IoT, Cloud Computing, AI/ML for Water Availability of 24/7 Drinking Water Supply Networks - a Technological Challenge for India

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***Abstract*— Internet of Things (IoT) comprises of things that have unique identities and are connected to the internet. Existing devices such as networked computers or 4G enabled mobile phones are some forms of unique identities, and in future thermostats, utility meters, a blue tooth connected headset, irrigation pumps, and sensors or control circuits for a water treatment plant or smart water grid or power grids are going to be the unique identities. Cyber Physical Systems which connect real world with cyber world through IoT enable the creation of smart environment and hence collects huge amount of data (through lakhs of 'things'] needs to be analyzed through search spaces and approaches. The situation of water availability in India for drinking water schemes needs such cyber physical systems and searching for the IoT resources. Drinking water supply is no more a single discipline endeavor but consists of plethora of disciplines and hence plethora of DPRs. Eighty percent of the water supply schemes in India are using ground water in rural villages whose water reservoirs nearby supply the water to Cities , near and far , for a continuous 24/7 water supply promises. The schedules of operations for such 24/7 schemes remains as elusive as continuous availability of water from nature. Large number of the Indian Districts has gone semi-critical or critical stages of development because of overexploitation of water in the watersheds recharge zones.**

In countries other than India also smart water supply networks in smart cities are taking shape concurrently. The sustainable development goals (SDG target 6.1- for) for water availability and use can be met with emergent technologies—including water meters, water pump sensors, and latrine motion detectors—can improve the objectivity of data collection. Satellite-based remote sensors linked to the Internet of Things can be aligned with smart phone-based surveys and online "big data" tools. In addition, high-resolution smart water meters and advanced data analytics allow for a new era of using the continuous "big data" generated by these meter fleets to create an intelligent system for urban water management. These technologies can also provide more transparency and accountability means from governments when delivering these types of services to the population. Governments fulfill this responsibility by using evidence and updated data for planning, regulating, financing, budgeting and monitoring services and providing information about them. Government decisions depend on the extent to which information is reliable and monitored on a timely basis, to also underpin the service delivery arrangement.

Uncontrolled land use activities (including surface water), and over exploitation (as in the case of 24/7 drinking water supply pressurized networks drawing water from nearby reservoirs continuously) can lead to deterioration of ground water quality and quantity. Use of appropriate guidelines can result in planning which minimizes short-term adverse impact , while providing long-term strategies controlling pollution sources and ground water resource management with the appropriate regulations and enforcement to enable on-going sustainable aquifer utilization (as is practiced in part of Delhi area drinking water supply scheme).

Integrated water resource management not only within water sector but encompassing power/ energy sector is also the need of the hour for sustainable water supply management. In order to develop a compact, accurate embedded performance analyzer and logger for a solar photo-voltaic (PV) power system, an embedded renewable energy performance monitor using National Instruments -Single Board RIO and LabVIEW Software has been developed. The system is "plug and play" and fully network-enabled. This was deployed in an application at a customer installation to guarantee performance in a scientific way to the customer. Similar water quality / quantity performance monitors are needed for smart water supply systems. IoT needs cloud computing to deliver required information pattern for water control infrastructure. The cloud computing patterns which has to mange sharing resources, dynamic scaling of resources and elastic (resource + network +disk provisioning) patterns are essential for using IoT in 24x7 drinking water supply schemes to make them sustainable as per SDG principles. The above aspects will be discussed in brief in the paper which will be presented to the seminar.

Keywords*— *Smart Wtaer Supply Networks (24x7), IoT search approaches , Cloud Computing Patterns , sustainability of water (SDG) , satellite remote sensing and communication for Water networks .

I. INTRODUCTION

The drinking water sector in India is an ineffective public sector and has supply driven approaches. There is an advocacy for DRA (demand responsive approach) which take into account the rich men, rich women, poor men and poor women who may want different kinds of service. DRA provides information and allows user choices to guide key investment designs, thereby ensuring that services conform to what people want and are willing to pay for. In exchange for making contributions, in cash or kind for a satisfactory service, the stakeholders shall have a voice and choice in technology type, service level, service provider and management / financing arrangements. The more demand responsive the project, the better the access to and use of the service. Demand responsive projects offer male and female users from all socio-economic strata information and choices in technology and service level, location of facilities, and type of local management, maintenance, and financing systems. The greater and wider the voice and choice, the better the access and use

The service levels could be the water quality or water quantity parameters. The IoT based services can ensure that type of offers in water service delivery. IoT with concomitant cloud computing patterns, AI/ML (Artificial Intelligence and Machine learning), internetworking technologies can be change leaders. The change leader puts every product , every service, every process, every market, every distribution channel , every customer and end-use, on trial for its life.

Smart cities have several networks for its services like power , water , transportation, buildings, crimes etc. The binding quality of smart city networks is that they are logically independent but functionally interdependent on each other. In order to ensure that city networks be sustainable, the networks must be constantly optimized, secured. Made reliable and flexible to the changing needs and demographics of prosumers (consumers who also have the capability to produce services) . There is a rampant need for such models in each of the constituent city networks. Typical examples where optimization, control and visualization play crucial roles are in determining power/ water grid states for most reliable operation, cheaper ways to power homes and offices, most efficient way to harness renewable water (ground water along with surface water) / energy sources through distributed control , dispatch and commit the generation units that yield lowest costs, manage and route traffic, in roadways that offers the least commutation time between two frequented locations during peak hours, schedule and manage processing tasks at a data center to ensure lowest response time , minimized processor power consumption or minimized computational complexity , and route large volumes of data packets over a potentially congested network to minimize the cost of transmission, and reduce the likelihoods of propagation delay or packet loss. The principles of IoT are neatly encapsulated by a communication infrastructure, with diverse devices spread across the vast geographical landscape of the cities, constantly sensing, reporting, and acting upon data. They typically employ wireless or wired communication media to transmit and receive data. Advanced metering infrastructure (AMI) smart meters for water and electricity , wide area monitoring , protection, automation and control (WAMPAC) devices like synchrophasors, vehicle-to vehicle (V2V), grid-to-vehicle (G2V), and vehicle-to-grid (V2G) applications , traffic control and management systems , smart inverters and weather stations, smart buildings, and other intelligent electronic devices (IEDs) for protection and control are only some of the many devices that require ubiquitous and pervasive communication support to perform their intended functions effectively. These devices engage in different forms of communication, ranging from machine to machine (M2M), machine-to-human (M2H), and machine-to-software (M2S). In a smart city, the candidate communication protocols can be divided into two : (1) long-range and (2) short and medium range protocols. A widely applied long-range protocol is LTE/LTE-U .On the other hand , some of the many short – and medium – range protocols, are Wi-Fi,Zigbee, DSRC, and NBIoT.

Security challenges of networked control systems in several of the smart city networks include attack detection and recovery from FDI (false data injection) attacks or TDS (time delay switch) attacks.

II. WATER SCARCITY,WATER AVAILABILITY,WATER USE AND WATER DEAMND

Rainfall and its distribution is the primary cause for all water sector activities on earth. It flows in watersheds (of sizes 500 ha getting enlarged in size beyond 5 lakh hectares or even more) and runoff/runon takes place and gets stored in depressions , lakes and tanks. Even before the meta diagrams are drawn for cluster of villages / cities the data on water / power / house holds / roads / vehicles etc should be available. The meta diagram is one of the most powerful tools available for systems thinking about infrastructure design and performance. It has two dimensions: it is visualization tool that illustrates complex information in simple and standard ways and it is a a calculation method that tracks the flows of energy, water, and materials through cities. The visualization tool is a type of Sankey diagram .Like all Sankey diagrams , its function is to illustrate flow directions and quantities. The reasons for using meta diagrams are (a) understanding the whole picture, (b) creating a common language for interdisciplinary groups, (c) developing and communicating alternative development scenarios ,(d) setting priorities for research and design, and (e) calculating performance indicators in transparent and comparable ways.

Water scarcity is considered one of the more pressing problems confronting the survival of humankind in the next century. The water scarcity can be constructed differently by different social and political actors, often to meet political ends. Water scarcity in global declarations is considered in absolute and monolithic terms ,obscuring the complex nature of scarcity and its linkages with ecological , socio-political , temporal and anthropogenic dimensions. [A] Water is a renewable resource (unlike other environmental resources such as forests and coal) which means its

availability is constantly subjected to variation, depending on its state in the hydrological cycle. One exception is ground water , which is far less renewable than other water sources. Not only is its state variable (for example , solid, fluid, or in gas form), but it is also variable across time and space , depending on factors such as climate , season and temperature. These are the biophysical and ecological attributes determining water availability. [B] Water scarcity has temporal and cyclical dimensions. People living in arid and semi-arid regions have long since recognized the temporal nature of water scarcity. Periods of dearth are interspersed with periods of abundance The contingency on factors such as rainfall, vegetation , snow and green cover make water availability uncertain. It would be fallacious to see water scarcity as something that is constant and permanent. Thus water supplies are relative to exogenous factors such as rainfall. [C] The distributional and relational aspects of water scarcity explains , tremendous inequality in access to and control over water resources. Scarcity is not felt universally by all. In water-scarce western India, irrigation pumps work twenty-four hours a day, while poor women find their drinking water wells run dry . In arid parts of the world, people consume 10 litres of water per day, while an average American , in contrast , uses over 700 litres a day. [D] The anthropogenic concerns of water scarcity: while water scarcity tends to be naturalized today, its anthropogenic dimensions are whitewashed. It is well known that degradation of the Aral Sea and the Caspian Sea are largely due to human interventions. .Furthermore many of the silted-up dams , broken hand pumps , poor well head protection measures , defunct water pipelines and bore wells are indicative of bad management practices and / or failure to encourage or create supportive institutional arrangements to govern water supplies.
It is here, in all A,B,C and D(as above) , that IoT , Cloud Computing , AI and ML , communication technologies help the water resources engineers to reduce the water scarcity effects on drinking water as well as agricultural water and industrial water supplies.

The anthropogenic scarcity in surface water is because of increasing devegetation and over-exploitation of groundwater aquifers. There is tremendous inequality in access and control of water here.In a research study in Kutch region of India (which is not much different from other regions in India) Rajputs and Jadejas comprise less than 30 percent of the population , but they control about 65 percent of the land. They also own most of the wells in the villages (where research is conducted).Well ownership goes hand in hand with land ownership. Those who have access to land, control the water below them. The rich irrigators are often responsible for depleting vast amounts of groundwater. But they attribute it to climate change. Blame game and vicious cycle of abuse of groundwater without regulation from anybody continues unabated. Hence groundwater monitoring devices using sensors is a necessity.

The latest equipments like GER – River F or GER –Fresh Results 2 or GER Farm Life devices which can assess ground water levels of fresh water sat water and natural waters. These also must be made use of while carrying out inverse modelling based analysis of aquifers. As there are some bad observations on the use of GER products, as we find in internet comments, it is better that these new GER equipments be tested and verified and later only procured in batches to meet our needs. Otherwise we should call all our IIT E & C people to coordinate in their institute the development of these infrastructures in house and have make in India capabilities. The hackathons (of long durations) on these infrastructures can be had at All India levels and guided by ISRO / BARC / CSIR / CGWB /CWC organisations. Isotope studies to identify sources as well as water quality are the best attributes which BARC/PRL can support in Geoinformatics based decision support systems for different Geo-hydrological typologies of aquifers [1].

The infrastructures like pumps, pipes, valves, and smart water meters for water are right now being imported from USA/ Australia / Israel countries as they are not manufactured in Indian mechanical engineers. This imported infrastructure only can make our cities smart water supply networks schemes. The All India hackathons for making these infrastructures make in India is the need of the hour. Even America is thinking of how to bring economy in water supply schemes using their own manufactured smart meters. USA is trying to find alternate methods. The economics of infrastructure provision is equally important as finding surface / ground water source availability and economics.

Similarly hackathons of using Geoinformatics data for arriving at rough estimates of water availability watershed wise in the region / aquifers may be undertaken throughout India by making use of freely available ISRO and other GOI websites data. The expense on consulting engineering on these at least can be avoided.As there is no education and prominence given to hydrology, hydraulics and water resources engineering and management in engineering course curriculum, there is a need for capacity building by various departments related to water supply.

Ground water assessments / estimates / predictions should have not only technical methods but also economic methods like water permits / rights, social methods like conflict resolution models / cooperation models, ecological law and hydro-logic embedded in it.

In surface water : annual demand for water at a particular site may be less than the total inflow, but the time distribution of demand may not match the time distribution of inflows resulting in surplus in some periods and deficit in some other periods. Some infrastructure to store and control water are needed which can be regulated by advanced technologies like IoT, CC,AI& ML, ICT etc.

The 24x7 water supply schemes can be planned only based on secured continuous water supply availability. Existing PHE department / PWD / RDPR engineers are to be capacity built in making these 24x7 water supply schemes. Otherwise they are prone to use ground water aquifers as water banks and do water supply 24x7 without comprehensive thinking about integrated water management

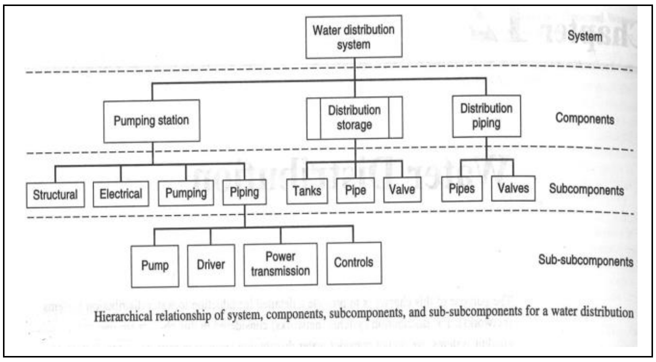
III. CYBER PHYSICAL SYSTEMS FOR DRINKING WTAER SUPPLY SYSTEMS

A. A Typical Water Supply System :

The essentials of a typical water supply system begin with the selection of a reliable and safe source of water. Thereafter, it is essential to design and construct a water intake structure to collect and transmit water to the treatment plant, water is treated either using chemicals (physic-chemical) or by simple physical processes to improve its quality to meet the consumer requirement. The treated water is stored in clean reservoirs from where it is distributed to the consumers.

In general, water distribution systems have three major components: pumping systems, distribution storage, and distribution piping. These components may be farther divided into subcomponents, which in turn can be divided into sub-sub components: pump, driver, controls, power transmission, The exact definition of components, subcomponents, sub-subcomponents merely defines a hierarchy of building blocks used to construct the water distribution system. Figure 1 shows the hierarchical relationship of system, components, subcomponents, and sub-subcomponents for a water distribution system.

Figure1. Water distribution network-hierarchical relationships of its components , sub components, sub-subcomponents



A water distribution system operates as a system of independent components. The hydraulics of each component is relatively straightforward; however, these components depend directly upon each other and as a result affect one another's performance.

Box 1 Indicates Water Resources Engineering, Hydraulics, Hydrology Syllabus useful for Water Supply Systems Networks.

A Hydraulic processes - Flow and hydrostatic forces - Pressurised pipeflow, Open channel flow, Ground water flow (steady state well hydraulics Transient well hydraulics) :
B- Hydraulic designs- storm sewers, storm water detention , open channels,Street and highway drainage and culverts, design of spillways and energy dissipaters, Sedimentation and erosion dynamics, water distribution systems, Hydropower and energy analysis.
C. Hydrologic Flow processes- Rainfall-runoff analysis , ground water flow processes. Reservoir and river routing, probability and frequency analysis , Hydrologic design of storm drainage/ aquaducts
D. Water Resources Engg and Sustainability **:** Probability , risk , and uncertainty analysis for hydrologic and hydraulic design. computer models for fixed flow frequency analysis , Hydraulics of simple networks, pump sytem analysis , network simulation , modeling water distribution systems (ex: REALM), In order to hydraulic transients , surge analysis, Integrated water resources Management, Multicriteria decsiosn making in Water Management.

B. Implementation of CyberPhysicalSystems for WDN :

Cyber Physical Systems (CPS) are integrations of' computation networking and physical processes. This is a system of' collaborating, computational elements controlling physical entities. CPS integrates the dynamics of the physical processes with those of' the software and networking 'providing abstractions and modelling, design, and analysis techniques for the integrated whole. CPS apply to multiple domains (a) smart manufacturing , (b) smart grid, (c) emergency response, air transportation,(d) critical infrastructure, health care and medicine, (e) intelligent transportation, (f) robotics for service etc. Due to the tight coupling and' strong dependence between the Cyber and physical systems integration of many domain solutions, distributed nature of resources, new technologies and needs require new approaches. Connecting the operations of' Cyber Physical devices (the things) with sensors, controllers, gateways and services and creating closed loop networks – emerging as the 'Internet of Things'(IoT).Figure 2 is symbolising the concept of representative formation of Cyber Physical Systems.

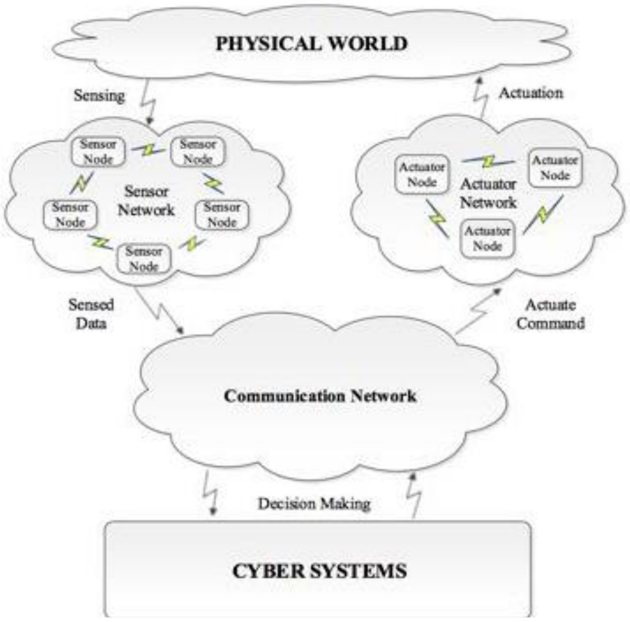


Figure 2. Cyber Physical Systems Representation

In order to design CPS systems for water supply distribution networks (WDN) to monitor and regulate the consumption of drinking water there is a need for (a) creation of IoT network, (b) installation of sensors and actuators, (c) real-time monitoring and control, (d) equitable distribution of water. This should be followed by development of software and hardware to perform (a) **w**ater data acquisition, (b) visualization of actual water flow, (c) water level in storage places, (d) analysis /evaluation of water consumption, quantity at different places.,(e) providing alternatives for manual control of water flow, (f) reduction of water wastage.

As the sensors capture data of a physical process of water flow in water pipes like pressure, head, volume, they are called as cyber physical systems (CPS). CPS use these data or its derivatives to actuate an action, say, of closing or opening a valve partially or desired extent using actuators. Figure 3 indicates water resources capturing, storage, distribution schematically useful for forming a CPS.

The risks and challenges of the eexisting system are (a) Complex/haphazard pipeline network system,(b) daily / weekly operation policy not coherent and un publicised and un accounted in public domain,(c) manual mode of operation,(d) several sources (wells) of water – operated by different pumps, (e) number of pumps are less to vast areas having several consumers. The challenges are (a) upgrading the system without disturbing the existing network, (b) protection of sensors and controllers against environmental changes. The technical issues of immediate attention are (a) availability of suitable sensors (non invasive type), (b) powering of hardware modules at outdoor places, (c) WDN should support all the (i) gravitational type, (ii) pumped type and, (iii) combination of gravitational and pumped type. Figure 4 indicates few water sensors, actuators and controllers.

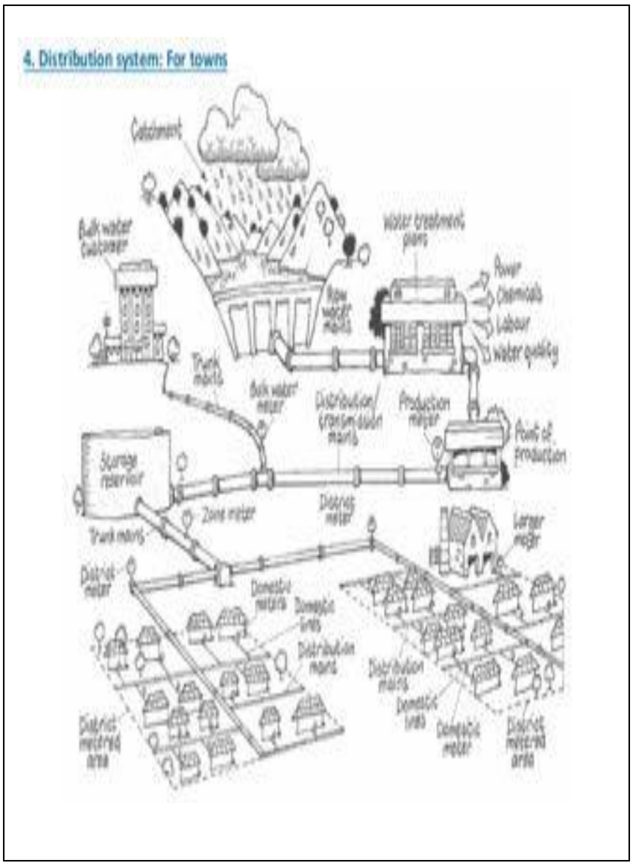


Figure 3.Water Resources for a CPS water supply network.

Figure 4. IoT manageable water sensors, actuators ,controllers

Figure 5. Water management assets instrumented for CPS

IV. STANDARDISATION OF 24X7 WATERSUPPLY NETWORKS THROUGHOUT INDIA UNDER SMART CITY SCHEMES.

There seems to be a wide gap in thinking the implementation of 24x7 water supply schemes in India. This is the main reason for non-utilization of all the funds granted for developing smart infrastructure. This is happening because of issues related to (i) standardization in assessment, monitoring and management of water scarcity (water availability), (ii) standardization of smart water meters , (iii) standardization of telecommunication networks, (iv) standardization of IoT and search spaces infrastructure ,(v) standardization of cloud computing patterns, (vi) standardisation of performance in water distribution ,(vii) standardization in finances , accounting and economics . These are the techno-governance standardizations required (water regulatory authorities included) for an efficient 24x7 water supply schemes. There should be change in policies

A. Performance in water distribution systems:

Water supply and distribution networks are designed , built and run in order to fulfill an apparently simple objective : to supply people with water. However, they frequently form such complex systems, in conjunction with the way they are operated, that the diversity of problems raised by their management quickly overwhelms that apparent simplicity. Many different objectives are pursued by the various types of analysis, procedures and policies developed to support the planning, design and operation of water distribution systems.
Traditional engineering design is based on minimization of cost factors provided some simplistic hydraulic constraints are respected. Optimal operation will look at pumping or disinfection efficiency, again subject to some simple constraints of a hydraulic nature. Leakage control concentrates mostly on excess pressure reduction, without much reduction, without much concern for the remaining performance of the system and so on. This diversity of objective makes it difficult at any moment for the water engineer to address the overall performance of a water supply and distribution network system in a balanced manner. However, the tendency in water supply and drainage organizations throughout India , driven by supply oriented, demand oriented or market oriented needs to to provide its customers with the best level of service at the lowest possible cost while satisfying the regulatory framework (wherever it exists, like in Maharashtra), is to progressively take into consideration and reduce to the same basis all the different aspects of water distribution that may be subject to informed or not-so-informed scrutiny. The diversity of objectives , if not accounted for and managed, lead to equity issues of great social concerns in development . World bank earlier had created such islands of salvation (which became islands of inequity) by funding for modular based water supply to crops in several irrigated command areas of India.
The crop water requirements considered were different : the entire command area atckut had used engineers duty/ delta and base period concepts(as prescribed in irrigation commission reports for protective irrigation) for water requirement of crops whereas world bank funded initiatives using modular structures (which reduce flexibility in canal operations and also for few example distributaries in each command area) gave full crop water requirements (as per evapotranspiration requirements and possibly for productive irrigation) for crops.
Water storages in reservoirs are based on irrigation commission reports for the entire acthkut area and hence, if extended as per module structures , provided by provisions of world bank, but now by Indian Government financing) would have faced a serious problems in irrigation water management.

In 24x7 water supply schemes also , an extensive inputs are required from disciplines of hydrology, hydraulics, water resources engineering , telecommunications networking , computer networking , IoT networking through cloud, provision of pumps, valves , regulation infrastructure for surges / transients of flow in water supply distribution networks. Moreover the possibility of continuous water supply to 24x7 is also a myth, unless one stops development of the city and gets a source of water from storage reservoirs built for agricultural purposes. There is so much of variability in reservoir operation policies for irrigation and water supply scheme from single source that both the demands cannot be reliably met. The reliability measurements of any 24x7 water supply scheme needs to be appropriately integrated with reliability measurements of water reservoir operations for agriculture / hydropower purposes.

The measures of reliability assessment for water distribution performance of any 24x7 schemes or intermittent schemes are the following: A water distribution system can be

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represented as a network consisting of an interconnected set of nodes and links. The network nodes normally represent pipe junctions, pipe size changes or indeed any discontinuity in their characteristics, connections to special links such as pumps, valves, and other pieces of equipment, measurement points, groups of consumers, particular spatial discretisation needs, etc. In fact a node is a conventional concept and can be inserted at any point of the network. Links , on the other hand , have a more physical meaning as they represent the actual components of the network, such as the aforementioned pipes, pumps and valves.

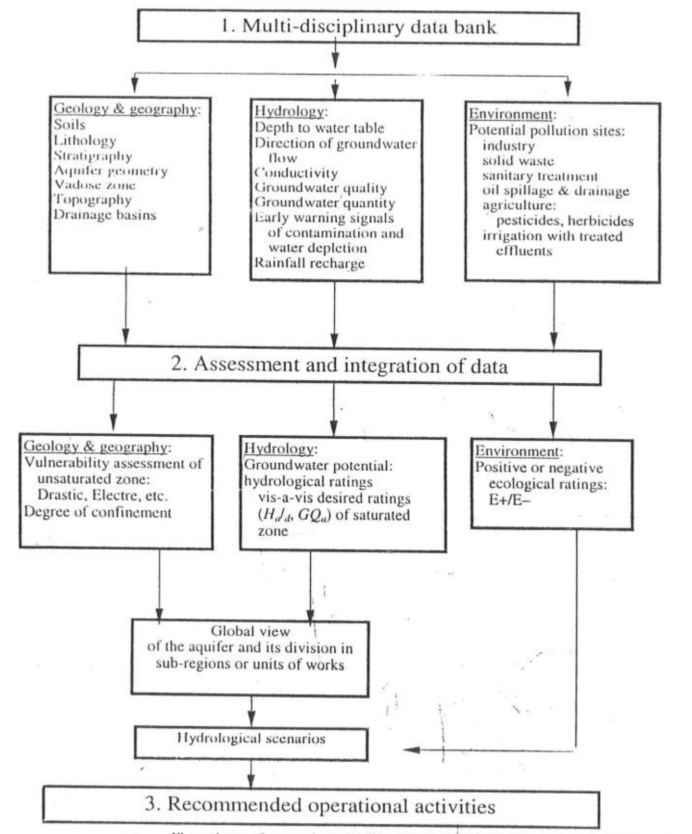
Three types of performance measures which are used in *hydraulic performance* assessment are pressure , velocity and energy considerations. The minimal nodal pressure (to meet the prescribed demands), maximum pressure requirements (based on structural capabilities of pipes and other network elements). The *water quality performance* measures use chemical, microbiological and aesthetic quality being adjusted at the treatment plant to ensure that it is both safe and palatable to the consumer. The performance of a water supply and distribution system can also be measured by how consistently or reliably it actually does so.This is called as *reliability based performance.* To ensure a reliable delivery of finished water to the user, the distribution system is conventionally designed to accommodate a variety of expected loading conditions. For instance, water system components will be designed to satisfy daily maximum hour consumption as well as daily or hourly averages and perhaps maximum instantaneous demands, including fire fighting flows which may be superimposed on those . Additionally some provisions may be made to accommodate abnormal conditions such as broken pipes and fittings, mechanical failure of valves and pumps, contamination accidents, power failures, and unexpected demand levels or patterns.

B. Standardization in bringing sustainability for Water quantity and quality :

Decision making for sustainable water resources management necessitates clear insight into the hydrogeology and the environment situation of the aquifer, as well as an accurate grasp of the economic, political and social milieu. Let us examine the complexity of multidisciplinary aspect of the former (hydrology and environment) .The main steps of this methodology consists of taking a conceptual view of the aquifer (it is to be remembered here that most (70 percent)of the planned 24x7 water supply schemes in India are dependent on ground water aquifers), assessing its hydrology and the environmental pressures on it at a local scale , determining which of a set of hydrological scenarios it fits and, thus, the operational measures to recommend for sustainable ground water resource management. The flow chart illustrates the three basic stages of this process: the development of a multi-disciplinary databank, the assessment and integration of the available information leading to assigning hydrological scenarios, and so recommendation of operational activities.
(refer to Figure 6).

Governance has three major components that of process, content and deliverables. The process of governance includes factors such as transparency and accountability. Content includes values such as justice and equity.

Figure 6. Flowchart of procedure leading to decision making for sustainable water resources management.



Flow-chart of procedure leading to decision making for sustainable water resources management.

Governance cannot be all process and values.It must ensure that the citizens, especially the poorest, have the basic needs and have a life with dignity. Increasingly good governance is understood as a process which when implemented in its totality leads to sustainable development and change.

This type of governance is followed in Delhi area water supply scheme from river Yamuna based ground water aquifers. The practice of pumping fresh groundwater from flood plains along riverbanks is widely known. The problem of pumping ground water from a stream-aquifer system becomes complex, when it is underlain with geologically occurring saline water. The amount of pumping in this case is mostly guided from water quality considerations rather than water quantity. This is because any excess pumping results in upconing of saline water leading to deterioration of water quality especially for drinking water needs. Therefore optimal pumping must ensure both quality and quantity. This is accomplished through regulated pumping in space and time from skimming wells. Skimming wells seek to pump seasonally recharged freshwater (floodwaters) floating on more dense underlying saline water, Skimming wells also find wide application in coastal regions prone to seawater intrusion. A combined simulation optimization approach which seeks to maximize pumpage from a series of existing production wells, while controlling the process of upconing from underlying saline water to desired levels. The results of combined simulation-optimsation model largely depend on the extent of calibration of an aquifer model to field conditions. Simulation model used is ANN. MODFLOW, PEST and SEAWAT-2000 are used to arrive at storage coefficients and parameters of aquifers. This field problem involved pumping from a series of 90 high capacity production wells installed along the bank of river Yamunato meet drinking water needs of Delhi [2].

The performance of QUAL2Kw model used for river quality modeling has been evaluated based on the monthly predicted and observed values of DO, CBODf, TN, and TC at four CPCB and CWC monitoring stations spread over Delhi. The model performance indices, viz. R2, RMSE, MBE, SDBE, and normalized RMSE, indicates that the performance of QUAL2Kw model is satisfactory for DO,BOD, TC, and TN for all the monitoring stations. The model can simulate parametric speciation for BOD and nitrogenous compounds. The sensitivity and uncertainty components of the model have been evaluated and considered prior to applying the model for the interventions. The results show that the calibrated and validated model can be applied successfully to generate the future scenarios for the study area. The results of this research show that it is possible to formulate and evaluate the regulatory intervention related to the river pollution control in developing countries like India using WQMs. In India, detailed environmental modeling tools are rarely used prior to the development of an RQRP (river quality regulating procedures). The outcome of all these analyses can be used by policy makers for planning RQRPs [3].

C. Standardisation in Telecommunications networks

Concepts behind CPS and IoT are not different, it is a matter of scale. Managing a CPS entails requirements far beyond the expectation of legacy control systems such as NCS and SCADA. CPS management addresses the following properties (a) highly dynamic, (b) safety critical, (c) uncertain environment, (d) physically distributed, (e) sporadic connectivity, (f) resource constrained . We need engineering models and methodologies for dependable cyber physical systems that work with other smart domains. Concepts for managing CPS domains are not new and we have to focus on smart water management here. The management at device level, edge, platform level and beyond. Leverage of cloud platforms and environments is needed to bring an aggregated view of large datasets from multiple domains and a large scale CPS of millions of networked smart devices, sensors and actuators. Sophisticated big data analysis techniques are required with deep learning and artificial intelligence on cloud computing platforms.

Network and Systems Management existed for over 40 years now. It managed thousands and later millions of intelligent network devices. Coordinated management systems for large networks got initiated. Long term data management is to be done on OSS /BSS Systems. Network / Storage / Compute are to be consolidated on the Cloud and this reduced need for separately deployable network management systems. Cloud introduced cost and scale advantages and globalization for connectivity. IoT introduced highly distributed billions of network devices. Ultimately this creates need for mid tier for effective management as before, at higher scale.

Operations Support Systems (OSS), or Operational Support Systems in British usage, are computer systems used by telecommunications service providers to manage their networks (e.g., telephone networks). They support management functions such as network inventory, service provisioning, network configuration and fault management.

Business support systems (BSS) are the components that a telecommunications service provider (or Telco) uses to run its business operations towards customers. BSS deals with the taking of orders, payment issues, revenues, etc. It supports four processes : product management, order management, revenue management and customer management.

Together with business support systems (BSS), they (OSS) are used to support various end-to-end telecommunication services. BSS and OSS have their own data and service responsibilities. The two systems together are often abbreviated OSS/BSS, BSS/OSS or simply B/OSS.

Different subdivisions of OSS have been proposed by the TM Forum, industrial research labs or OSS vendors. In general, an OSS covers at least the following five functions: (a) Network management systems, (b) Service delivery, (c) Service fulfillment, including the network inventory, activation and provisioning, (d) Service assurance, (e) Customer care

A lot of the work on OSS has been cantered on defining its architecture. Put simply, there are four key elements of OSS: (a) Processes- the sequence of events, (b) Data -the information that is acted upon, (c) Applications -the components that implement processes to manage data , (d) Technology- how we implement the applications

D. Why Analysis by forming Water Supply Distribution Networks need ?

The water supply distribution networks (WDN) of cluster of villages lead to cooperative solutions using game theory approaches suitable for either supply driven, demand driven or market driven methods of water management. The sensors, actuators, control infrastructures using IoT, cloud computing ,AI/ML is being done throughout the world. The purpose of going for WDN (node-link analysis) formulation is for the following: **[A].** Smart water grids bring (i) *Autonomy* **:** ability to control its actions and internal state without the direct intervention of human or other agents (CPS systems) ,(ii) *Social-Ability* **:** CPS systems (agents) can interact with human and other agents (Whats app) utilising agent communication language ,(iii) *Reactivity* **:**CPS systems can analyse the environment and respond to the corresponding changes that happens in it, (iv) *Pro-activeness***:** the response of CPS systems to the environment is in object-oriented direction.

[B]. WDN have security features as well as privacy features which propels to good governance. Security features- 1.Physical Network Security – water grid infrastructure has pumps / motors , ER ,GLR, valves, hydrants , pipes , water quality mixes, bulk water / consumer water meters, energy consumptions for multi-sources etc) . 2. Information Network Security - Cloud Computing, Big Data Analytics, SaaS, PaaS, DDoS[, data blocking , data leakage,] : Detection mechanisms and Mitigation mechanisms. Privacy features- 1. k-anonymity cloaking**:**joint spatial temporal cloaking algorithms; third party to report k- neighbors requests, 2.Location Obfuscation - Hide users real locations, fake LBS requests , (industry requests, commercial requests.

[C] WDNs provide information for social engagement on (i) water governance –transparency (first step is smart metering schemes at all hydraulic levels, if not at each house hold level) -need is there to know what information is needed for transparent governance. (ii) foundation information (water movement process states-steady state and surge analysis, calibration, fire flows and flushing, pressure surges , transients , water quality ,(iii) productivity information (bench marking- comparing one's performance with the best in the industry, or best anywhere in the world), (iv) core competence information [Hydrology / geo-hydrology , Hydrauilics , WRE , Computer programs/analysis, IoT, Clouds ,Block chains, ICT , mechatronics, AI, Deep Learning, Cyber Security] Ex WhatsApp in Shimoga Roads , Whats App Reservoirs (WRDO and IWRM Engineers of GOK are developing this etc], (v) scarce resource allocation information (continuous supply vis-a-vis intermittent supply WSN , Water quality , WSN Performance – successes , near successes , near failures and failures reports, SCADA), **[D]** Analysis on a Computer as water distribution networks of different scales and modes based on Cyber physical systems / SCADA that we have developed leads to (1) adaptive reconfiguration of networks for (a) Leakage Detection or Pressure Management zones (b) Identification of the minimum loops in a multi-source looped water distribution network, (2) To monitor water quality in distribution networks: optimization of sensor placement & contamination impact assessment , Leakage assessment and model calibration in WSN for DMA (District Metering Areas) or Assembly Constituency Areas (ACA), 4. Optimal Placement of Flow meters in a DMA or **ACA** (In Dharawar 5 automatic meters for 15 wards) ,5. Cloud-based platforms for implementation of Oblivious flow routing for clusters of micro grids (in WDNs) (For cities like Bangalore it is a must)

E. Standardisation in IoT Search spaces and Cloud Computing Patterns

As the society is moving towards IoT, the number of sensors deployed around the world is increasing at a rapid pace and these sensors continuously generate huge amount of data. Sensors are embedded into the IoT projects that collect real time data about the surrounding environment. In the real-world , they detect events and then generate data about the detected events. These objects are networked at various levels (eg., local or global) and then a middleware is used to manage them.The objects register with the middleware through a subscription process, the APIs are provided by it for application development and to perform management operations. Users/Machines submit their query to middleware either by using an interface provided by the application or through the API. The search algorithm is then initiated by the middleware and results are returned back to the query requestor. The query resolution process in the IoT is carried sequentially by query capturing, query analysis, query matching , query result analysis and report generation. Once a query has been received by the search system, it can be processed (through techniques like transformation, filtering, normalization, etc.,) and divided into sub-species. The system then contacts the nodes (cloudlets) in IoT network to retrieve a list of matching resources, that is further indexed and ranked based on some scoring method employed by the search system. Based on the query request, the required number of matching resources is selected at the final stage to resolve the query. Search techniques employed can be classified as two types: Functional view point and Implementation view point. The functional view point searches are (i) event based, (ii) location based,(iii) time related, (iv) content based, (v) spatiotemporal based , (vi) context based , (vii) real time, (viii) user interactive type. The implementation view point searches include (i) text based, (ii) meta data based, (iii) ontology based searches. The search and discovery techniques for the IoT are faced with numerous challenges that reduce their performance quality. They need to support certain requirements to enhance their applicability and usability across different IoT application domains.Water domain, power domain, economics domain, ecology domain , industry domain (cement , steel, fertilizers etc) are some of the IoT application domains. Please refer to reference listed for more details [4].

Cloud computing design patterns emerge from different IoT application domains. Cloud computing design patterns provide proposed design practices and technology architecture, as well as established feature-sets offered by industry tools, technologies, products and platforms. There are (a) sharing , scaling and elasticity patterns, (b) reliability , resiliency and recovery patterns, (c) data management and storage device patterns, (d) virtual server and hypervisor connectivity and management patterns, (e) monitoring , provisioning and administrative patterns, (f) cloud service and storage security patterns, (g)network security , identity and access management and trust assurance patterns, and (h) common compound patterns like private cloud, public cloud SaaS ,PaaS, IaaS etc.,

Please refer for cloud computing design patterns to [5].

V. SATELLITE REMOTE SENSING AND COMMUNICATIONS TECHNOLOGY FOR SUSTAINABLE 24X7 WATER MANAGEMENT SECTOR

Water availability/ scarcity over the entire Indian geographical region , basin wise / watershed wise can be extracted after appropriate analysis using data available with various water resources connected departments in India like CWC, CGWB, State water resources development organisations, agricultural departments, meteorological department, watershed departments, Ministry of Water Resources, GOI etc. The websites created by ISRO and other related water departments

The rainfall contours over India, runoff contours over smaller regions, recharge areas, ground water aquifers, drought affected areas, PMP regions, rainfall harvesting areas, water storages of small and big size are all already available and put in the websites. These can be used for knowing water availability / water scarcity as a first level information for either 24x7 water supply is available for all villages in the region , intermittent or 24x7 continuous water availability is possible in the sub-catchments, catchments , sub-basins, basins (consisting of villages , hoblis, mandals, talukas , districts) under consideration. The basin-wise water resources assessment using space inputs are made available by ISRO-NRSC-CWC under a joint project and are now available with CWC regional offices [6]. The ground water potential maps are available on 1:50000 scale throughout India for all districts and is available in websites mentioned in earlier sections of this paper.

A water supply system (WSS) be it continuous or intermittent can be easily planned using spatial databases and use of GIS/ Geoinformatics techniques. Derivation of plan and profile of pipe lines and network visualization are possible using spatial maps provided in the websites along with digital elevation models. It is concluded in one of the studies in Iran that the GIS and RS is powerful tool in developing water supply system and facilitates to use the following process: (i) Data collection and monitoring,(ii) Site selection for source of water, (iii) 3. water quality assessment, (iv) Network analysis and design of pipe line path, (v) site selection for reservoirs and pumping stations, (vi) site selection for surge tank and control valves, (vii) routing optimization and visualization [7].This can be done for the entire India also simultaneously, so that investments on WSS will be proper and productive. Policy making will be needed for effective implementation of this through existing institutions. In Karnataka , every village has around 30 0r 40 borewells dug by village panchayats /district administration / water supply departments But only four or five of them will be functioning wells , all others are dead wells. They need artificial recharge or proper aquifer management, if proper rainfall or runoff is available with 95% dependability.

In another study it is explored that the performances and the opportunities provided by the European satellite Sentinel-1 for water resource management applications in low-income countries. The analysis is supported by a synthetic aperture radar (SAR) simulator, which allowed the quantification of the expected characteristics of Sentinel-1 products in three applications: interferometric digital elevation models (DEMs) generation, land cover mapping and estimation of water volumes retained by small reservoirs [8]. An Indian study showed the optical remote sensing (MSS) use for monitoring water availability in between two satellite overpass dates for large reservoirs [9].

VI. DISCUSSIONS AND CONCLUSIONS

** The water supply schemes for 24x7 continuous or even intermittent ones should have detailed project reports prepared with equal importance for hydrology, hydraulics, environment, socio-economics, IoT, Cloud computing, telecommunications, and other ICT technologies.

** All India based standardisations in the sustainable management of water supply schemes and its governance should happen both for villages and towns.

** The hackathons should be encouraged for all regions of India to develop sustainable water supply schemes be it 24x7 or intermittent type using spatial data available in India / other country websites depicting Indian land regions.

** There should be 30 percent different disciplines of engineering / science practicing people [Computer science , geology, hydro-geology, electronics, telecommunication , mechanical , mathematics, water resources engineering , environment/ ecology , social anthropologists] should be engaged with existing civil engineers.

** The water availability / water scarcity should be assessed with high reliability by using remote sensing and GIS and related hydrology / hydraulics for 24x7 continuous or intermittent water supply schemes.

** Integrated water resources management principles (by using surface water, ground water , conjunctive use, water quality aspects, power, indigenous availability of pumps / valves / smart meters as much as possible be included) should be applied while ensuring 24x7 water supply schemes

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