SMART WATER FOUNDATION

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Abstract
50% of world population is going to be under high water scarcity according to World Water Development (UN) report. Countries of Africa and Asia like Cambodia, Bangladesh, China, and India who is still developing are likely to face water scarcity more. It was expected that till 2050, 70% of population will leave in city of India. With shrinking of water reservoir, low rainfall, etc is hard to feed and provide resources like water, electricity to such high population. Using sensor, Information and communication Technology (ICT) water resources can be managed and be saved for future use. Sensors provide real time monitoring of hydraulic data with automated control and alarming in case of events such as water leakages etc. Analysis of data will help in taking meaningful actions. Smart water system provides reduced water non-renewable water losses and reduced water consumption in field of agriculture. This paper tries to provide problems arising due to water scarcity in India and how technology will help in finding out the solution. Paper also provides review on smart water technology currently available that can be utilize by Indian citizen to save the nation from scarcity. Conclusion is drawn that there is requirement of low cost devices works on non-renewable energy.

Keywords: Smart Water Systems, Non-Revenue Water (NRW), Water scarcity; Smart farming.

Introduction

Water is now going slowly to be scare in the world. Earth is full of water but 99 percent of water is in sea which is salty hence can't be use. Others sources are locked in glacier in ice form hence only 1% of water is available in groundwater and surface waters for human survival. Near 60 % of water resources is present only in 10 countries, this leave other country into high stress. Changes in environmental condition like low rainfall, climate changes make water scarcer. Water resources like river ponds are shrinking slowly. Water management has become major issues in many countries. Even for drinking purposes. 786[12] million people don't have access of clean water for drinking. UN in 2012 has declared water and sanitation as basic human rights. 2.5 billions Of people don't have proper sanitation facility. It is expected that nearly 1.8 billion people till next decay will live in areas having absolutely scarcity. With population close up to 10 billion till 2050. This will increase the demand of water and food further by 50% then present. The figure shows the current water scarcity position, 46% of world population is under high risk. Even developed countries like USA, UK, Canada and China will suffer from high water stress along with Southern part of Africa and Asia.

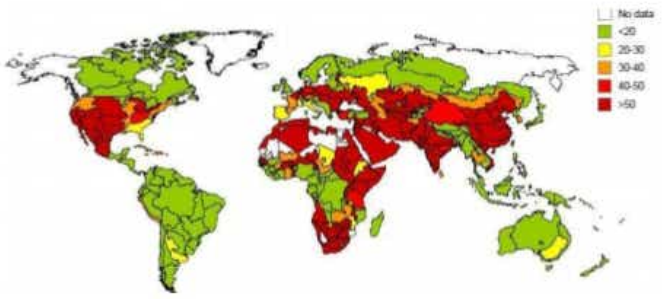

Figure 1: Water stress area in 2050

Paper is arranged in following manner, section two throws light on Non-Revenue water (NRW), section three deals with the problem that are arising due to water stress in India. Section 4 gives review on smart farming, Smart water treatment plant, Smart system for domestic and township. Conclusion is taken out in section 5.

Non-Revenue water (NRW)

NRW is water that is generated from the source but hasn't been reached to the person for utilization [22,23]. This water gets lost due to miss management, poor metering, corruption, leakages or may be theft by other person. Even is also having high NRW percent. [32] According to report given by World Bank Non-renewable Water that is lost costs around 14 billion dollar per year. It was expected that average NRW loss is around 30% for developed countries including Mexico, China, which will rise further. Yearly 45 million cubic meter water is lost due to NRW. 200 billion people can be served by reducing losses to zero and will also reduce water and carbon footprint. If we be able to save 50% of NRW losses then we can serve 90 million more people and will generate $ 2.9 billion revenue. NRW also increases the risk of contamination in water. World Bank Database tells that 44 developed countries are having NRW losses of 35%. Corruption also plays important role, illegal connections have been ignored by concerned people by taking money.

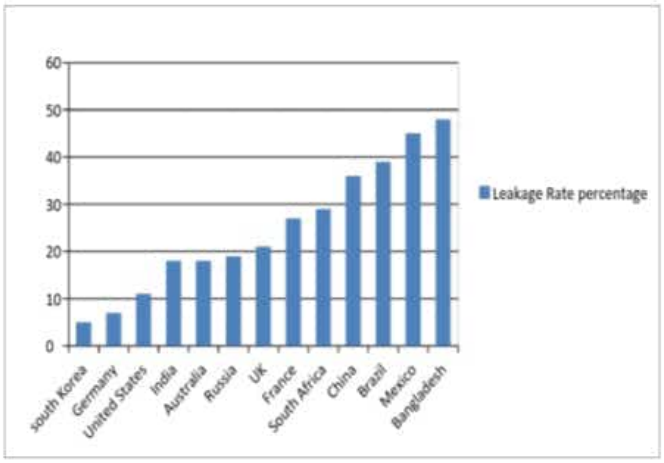

Figure 2: Leakage percentage in water distribution system for different countries

There are three types of Non-Revenue Water Loss

1) Physical Loss: Due to breakage of pipe etc there are leakages causing water loss. Poor management and aging pipeline are main reason for this.
2) Commercial Loss: This cases when water is been theft by some people (illegal usage) or due to data handling errors.
3) Unbilled Authorize user: There is some consumer like fire fighter or to poor people which is free to them.

Water Leakages:

Water leakages are being [29] one of the major issues which every county is facing. It comes under cater category of physical loss in NRW type. Water leakages occur due to aging of pipeline which corrodes. Excavation across the road also causes pipe damage. High pressure across the pipe line also causes bursting of pipeline. Leakages are hard to detect as they can be in the pipes which was underground. In underdeveloped countries or major countries there is no automatic detection method present. Leaks are detected by the local people if it is visible. This is so much lost in economy in finding invisible leakages and fixing them. In 2003 AWWA water loss control committee estimated that, in USA alone 10 billion kilowatt energy loss each year for pumping out water which gets lost due to leakages. Leakages will also reduce the pressure present in the pipeline. This problem may reduce the efficiency of water supply infrastructure during the peak hours.

Problems in Asia:

Asia is home for almost 60% [15] of world population but having only 36% of water resources. In Asia around 29 million cubic meters of water have lost which cost around 9 billion $ annually. According to report by World Water Development Report 480 millions of people in Asia alone will face water scarcity. According to Amy Leung, Director, Asian Development Bank, it is expected that water demand will be double as compared to present till 2025.

Report on Water in India

India is an agricultural land. Here 70% of water is being utilized for the agricultural purpose. It was expected that water demand is going to rise by 50% and one can't ignoring the fact that India is already under high stress level. Only in India and China 2.7 billion people leaves in water stress level. In India sufficient water resources are available but water is unevenly distributed. There is case in which only one tap is installed for 100s of slum people and one tap for one house. Water Infrastructure present in many cites was quite aging. This aging pipeline suffers from erosion which ultimately causing water leakages. General awareness in people regarding water saving was also not found. Causing water waster thus results in extra water usages.Counties like India physical and commercial loss are major area to work out. That can be reduced.

Community conflict:

The water from dam has been given to industries for their purposes as a result of which many land of farmers remain dry. There is complaining from the farmers that water from dam that has to been to them for irrigation purposes. It is reported that there is conflict between the local people and the Posco. Posco was looking to develop a steel plant in Orissa, India. But it takes more than 10 years to them to settle the plant. Framers not able to cultivate their land due to lack of water, thousands of farmers where committing suicide (13,600 in 2012). In Amravati, India there is dispute between the farmers who are local people and the sugar cane industry regarding water distribution.

Health Issues:

Water is an essential for human life. Presence of some undesirable substance on water leads to water contamination and makes water unfit for drinking purpose. Drinking of water contaminated water leads to diseases like die aria, Cholera. This is most common is countries like India, Pakistan, Bangladesh and many African countries like Kenya, Cambodia. Water contaminated diseases causes' death of nearly 6-7 million children yearly. It also causes malnutrition to millions of children.

Social problem:
There is small place in Gujarat, known as the town of bachelors. Shocking Reason behind is that as there is water scarcity so no people want that their daughter should travel 5-6 Km daily for water fetching. Near about 70% women's in Kenya use to go to 5 km to fetch water.

Food Stress:
India's population have reached to 125 corers. Supply food for such population is as real challenge for existing government. Lack of rainfall and unreserved water causes decrease in food production. This will increase food stress. Lot of food has been imported which increase prices of food commodity.

GDP problem:
Water scarcity affects GDP growth also. Right now 36% of area is under water stress level but only generate 22% of GDP worth $ 9.4 trillion as compare 59% in low stress level. It was expected that 52% of GDP will come from this water stress level. Communities do not provide guarantee of reliable water supply to the industries create business risk for the company to invest due to lack of water availability in the area. It affects job opportunity for local people.

Energy Problem and increased carbon foot print.
Water is used to produce energy and then again energy is used to pump out water from land. Lot of amount of water has to be pumped out due to increase in demand of water as well as energy demand. If we able to save water can also save energy and can reduce carbon footprint.

Quality of Water: There are almost one billion people around the world who don't have pure water supply. Due to pollution and leakages there is high chance of contamination. Providing pure water from source to tap is a real challenge for African and Asian countries. It is seen that children under 5 years affected most by water contaminated diseases. Diseases like cholera, Diarrhea are the most common diseases of contaminated water. Sand filters were installed in Cambodia to filter water for slum people. World organization has taken this step to provide quality water. Important thing is that coarse sand and Gravel sand are used as main product. This filter can be easily constructed for slum people.

Table 1: Report of NSS 69th Round central survey [3], 2012. 4475 & 7997 blocks were selected from rural and urban area from 29 states of India. Total of 53393 and 42155 households are considered from rural and urban area for survey

Water quality	Rural (Per 1000 person)	Urban (Per 1000 person)
Consume good quality of water	877	881
Household having drinking water facility at premises	461	768
Without Sanitation	644	215
Sufficient water supply at home	885	953

Irregular water distribution:
There is limited amount of water to be supplied than demanding or need in industries, farming, domestic use hence government not able to provide require water. It is seen that dam water which is there to be for irrigation is being given to industries for their use. More amount of water is been supplied to the hotels, luxury apartments than slum area. It is found that in some tourist spots around 50% of water is wanted by hotel and at the same time people having lower income don't have access to clean drinking water.

Water usage restrictions by Govt. on water:
Many Municipalities have decided to put some restriction on the use of water which is supplied.

Table 2: Shows water availability and consumption in LPCD of 7 cites (Delhi, Mumbai, Kolkata, Hyderabad, Kanpur, Ahmedabad, and Chennai)

Facility	Affected population (in Percentage)
24 hour Water supply	17.5%
Few hours, twice a Day	24.9%
Percentage of citizen using Multiparty tap	92%
Consumption less than 100 liters/consumer/day	65.4

Smart water system
Farming and Industries are the main scope of water saving. Industries consume lots of water. Around 19% of water in India is consumed by the industries. Around 70% of water is utilized in farming. Industries can again use water. This will also cut down their electricity costing. To improve stress water condition in India efficient utilization of resources is required. It is important to identify amount and quality of water consumption. Improvement in water infrastructure is requiring like aging pipeline. Private firms should be involved for development of new water infrastructure that can sustain large population with improved quality of service. Along with rules and regulations rectification of leakages also need to be rectified to avoid excess water consumption. Awareness must be created among people regarding present condition and upcoming water stress issues and the method to save water. Online complaining portals in which complaining regarding leakages can be made by citizens. Water quality and water availability can be made. Database collected by local authority like leakages, NRW losses etc. can be accessible to local people. Indian can't deny the fact that they are under high stress. It is important to know the area for these water losses that can be improved.
Lack of education and awareness is also one of the causes for water waste. World Bank has asked for education of women particularly in underdeveloped countries like Cambodia, Bangladesh, and Rural part of India where education rate is low. In such places family consuming contaminated water without knowing the effect. By educating women we can save the whole family from such disasters.

Water Footprint:

Water footprint formed by UNESCO, is defined as amount of water used by the people and the commercial sector. This will help in study of water consumption by country to produce unit production. It can also be used to correlate carbon and water footprint. For example 1300 litres of water is been consumed for 1 kg of wheat. Water footprint data proves to be use full for business man for establishing new industries. Countries like Portugal (2260 cubic m/yr/capita), Italy (2330 cubic m/yr/capita) and Greece (2390 cubic m/yr/capita) which consumes high meat and industrial goods have high water footprint. On other hand, countries like UK, Australia having low water footprint due to favourable climate for crop production. Reduce water footprint may reduce carbon footprint in one case.

Control Measurements:

Pressure plays an important role so controlling pressure also reduces the NRW losses. Real time monitoring network can be employed for detection of NRW losses and manage it. Commercial loss can be reducing by identifying out the illegal connections that is using water supply. Smart meters can play important role to reduce NRW losses. Involvement of private firm can improve NRW losses, they are high on technology side with sincerely in work can increases the management power. Flexibility and services will improve. Lack of skill labors and not able to understand the depth of problem. To deal with NRW team of skill labors require. There is lack of monitoring devices which will help in understanding the depth of NRW losses. There is also no standard is available for NRW losses like how much is NRW losses per hour, per liter, per house.

Although many people is having filter faculty at their home in developed and developing countries. Every citizen's special poor cannot effort to have it. Hence it is responsibilities of government to check for quality of water which is being supplied at homes. To check for purity pH and ORP check can be done for assurance. There have been certain places in the world where action against NRW has been taken. One of fine example was in Jamshedpur India where NRW losses have been reduced to 10% from 36%. Jamshedpur utilities and services company a private firm. They are developing and maintaining civil infrastructure. In Sate of Selangor, Malaysia there is 40% of NRW losses. Only 25% of loss is only due to leakages. Contract has been give to private firm to reduce NRW losses. This project is carried out in 2 phases with aim of 1st face is to save 18540 cubic meter water daily. Here of new thing comes is Pressure Reduced valves have been implemented. This alone helps in reducing NRW losses by 10%. Such initiatives was also taken by Bangkok, Brazil (2004) and Ireland to improve NRW losses.

Leakage detection methods:

Leakages highly depend upon the pressure. There are various methods for leakage detection from acoustic sensor or from visual. Common methods for detection leakages are observing the creation of small pond near pipeline buried in soil also detects chances of leakages. Fluid exerts high frequency oscillation in pipeline. This vibration can lead to find out the leakage detection location. This can be done using acoustics sensors. They are most commonly used sensors for leakage detection. There are other techniques which developed with time like ground penetrating radar (GPR), electromagnetic sensors. This technique depends mostly on character stick of pipeline all such technique is having limitations of their own. All suffers from range problem like electromagnetic sensor works for 4-5 meter, acoustic works fine up to 200 meter. Leakage detection in recent past using Transient analysis such as Inverse Transient Analysis (ITA) (Liggett and Chen, 1994), Impulse Response Analysis (IRA), Transient Damping Method (TDM) have grabbed attention of many researchers.

Savić &Ferrari [45] have shown use of flow meters and pressure transducers as assessment tool for identifying leaks in Lisbon water supply system. Leak location is identified by acoustic sensors. These leak reduction results in 40% reduction in water loss with a saving of 63,500 €. Head loss monitoring by sensors followed by Joint Time-Frequency Analysis lead to identification of bursting event[21]. Transient change in head loss leads to identification of abnormality. This algorithm is implemented in Singapore, smart water networks. Smart Water system prototype using flow, pressure sensor for smart Cities is discussed in Ghazali et al.[18], Savic, D. A., et al [40], Nazif et al. [47], Mounce et al. [30]. In UK, under Neptune Project Research Consortium pressure and flow sensors have been installed in WDS. Decision Support System (DSS) perform analysis of data to point out any abnormal events. Smart water system [31] came up with smart systems which inform water tank level on smart phone. This system helps in finding out internal leakages. A smart water network [24] consist of magnetic valves, flow and pressure sensors is installed at Graz University. Aim of this, is to identify leakages in WDS and to generate alarm in abnormality condition. Adaptive kalman filtering on flow data have shown efficient results for detection small size leakages [28]. This method is less complex and requires less data for analysis as compared to ANN, GA.

Smart farming:

Nutrient and moisture is an important content need to be present in soil for proper yield in field. By adopting smart farming using sensor technology, can reduce water consumption by 20%. These sensors monitor moisture, nutrients, temperature present in the soil. Real time monitoring protects field from damage with reduced water and energy consumption. Database from sensor can be stored for future purpose. By knowing amount of nutrient contains helps in determine additional fertilizer required to added in field. IBM came up sensor based solution with smart farming tools with aim to reduce water usage and better revenue. These tools analyze moisture and humidity present in soil. It also suggest suitable crop that can be grown at given location which depends upon quality of soil and weather forecast. It also tells their harvesting time. Edyn Garden Sensor **[32]** records moisture, humidity, temperature and soil nutrition of working field. These are portable sensors and work on solar energy and suggests best crops suitable for field. This sensor communicates information on mobile phones. Edyn water valve sensor controls watering to crops, which depends on weather forecast and soil moisture content. For any change drastic change observed alerts are also send on mobile.

Electricity in rural area of India are one of the major issue hence such solar sensor are useful. These sensors are of moderate cost hence can be implemented in fields of rural India.

Dacom came up with smart farming which uses weather forecast, sensors and mobile communication technology to improve quality farming. They provide information about Farmer can get information regarding soil moisture humidity and water quantity that has been consumed by crop each day. By sensing and supplying required water, helps in saving of 30% of water in field. Smart garden [21] based on sensor technology has been proposed. Moisture sensors detect moisture and data is sent to central location via radio module. Depending upon moisture content watering on plantation is done. This results in reduction of water consumption. High cost of these devices can act as a barrier for field implementation in developing countries like India, Bangladesh etc.

Water Monitoring:

Rivers are the main source of water hence is important to monitor river contents and to track the flow of river water. Floating sensors node, deployed in river can monitor the freshness and harmful content present in river water. Sensors also help in providing early alarm during floods by checking the level of water. Such sensors are currently being used in china to tackle flood events. Different case studies regarding sensors technology for water monitoring is discussed in by Murray. Temperature monitoring of water bodies [19] using 100s of Temperature sensors is done. Noticeable temperature variation (.58ºC) has been observed at variable dept. Zhang (2010) have shown monitoring of supplied water quality using smart water system. Toxic substances present in water bodies [40] is detected using ToxProtect sensor. It is also able to detect the presence of Cyanide in water bodies. But this system is unable to detect fluorocetate and requires high maintenance. TOXcontrol sensors[9] have been installed to monitor microbial population present in the aquatic ecosystems.

Smart water system for Water Treatment Plants:

High infrastructure is required to provide water services from door to door in cities. Maintaining such infrastructure having challenges like linkages, purity of water etc. It is important to maintain the quality of water from source to tap hence real time surveillance is required. Water contamination causes diseases like cholera, hence there is need to identify harmful components present in water. Water treatment plan (WTP) provide clean water supply to the city or locality but consume high energy and have large carbon foot print. High monitoring is requiring for proper functioning of plant. Development of ICT devices makes online monitoring possible by optimizing device utilization with real time alarming.

IBM & NYSE introduced a website which informs details about quality of local water. It deals with problem like soil loss, water availability and crop production. An industry [46]uses 20% of water around the world but this distribution varies with the country. Schneider [44] have developed smart systems for maintain water treatment plants with real time quality check of water. Real time field monitoring using cameras is also provided which helps in managing labors. The system centrally monitors the data and also gives visualization and the analysis of collected data. Data can also be saved for future reuse. These system implementation results in reducing carbon footprint by 20% and electric bills by 15% by using hydraulic monitoring. Online monitoring and analysis facility increases efficiency by 25%.

Combined sewers overflow (CSO) causes pollution as polluted water are drained into nearby river. Schneider came up with the system to monitor storm water and waste water. Using weather prediction, system also predicts that how drainage system can be affected by rainfall, floods (if any), etc. This helps in diluting the effect and also save time and infrastructure. With networking modelling, we can reduce the electricity demand by 15%. Energy harvesting concept has to be applied to reduce electricity and carbon footprint. Siemens [38] also came up with water solutions for water waste industries. It regulates waste water flow to provide even load on sewage treatment plant. Water monitoring system named as SIWA, provides water quality monitoring with leakage detection in WDS. IBM & DCWASA [33] works on issues related to the aging water and sewer infrastructure. Software solves issue related with valves, pipelines public fire hazards. IBM provides a real time mapping application. Automated meters have helped to analyse the data and also reduce the bill. The software tells the area of WDS where maintenance is required. In city of Gresham, US, OR Waste treatment Plant is first water treatment plant which generates greater or equal energy used by plants. Electricity is generated from biogas and solar panel. This helps in saving total amount of $500,000. This system can be adopted in water treatment plants of India.

Smart meters:

In India we use old mechanical metal. To collect meter reading access labour work is required. This process is time consuming and having less data reliability. Smart meters are replacing this conventional meters in European and North American nations like USA, UK etc. It is also helpful in leakage assessments. Smart meters [24] have been used to calculate average and peak demand for maintaining pressure of supply system which resulted in reduced leakages. He developed a simulator which models water system with more operational variable, making implementation of ICT devices easier in WDS. Smart water system management have developed devices for detecting internal leakages. Smart water technologies available have been discussed in a report by Oxford [42]. Flow meters design for peak hours lacks in giving appropriate readings during low flow at night hours. These mechanical meters are less reliable. AquaMaster by ABB, is digital flow meter which automatically transmits reading. For data collection SCADA is installed in DMA in North Yorkshire, UK (Mounceet al. 2007). Alarming system has been developed for burst events. DMA requires high resolution and costly devices for monitoring purposes. Installation of high cost devices makes it difficult to use in underdeveloped or developing countries. Other case studies regarding smart meters can be found out in Beal C, Stewart RA [24], Redhead et al. [13], Masia et al. [35] etc. Kennebec Water District (KWD) is water industry, responsible for

supplying 1.2 gallons of water daily to 23,000 customers [27]. Challenges like handling water meter reading and labour cost are merged as major issues. KWD installed AMI (Automatic meters) meters at home. These meters communicate meter readings. This results in improving services with less requirement of men power and is able to find out leakage problem more easily.

A [25] mechanical meter can used as smart meter having additional circuit. Reading acts as sensing pad (figure 3). Water acts as a capacitive medium between sensing pad and arrow. Whenever arrow is above sensing pad code is generated. The data is collected in microprocessor. Then message is transmitted via RF modules. GPRS is used to transmit signal to control room.

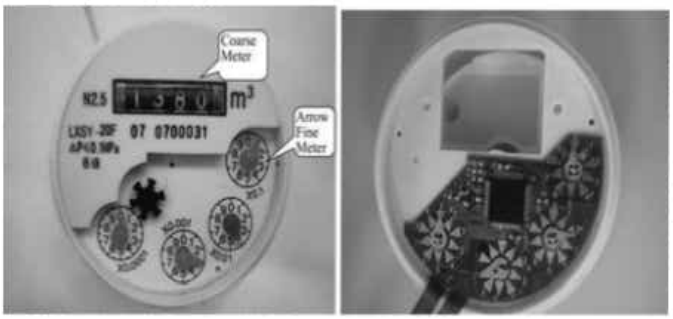

Figure 3: Mechanical meter as a smart meter (Hsia et al., 2012)

Di Nardo has suggested remote controlled valves for water networks. Zhang, B., & Liu, J. [1] have proposed Zigbee based wireless smart meters. All the devices transfers meter reading via zigbee to master node. The master node collects readings from sub area and sends to central processing center. Wang et al. [8] have extended usage of smart meter data for predicting the water usage activities. Smart meter suffers from several challenges. Data privacy, Interference with other electronic devices, high cost of meters and power consumption. These meters cannot work efficiently for low pressure (less than 35 Psi).

Conclusion

Water stress is increasing day by day as earlier mentioned India is going to face high scarcity city. Low rainfall, floods, climate change are standing as challenges which will amplify effect of scarcity. ICT have already playing its major role by proving weather information. Information of cyclone has helped in saving life of thousands of Indian living in coastal areas of Orissa, Andhra Pradesh. Wireless sensor technology along with information technology can help in solving problem of water scarcity. Smart water systems are can assist sustainable management of water. Smart water technologies are currently being used in developed countries only. Deployment of such sensors and their protection against India unplanned water infrastructure can be a challenging task.

Using smart water technology for agriculture is a challenging task due to poor condition of farmers. Low price devices having appreciable accuracy need to be developed in future. Subsidies in such devices are required from government side to make it practically implemented in Indian fields. These device need to been run by own using solar energy as electricity is not available to every village for 24 hr. Energy harvesting [26] is going to be one of future scope in sensor technology. Smart water industries must be encouraged by government by introducing special schemes like low interest rate loans. Awareness also needs to be created between citizens regarding usefulness of these devices. Wireless transmission of data from sensor may cause interference with other devices. Band allocation dedicated for data transmission of smart water devices can be done to avoid interference with other devices. Handling of millions of data in control centre transmitted from sensors implemented in WDS will not be easy. Data privacy is still a challenging task. To generate useful information, big data concept can be seen as next step. MAC layer modification for increasing the data reliability and privacy will be future tasks of researchers. Standardization of data at world level is also required which will make data exchange convenient. Burst event detection of pipeline by analysing the hydraulic parameters can be implemented in metro cities like Delhi, Mumbai etc. Although this system still suffers from false alarm due to different hydraulic operations. Research can be done to classify burst event among different hydraulic operation like pump switching, valve closing etc. There is a need for low cost and low maintenance smart water system which is simple in field implementation and has high efficiency in terms of data reliability.