nation General Assembly and intended to be achieved by the year 2030, are part of UN Resolution 70/1, the 2030 agenda.

The sustainable development goals are 1) No poverty, 2) zero hunger, 3) good health & well-being, 4) quality education, 5) gender equality, 6) clean water and sanitation, 7) affordable and clean energy, 8) decent work and economic growth, 9) industry, innovation and infrastructure, 10) reducing inequality, 11)sustainable cities and communities, 12) responsible consumption and production, 13) climate change, 14) life below water, 15) life

on land, 16) peace, justice and strong institutions, 17) partnerships for the goals. With “UN’s “Leaving No One Behind” initiative India is aiming to achieve that goals steadily.

Urban drought in India will directly related to SDGs goal no. 6) Clean tare and sanitation, 11) Sustainable cities and communities, 12) Responsible consumption and production, 13) Climate change, 15) Life on land.

An overview of urban drought India: about 42% of India’s land is facing drought, with 6% exceptionally dry four times the spatial extent of drought last year, according to data for the week ending March 26, 2019 from the drought early warning system (DEWS), a real time drought monitoring platform.

2. Urban drought as an important nationwide phenomenon

2.1 Urban drought definition

There are five types of drought, including Meteorological drought, Hydrological drought, Agricultural drought, Socio-economical drought and Ecological drought. Each represents a temporary water shortage in precipitation, ground water, crop and urban life respectively (white and Glantz, 1985; willhite, 2000). In particular, socio-economic drought is associated with the supply and demand of economic good (e.g. water, forage, food grains, fish and hydroelectric power) with elements of meteorological, hydrological, ecological and agricultural droughts that include precipitation shortages, high demand of evapotranspiration, soil water deficits, and reduced groundwater or reservoir levels. In the context, I propose that urban drought of socio-

Andhra Pradesh (AP), Bihar (BR), Gujarat (GJ), Jharkhand (JH), Karnataka (KA), Maharashtra (MH), parts of the North-East Rajasthan (RJ), Tamil Nadu (TN) and Telengana (TS) are the worst hit. These states are have to 500 million people, almost 40% of the country’s population.

India has experienced widespread drought every year since, with the exception of 2017, As EL Nino- the unusual warming of the equatorial pacific ocean that makes Indian summers warmer and reduces rainfall-looms (March- May) this year have also been deficient. India has received 36% less rainfall than the long-term average between march 1 and march 28, 2019, as per Indian Meteorological Department (IMD).

economic drought, which represent a temporary water shortage condition in urban area and urban life either due to a sharp decrease in water supply or a sudden increase in water demand. Urban drought has direct impacts on a city’s well-being, including public health issues, strained economic situation, increased water prices, and an overall decrease of the life quality within the city.

2.2 Urban drought versus water scarcity

It is important to distinguish between the term “urban drought” and “water scarcity”. Both terms are being used to describe the imbalanced between water supply and demand. According to the food and agricultural organization, water scarcity in

defined as “a gap between available supply and expressed demand of freshwater in a specific domain” (Steduto et al., 2017). In most cases, the terms urban drought and water scarcity are used interchangeably in the academia. However, this study would like to make several distinctions between them. First, the term urban drought places specific focus on the imbalance of water supply-demand in urban area whereas water scarcity can be used to describe all manner of water shortages in all geographic locations around the nation. Second, urban drought is used to describe a temporary other than long-term water stress. Third, urban drought represents the change of balance, while water scarcity, since mainly describes the imbalance state. For the above reasons. My study has opted to use the term urban drought to illustrate the need for enhancing water supply resilience in Indian cities (see Table 1).

2.3 Urban Drought Occurrence And Characteristics

According to my statistics from various source, since the year 2007, at least 4 India’s big cities have already suffered from urban drought disaster at least once, as shown in Fig. 1. In other words, urban drought occurs not only in arid or semi-arid regions but also in semi-humid and even humid regions. According to the NITI Aayog report metropolitan areas including Chennai, Mumbai, New Delhi and Bengaluru are all vulnerable to urban drought. Therefore, it is

imperative to recognize that urban drought national challenge, unlike other urban disasters (e.g. flood, earthquake, and fire), urban drought happens silently and often without visible warnings.

A further investigation into the recent urban droughts that occurred in Chennai (2019) and others can provide more insights on the causes and impacts of urban drought, as shown in Table 2.

It was found the water supply system of Chennai and Mumbai were consisted mostly of passive water reservoirs depend heavily on the availability of the natural rainfall and stream flow. And in many parts of the country, rule curves are still being used for operating dams and reservoirs, and seasonal forecast are not considered at all. This type of water supply lacks the resilience when facing drought shock. Our satellites have also observed that water reservoirs in many cities have shrunk sharply.

The chain effect of drought would also extend to other urban disasters such as wildfire, spread of disease, air pollution, migration of the most affected population, suicide and other forms of social disturbance. In a context-sensitive model that examines the level of vulnerability of different population groups, it reveals drought has significantly contributed to the sustained conflicts between agriculturally dependent groups and politically marginalized groups in undeveloped areas of the country.

Table 1

Differences between the recent of urban drought and water scarcity.

Term	Urban drought	Water scarcity
Definition	A temporal excess of demand over	A gap between available supply

	available water supply in an urban area	and expressed demand of freshwater in a specific domain
Period	Temporary water stress	Long-term water stress
Focus	Change	State
Causality	Cause	Consequence

3. Physical And Anthropogenic Mechanism Of Urban Drought

3.1 Urban Drought Formation

From a nominal perspective, urban drought is caused by a temporary imbalance between city water supply and demand along with water mismanagement. However, if looking from a systematic perspective, the cause of urban drought is codetermined by multiple physical and anthropogenic factors that influence water supply and demands, including climate, hydrology, anthropogenic activities, urban demand and environment demand, as shown in Fig. 2. In other words, urban drought is a typical disturbance of Coupled Human- Environment System (CHES; Turner et al., 2003a, 2003b)

On the one hand, the earth's climate system determines the total amount of potential water coming from precipitation, snowfall, and snow melt. On the other hand, climate also controls the evaporation and evapotranspiration processes, which deplete water from plant, soil and surface, meanwhile, a hydrologic system is responsible for the natural transfers of surface and underground water, thus controlling water availability (Pedro-Monzois et al., 2015). Therefore, a mixture of climate and hydrologic systems controls the potential amount of water supply in a given urban area.

Urban and environment water demands mainly determine the urban water requirement, including evaporation and evapotranspiration, residential, commercial and agricultural water

uses. Urban water demand varies greatly depending on the cities, the time of the day and the behavior of the citizens (Diffenbaugh et al., 2015). When water demand is greater than water supply, which means when not all water requirements are fully satisfied. Water shortage occurs. If the water shortage persists for so long that the adverse effects are beginning to appear in urban areas, then an urban drought occurs. In this process, a drought resilient infrastructure must be able to meet the most basic water needs of the city in order to extend the time before drought adversely affected our urban community.

So far, this paper has shown that the formation of urban drought is codetermined by the balance between urban water supply (i.e. climate, hydrology, anthropogenic activities), water demand (urban water demand and environment water demand), and time. To better understand this physical and anthropogenic codetermining mechanism and the complex nature of urban drought in India a new approach is required. This new approach would fall under the new urban science category (Acuto et al., 2018), in which the multidisciplinary knowledge from the nature, social and engineering fields is the key.

South Asia Drought Monitor
Ending on: 26/03/2019

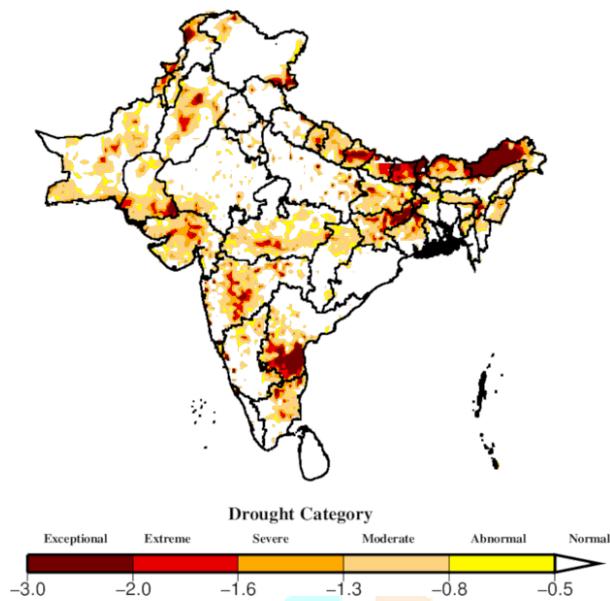


Fig 1: Typical urban drought occurrences in India

3.2 Urban Drought Classification

In this review, I propose to classify urban drought into four distinct categories: precipitation-induced urban drought, runoff - induced urban drought, pollution-induced urban drought, and demand-induced urban drought.

Precipitation-induced urban drought and runoff-induced urban droughts are the most common types of urban drought, which represents the temporal urban water supply deficiency due to lack of precipitation water and surface runoff water, respectively. Pollution-induced urban drought is quickly becoming a major concern as industrial activities are becoming more frequent and intense in most areas. Sewage water, industrial

Table 2

Four representative and recent urban droughts across the country

City and duration	Delhi (2014-2019)
Water supply	Complex and highly decentralized with over 200 utilities record-high
Demonstration and impact	temperature, reduce water stored in the Bhalwa dairy locality, below normal reservoir level.

waste water and pesticide are affecting the water quality of water source and water distribution systems. As a result, the amount of usable water for a city is reduced (Masia et al., 2015). For example, it had been observed that the algae bloom in Yamuna River led to urban drought in the surrounding areas of Delhi. In global scenario salt tide can also trigger urban drought when ocean water flows back into Inland River, greatly reducing the availability of fresh water for coastal cities in Ganga river basin, Brahmaputra river basin and Meghna river basin. However there is yet to be a comprehensive program that covers all the necessary steps to ensure effective water quality monitoring. Demand-induced urban drought will be another non-negligible issue for future Indian cities. Urban water demand prediction is still facing the challenges of generating high accuracy forecast and long-term estimations. However, existing simulations studies have shown that under the current anthropogenic and climate trends, the water demand is expected continue to increase until 2050. Therefore, it is vital for cities to ensure that have a sustained and growing water supply system that can meet the future water demand and minimize the risks of urban drought.

Action	Recycle and rescue of its waste water, urban water use report; 20% voluntary conservation; mandate 25% water conservation; extend mandatory conservation regulations.
Lesson	Forster water system flexibility and integration; Improving water suppliers fiscal resilience; Balancing long-term water use efficiency and drought resilience.
City and duration	Bengaluru (2014-2019)
Water supply	Thippagondanahalli, Harangi, Kabini, Hemavathi reservoir system; two dry rainy seasons, lower 3% capacity of reservoir, daily life and violent incidents.
Demonstration and impact	
Action	Initial disorder actions, official water countdown
Lesson	Avoid pollution in reservoir and river, detection of urban drought in real time, long-term planning that integrates climate change and variability across all sectors of urban development.
City and duration	Mumbai (2014-2019)
Water supply	Mumbai water consisted by 6 storage reservoirs
Demonstration and impact	Poor rainfall during the cool season and rainfall declines during the warm season, water storages had fallen to below 30%.
Action	Reduced water demand per capita by almost 50%
Lesson	Prioritized conservation efforts, saving water with electronic billboards, purchase water rights for the environment, tax water authorities and use the money to promote sustainable water management and address adverse water-related environmental impacts.
City and duration	Chennai (2014-2019)
Water supply	Three reservoir dams.
Demonstration and impact	Three consecutive years (2016-2018) of below average precipitation, below 20% of capacity of dams, local daily lives. Day zero begins
Action	An extra 10 million liters to supply per day.
Lesson	Reducing water consumption, increasing water storage, improving the management of existing resources.

4. Urban drought challenge to Sustainable Development Goals

As demonstrated in Table 2, cities have implemented some measures to combat urban drought. Yet, it is clear that those measures are insufficient in mitigating the devastating consequences of urban drought. It is noted that urban drought would also more likely to disproportionately affect marginalized groups and population. Therefore, the majority of those who would be affected directly by urban drought live in there areas. This contradicts

directly to the motto of the UN 2030 Agenda for sustainable development goal (SDGs), which is “leaving no one behind” (Griggs et al., 2013; sachs, 2013; Stokstad, 2015).

After analyzing the SDG targets and corresponding indicators, this study found that urban drought is directly connected to at least five SDGs, twenty of their targets, and twenty-eight corresponding indicators at both national and city levels. The the five SDGs include;

Goal 6 “Clean water and sanitation”, Goals 11 “Sustainable cities and communities”, Goals 12 “Responsible production and consumption”, Goals 13 “Climate action”, Goals 15 “Life on land”. The corresponding twenty targets and twenty-eight indicators are listed in table 3. The specific contents of these

5. Building resilience to urban drought to achieve SDGs

To meet the challenges brought on by urban drought, we need re-think our resilience strategy and incorporate new priorities into a city’s agenda. In this review, I proposed the following five actions that city stakeholders can undertake to build resilience to urban drought and to achieve the associated SDGs. I acknowledge that the priority of each action is varied, but these actions as a whole are fundamental steps towards making cities resilient to urban drought.

5.1 Raising public awareness on water right and water saving

The urban drought in Chennai reminds us that water does not automatically flow from our taps. This modern privilege is under threat from rapid urbanization and more frequent climate hazards. People are often unaware of drought until water restrictions are applied, while local water-use activities do have a global impact (Jaramillo and Destouni, 2015). Therefore, information transparency and access to water information play vital roles in educating the public about the current water challenges. Awareness raising campaign is thus a valuable tool that enables information decision making and encourages behavioral change. Therefore, the first action I propose is

targets and indicators can be found in Griggs et al., (2013), Sachs (2013), Stokstad (2015), and United Nations (2018). In Table 3, I have further analyzed how urban drought aligns with each of the SDGs and their current progresses at the global scale (United Nations, 2018).

to provide educational tools to raise awareness and understanding on urban drought, i.e. training drought-resilience residents.

First and foremost, water security is as vital as food security. A cohesive strategy that brings visibility to the challenges of urban drought and the international commitments that it associates with, including the SDGs and the Sendai framework for disaster risk reduction, is urgently needed. It is important to disseminate the key facts on water usage at the national as well as international level. For example, the world health organization has observed that over 32% of water is wasted during use. Second, it needed to promote behavioral changes among city dwellers and their water consumption habits. Encouraging citizens to alter their their consumption patterns gives cities best chance to avoid potential water crises. By educating people about water conservation policies, techniques and strategies, water usage will likely to be reduced, enhancing resiliency against urban drought crisis (Grant et al., 2013; Dilling et al., 2019). Besides the conventional educational approaches, it was also found that video games and other form of media are effective means to raise awareness on key

climate change issues including urban drought. As extreme climate conditions continue to play a substantial role in shaping modern societies, urban drought disaster will also demand new responses and solutions from modern urban citizens (Carleton and Hsuang, 2016).

Raising awareness on water saving is equally important among different city sectors. For example, the agriculture sector alone accounts for around 65% (Central Water Commission, 2018) of India's water usage. It was also estimated that if water usage in agriculture was reduced by just 10%, the supply of drinkable water would be double, farmers need to know that by improving irrigation techniques, such as trickle or drip irrigation, they could conserve the use of water while improving crop yield. Studies have already shown that techniques such as recycling urban waste water for irrigation are particularly suitable for water saving in India's agriculture. Though awareness raising and knowledge dissemination activities, such as water saving technique would be able to enhance the drought resilience of even the most water-stressed cities.

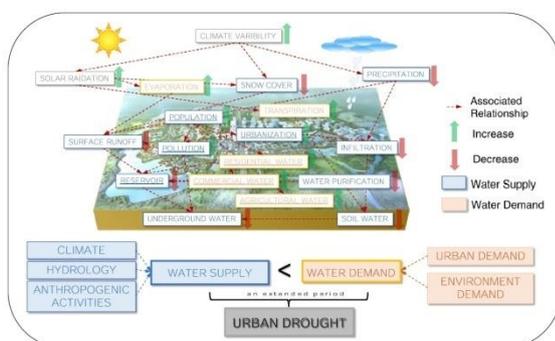


Fig 2: Physical and anthropogenic mechanism of urban drought

5.2 Fostering flexible, reliable and integrated urban water supply

Climate change rendered dams and reservoirs vulnerable to drought. City needs to diversify its water sources in order to avoid another “Day Zero” case like Chennai. As demonstrated before, cities with only single water source are susceptible to urban drought and its chain effect. Therefore, the water supply portfolio of a city should be diversified in order to enhance the reliability of water supply. Recent studies have highlighted the different alternative water sources including artificial rainfall, urban water tanks, and sea water desalination. Stream-water utilization, sectional water transfer, waste water reuse and voluntary water trading. Among them, sea water desalination is particularly popular in coastal cities and is on the rise in places like Chennai, Mumbai, Surat. However, desalination is still facing technical limitations and uncertainties. The cost associated with sea water desalination is still relatively high in Indian society. But certain utility companies like IVRCL (India) and Abengoa (Spanish) are still willing to pay a higher price for seawater desalination because of its reliability in the drought scenario; therefore, I believe there is a huge national as well as global business market opportunity in making alternative water sources affordable, accessible and reliable.

Meanwhile, cities with diversified water supplies should also shift their focuses on enhancing the efficiency and collaboration of all water suppliers, including national, state, and local water suppliers. A government-lead

committee should be established to develop an urban's water supply system that could response to climate emergency such as drought. In addition, every household should have a dual-water supply system with treated water for drinking and non-treated water for cleaning, watering and flushing. This approach has been proven very successful in

Chandigarh, Bokaro for building resilience of water supply.

Another approach to improve water supply is to reinvent the traditional urban fabrics to allow natural water to be absorbed into the ground. Studies indicate that only 20% to 30% of rainwater infiltrates the ground water in urban areas. This cause water logging and surface water pollution.

Table 3

The interconnection between urban drought and SDGs at national level. The specific content of these targets and indicators can be found in United Nations (2018) and SDG India Index 2.0. Overall, it is found urban drought seriously will hinder the achievement the five SDGs with the poor performance of corresponding twenty eight indicators in the near future.

SDGs	Targets, Indicators	Urban drought challenge to improve SDG indicators
Goal 6: clean water and sanitation	Target: 6.1, 6.2, 6.4, 6.5, 6.6, 6.A, 6.B, Indicator: 6.1.1, 6.3.1, 6.3.2, 6.4.1, 6.4.2, 6.5.1, 6.5.2, 6.6.1, 6.a.1, 6.b.1	1) By 2030; improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemical and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally 2) The 48% average of having implemented an integrated water resource management (United Nations, 2018), which will lead to national conflicts when these water resources are being utilize to fight drought. 3) By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lake.
Goal 11: sustainable cities and communities	Target : 11.3, 11.5, 11.6, 11.B Indicator: 11.3.1, 11.5.1, 11.6.1, 11.b.1, 11.b.2	1) By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums. 2) Proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated, by cities. 3) Though 60% of municipal solid waste is being collected, this waste is often is a major pollutant to underground water around urban areas and water sources. 4) By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.
Goal 12: responsible consumption and production	Target: 12.1, 12.2, 12.5, 12.8, 12.A INDICATOR: 12.1.1, 12.2.1, 12.2.2, 12.5.1, 12.8.1, 12.A.1	1) By 2030, achieve the sustainable management and efficient use of natural resources. 2) Percentage of ground water withdrawal against availability. 3) Hazardous waste generated per capita and proportion of hazardous waste treated, by type of treatment.

Goal 13: climate action	Target: 13.1, 13.2, 13.3 Indicator: 13.1.1, 13.1.2, 13.1.3, 13.2.1, 13.3.1, 13.3.2	<ol style="list-style-type: none"> 1) Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all over the country. 2) Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population.
Goal 15: life on land	Target: 15.3 Indicator: 15.3.1	<ol style="list-style-type: none"> 1) By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation nationally. 2) Although the earth have become greener and the rate of forest loss has been cut by 25% since 2000-2005 (United Nations, 2008; Chen et al., 2019), the overall land degradation is still reducing useable water in our cities. 3) Urban drought drives out local species, alters the structure of forest, induces wildfire, and causes other negative impact on biodiversity.

5.3 Improving efficiency of urban water management

Urban water management, including the corresponding river basin management determines the overall efficiency of water resource usage (Pistocchi et al., 2017). There are still a lot of urban water managers who rely on outdated data and strategies. To improve efficiency of urban water management, I suggest that a cyber-Physical System should be developed (CPS; Kim and Kumar, 2012) for the purpose of urban water management. Based on numerous web-ready sensors, world wide web, interoperable standards, and decentralized computers, the urban water CPS can obtain and analyze water data in real time edge technologies including different internet of things-driven solutions (Atzori et al., 2010), sensor web (Zhang et al., 2018a) spatial cyber infrastructure (Wright and Wang, 2011), big data mining (Wu et al.,

2014) and Cloud computing (JoSEP et al., 2010). In particular, urban water big data will be valuable inputs for city managers and scientists to make informed decision and to develop a more sustainable approach to water management and consumption (Webster, 2018). One of the first urban CPS paradigm developed by the international community was the Smart Water Management (SWM), which was proposed by the International telecommunication Union (ITU) in 2014. The SWM project has been successfully tested in different cities worldwide (Gemma et al., 2014). I believe that this big data-driven approach will play a fundamental role in improving urban water resilience in the near future.

Conjunctive Water Management (CWM) is another key to improve water management efficiency, in which surface water and ground water are used in combination to improve

water availability and reliability. In particular, fresh water in wet lands should be paid special attentions. They are critical backup urban water supply sources in emergency situation. New approach for fresh water sustainability are required to protect freshwater system through periods of changing societal needs and scientifically informed adaptive management (Gleick, 2018), such as the clean rule introduced in the US in 2015. In recent years Poff et al., (2015) has proposed an innovative sustainable water management paradigm called Eco-Engineering Decision Scaling (EEDS). This approach can quantitatively explore the trade-offs in stake-holder-defined engineering and ecological performance metrics across a range of possible management actions under unknown future hydrological and climate states. Meanwhile, the Forecast Informed Reservoir Operations (FIRO) has also been proposed as a new management strategy for reservoir and water management (Anghileri et al., 2016; Turner et al., 2017). The FIRO approach uses data from watershed monitoring and modern weather and water forecasting to help water managers selectively retain or from reservoirs in a manner that reflects the current and forecasted weather conditions.

Improving water distribution is also important to enhance urban water management. In particular, reducing water losses in water transport within the distribution networks has a significant potential in saving a large volume of water (Abdulsaheed et al., 2017). The centuries old plumbing system is leaking two billion liters of water every day. In Chennai,

an average of 25% of drinking water is lost to leakage in the distribution network (this reaches up to 40% in remote areas). But locating and repairing leaks are challenging tasks, considering the size of water distribution networks. Meanwhile, it has been proven that by reducing the pressure of pipeline network at night, the loss of existing leakage can be greatly reduced. This also highlights the importance of building an urban water CPS to improve the intelligence of the whole water system.

5.4 Investing in sustainable science research for urban drought

Pioneering studies in climate change have given us the basic understanding of urban drought. For example, white (1935) discussed the effects of water on the lives of human beings. However, there are still many unresolved scientific issues on urban drought which demand inputs and contributions from multidisciplinary studies.

First, a systematic, reliable and high-precision numerical urban drought model should be established by deriving from the physical and anthropogenic activities and the drought variables. A large number of datasets, including every aspects of an urban drought (i.e., big data in urban drought) will be needed to develop such a model. A recent study has shown that including water management in the numerical urban drought model resulted in more accurate discharge representation (He et al., 2017). After establishing the numerical urban drought model, the propagation of urban drought can be simulated and tested. The result will give valuable insights on how an

urban drought develops in a particular area. This is one of the most promising tools for improving the sustainable management efficient of urban drought.

Meanwhile, research on urban drought prediction is also needed, particularly at the seasonal and annual scales. Urban drought prediction is mainly consisted of climate prediction, water redistribution capability prediction, human activities prediction and water demand prediction. Although it is still a great challenge to generate accurate seasonal climate and hydrological predictions (Aghakouchak et al., 2015), recent studies have demonstrated that post-processing of the hydrological ensembles substantially improves the accuracy of the precipitation and hydrological forecasting (Madadgar et al., 2014; Roulin and Vannitsem, 2015; Khajehei and Moradkhani, 2017; Khajehei et al., 2018).

Another promising research is the development of an urban index. Based on urban drought magnitude can be reduced for urban vulnerability and resilience analyses (Turner, 2010). Which can link with SDGs. This index should be a user-friendly representation of temporary urban water shortage. The quality of this urban drought index will be closely related to be the completeness and accuracy of the data input. Existing droughts indices should be used as a reference. While urban vulnerability to drought and urban water consumption should also be taken into consideration (Buurman et al., 2017). Meanwhile, the Indian govt. has estb. A quick monitoring by NITI Aayog

through selected priority indicators & the SDG India index

5.5 Strengthening resilience effort via international cooperation

To tackle the critical and urban drought issue, we must also focus on fostering collaborative efforts among Indian city managers, academia, technical experts and all other relevant stakeholders.

The far-reaching effects of urban drought and the complexity of its formation call for international communities to establish global platforms that would facilitate collective engagements on resolving this issue through an inclusive process.

The United Nations has already taken the lead in this regard. The UN specialized agency in information and communications technology (ICT). International telecommunication union, has long recognized ICT as the key enabler for smart water management. To support cities in implementing ICT solution for urban water management, ITU-R study group 7 has already carried out standardization works that assist cities in developing weather satellite, radio-based meteorological aid systems, radar systems for tracking drought and other disasters, and various radio communication systems that can be used in emergency situations. ITU-T study Group5 on environment, climate change and circular economy has also carried out standardization works that can assess the water footprint of cities and facilitate smart water management in urban areas. Meanwhile, ITU-T study group 2 has developed a standardized language for emergency rescue work which is vital when

conducting urban disaster relief efforts. These are the global platforms that city stakeholders can proactively engage with to gain technical expertise on building urban drought resilience and to form strategic partnership with other similar actors. Other UN initiatives such as

6. Direction for future:

The IMD has warned that there will be 500 million people experiencing absolute water scarcity in 2030 and 21 Indian cities will be living under water- stressed conditions. Given that, urban drought is posing to become one of the most significant barriers in achieving the SDGs in last 5 years. I have witnessing the devastating consequences of urban drought throughout the various Indian cities. Cities like Chennai and Bengaluru had almost turned off the water taps for the first time in history. Therefore, understanding, contextualizing and meeting the challenge of urban drought to SDGs under UN 2030 Agenda are urgently needed.

In this systematic review, I firstly explore the mechanism of urban drought, highlighting its physical and anthropogenic driven factors; it suggested that urban drought was a sophisticate event codetermined by climate, hydrology, anthropogenic activities, urban and environment water demands. This transdisciplinary and cross-sectoral disaster has had far-reaching impacts on the global community. If we continue with business as usual, cities would only become more vulnerable to drought and likely to suffer the

UN water and UN-Habitat have also been raising awareness on critical water issues and they are the ideal platforms for multi-lateral discussion on urban drought and associated SDGs.

devastation consequences. Therefore, I call on future research on this topic, particularly from the national, engineering and social science disciplines of the academia. In particular, it needs our deep understanding of the intricate relationships between human and the natural world.

To build resilience of urban drought and realize sustainable development. I have suggested five promising actions; 1) Raising public awareness on water right and water saving; 2) Fostering flexible, reliable and integrated urban water supply; 3) improving efficiency of urban water management; 4) Investing in sustainability science research for urban drought; and 5) Strengthening resilience efforts via international cooperation.

Though urban drought will continue to be one of the major threats to many cities in India, I believe that its impact can be minimized or even prevented as long as we are scientifically prepared. I encourage Indian policy makers, researchers, entrepreneurs and non-government organization workers to work together on building urban resilience and meeting urban drought challenge to SDGs under UN 2030 Agenda.

Acknowledgements:

The urban drought in India was much alarming and database related study. I have not included All India drought scenario for this study; it is one of the limitations of this study. The other limitation is that I have represented

mainly 4 cities out of 21 endanger cities in India. However, I tried to explain a deeply and thoroughly near future scenario of Indian context with effective to Sustainable Development goals (SDGs) 2030 challenges.

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