ISSN 2229-5518

Smart Water Management System for Jal Jeevan Mission

P A Devaraj Senior Technical Director NIC Bangalore, R Sudarshan Principal System Analyst NIC Mysore , Dr. Ravish. B, IIHMR, Regional coordinator (Mysore division) Zilla panchayath , Mr. Chethan Kumar M District Program Manager Jal Jeevan Mission Zilla Panchayath Mysore, Ms. Bharathi.S CEO & Founder. Tamopahaa technologies Pvt Ltd

Abstract The government of India (GOI) with the motto of supplying piped water to each household has taken up the activity in the Jal Jeevan Mission scheme of RDWS dept under the ministry of Jal Shakti. The module is to supply water from the nearest source to the village /urban hold via an Overhead Tank (OHT). The consumption of each household will be metered, and the charges will be collected from each household (which is nominal). Here an attempt is made to overcome the problem associated with such distribution and how technology can help to overcome the problems is being put forth.

Keywords Smart water management, Jal Jeevan Mission, RDPR, NIC, IIHMR

1. Introduction

Jal Jeevan Mission henceforth referred as JJM, is envisioned to provide safe and adequate drinking water through individual household tap connections by 2024 to all households in rural India. The programme will also implement source sustainability measures as mandatory elements, such as recharge and reuse through grey water management, water conservation, **rainwater** harvesting. The Jal Jeevan Mission will be based on a community approach to water and will include extensive Information, **Education,** and communication as a key component of the mission. The Jal Jeevan Mission will be based on a community approach to water and will include extensive Information, **Education,** and communication as a key component of the mission. JJM looks to create a Jan andolan for water, thereby making it everyone's priority. JJM scheme belongs to RDWS dept under Ministry of Jal Shakti. Govt of India. Rollout of JJM across the country with last mile as households of Villages both urban and rural consumer.

The broad concept is to identify the nearest source (like river,ponds, lakes) to the village and pump to Over Head Tanks in the village and distribute the water through individual pipes to each house hold with metering to record consumption of the water. The minimum amount of drinking water to be supplied to each household is 55 lpcd (liter per capita per day) with additional 30 lpcd.

This distribution is controlled by central valve and also the thickness of water is maintained to 1-1.5 inch so that the dispute related to uneven distribution is overcome. The Govt of India would contribute 42.5%, State Govt will contribute 42.5 %, state government (govt), gram panchayath will contribute 5% from the 15th finance commission and rest of 5% to 10% (accordingly other percentages shall be reduced) will be collected from each household. Further the drinking water will also be given to AWC, PHC, schools.

The monthly charges for water consumed will be as per the meter reading installed in each pipeline at consumer end.

1.1 Issues Identified

- The issue is identified in monthly charges collection as these meters are locked and the key is made available with household. Due to not availability of consumer during water billing, the reading does not get recorded so unpaid arrear bills are generated in later dates which consumer does not pay due to accrued larger amount.
- The scheme cannot record the statistical data related to the water distribution and consumption which would help to improvise the scheme and also extend to larger domain.
- Monitoring of the scheme is not available.
- The govt is concerned that for a country with 600,000 villages and 1.7 million habitations, the cost of tracking the supply and use of water could become very high.
- Drinking water supply systems in Indian villages face multiple challenges of drying up of groundwater source, pump failures, irregular and inadequate water supply, etc. These challenges invariably aggravate socio-economic disparities, like women transporting water, often on foot over several kilometers; several waterborne diseases, which could easily be avoided; also, economic – wage loss and expenditure on medical care. The need of the hour is to ensure and put in place systems to effectively monitor and manage rural water supply.

1.2 Technological Solution

The solution is to take the digital route to use sensor-based IoT devices to effectively monitor the implementation of Jal Jeevan Mission (JJM). The feature is to use frugal yet sturdy sensors, which makes the solution scalable and sustainable. The Internet of Things (IoT) based remote monitoring provides near real-time information without any manual intervention by using sensors. This would not only allow effective monitoring and management on-ground, but also enable real-time visibility to State water supply/ officials, and citizens. With a futuristic vision to ensure regular tap water to every home, real-time measurement and monitoring is critical for rural drinking water supply schemes, with enormous gains in terms of operational efficiencies, cost reduction, grievance redressal, etc. Data will drive improvement in service delivery and instill transparency for precious natural asset such as water. Thus, making a strong social and economic case for deployment of such a system.

Customizing IoT for rural India is critical considering the Wi-Fi broadband and cellular connectivity. In fact, most locations in rural water network lack easy access to grid for powering such IoT devices, which is in an urban setting. “It requires using a combination of technologies such as RF and cellular for communications and using solar or battery-based powering mechanisms for difficult to access locations. Further, optimizing data transmission rates can play an important role in enhancing battery life and keeping operating costs low, partnership with States/ UTs to provide tap water connection to every rural household by 2024 envisions creating a Digital Wall and Remote Command & Control Centre for monitoring and managing supply of prescribed quality water in adequate quantity (55 Liters Per Capita per Day - LPCD) every day through household tap connections across all rural villages.

Through distributed sensors gathering real-time data, integrated management interventions can be derived whilst opening the door to new forms of water governance. To make the implementation accessible to all in the world, it should be viable in terms of cost and implementable across different geographical areas.

This paper presents Intelligent Water Management framework (IWMF) to build IWM (Intelligent Water Management) solutions, a SWM plus intelligence or a SWM 2.0.

2. The Problem Space – Features of IWM

Major elements of the water eco system are sources (both natural (lakes, rivers, etc.) and manmade (dams, tanks, etc.)), distribution network (the infrastructure from source to destination) and destinations (the users – houses, industries etc.).

Feature set: The features by IWM solution are segregated into different three major categories namely: i) *Basic set*, ii) *advanced level1* and iii) *advanced level2*. This categorization is to facilitate configuring the solution as required starting with basic set and adding addition features when required. This will make the solution affordable and viable to one and all.

i) The basic set:

i. All the features shall be part of web enabled tool to support different stakeholders of the water eco system and distribution network – the service provider, the users, the management, the maintenance and support engineers, other organizations that are contributing to the water eco system sustenance.
ii. Real time dashboard water information (water consumed, water available - status, alerts, warnings, billing, maintenance administrative etc.) on need-to-know basis, shall be available to each stakeholder.
iii. Automated remote water meter reading
iv. Automated remote data access and capture
v. Automated bill generation and delivery
vi. The application tool shall be accessible from all types of devices like laptop, PC, tablet, Mobile or a custom-built device.
vii. Realtime Alerts and status for failures like pump failure, leak detected and actions to be taken etc.
viii. Interface for maintenance and support personnel
ix. The complete application shall be secure and accessible with relevant access rights to different stakeholders as required to perform their respective tasks.

ii) Advance set I: This set of additional features require additional processing and using the sensor data in an integrated fashion exercising the interdependency of the sensor data and feedback and, building algorithms to give holistic inferences and knowledge. In addition, a few features to provide improved user experience

i. Dashboard for Water quality and pollution data patterns and its effects
ii. Dashboard for Leak detection patterns and its effects
iii. Visual recreation of water distribution network and live status update and display.
iv. Projecting optimal reconfiguration of the distribution network (Addition/deletion of sources, destinations and reconnect scheme) and display status update once action is completed.
v. Multi language support
vi. IVRS/Chatbot for customer support, awareness and acceptance campaign

iii) Advance set II (Intelligence): This set of features require external third-party data of soil, weather and environment plus the IWM’s data analytics and learnings from basic data collected.

i. Discover water usage patterns, water eco degradation patterns and suggest actions, investigate future scenarios and management interventions to revive and reverse degradation
ii. Alerts /Status of water sources level dipping/drying up and give out proactive alert and actions that are needed to recover /rejuvenate
iii. Develop Inference engines and AI based learning models to warn/alert status and suggest actions to maintain the water eco system
iv. The AI algorithms shall be designed to provide objective information-based criteria to define the apt loca-

tion for a given number of sensors in a particular network, in order to extract the maximum amount of information about the whole system with the lowest CAPEX.

v. AI algorithms assist to optimize a response based on the level of risks (from service interruptions to health threats). Such contingency protocols can be predicted, predefined (for example algal blooms in reservoirs, drying up of water sources or contamination in a particular area) or determined in real time the valves to be closed to minimize the impact of a pipe burst to the consumers etc.

A SWM should address the basic set features as bare minimum to qualify as a SWM. This is prevalent in most implementations that exist as on date. And there are a few smart meter implementations that address a few of the advance set I features. IWMF based IWS addresses the complete range of features.
The user requirements using an interactive user interface. Based on the inputs, the required modules are configured and the IWS is built. A typical functional flow is depicted in the figure 1.

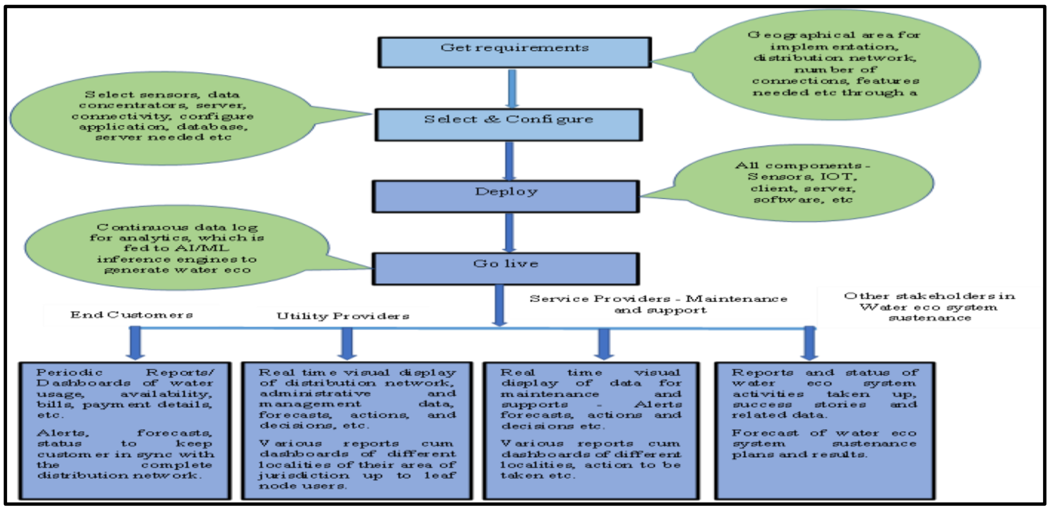

Figure. 1

The solution shall be scalable as required that is, the user could have the basic metering solution or opt for high end features like predicting water source availability and reconfiguration of source and destinations optimally
Based on the environment and the water eco system status, usage patterns, the weather conditions of the specific geographical area, using data analytics and AI/ML course correction shall be suggested.
All the above constitutes the intelligent water management system which shall depict status, information, and knowledge, shall prompt action, alert and flash urgent actions to be taken in real time. And this shall be built complementing the existing systems and infrastructure.

3. The Solution - IWMF, technology and a typical IWM solution

IWMF provides architecture definitions, the major blocks definition and the implementation using these. Technology elements of interest are IOT, Sensors, communication, software, AI, ML etc. These can be group into four major functional blocks - sensors, communication, processing, and Intelligence, see figure 1 and figure 2 for a visual presentation.

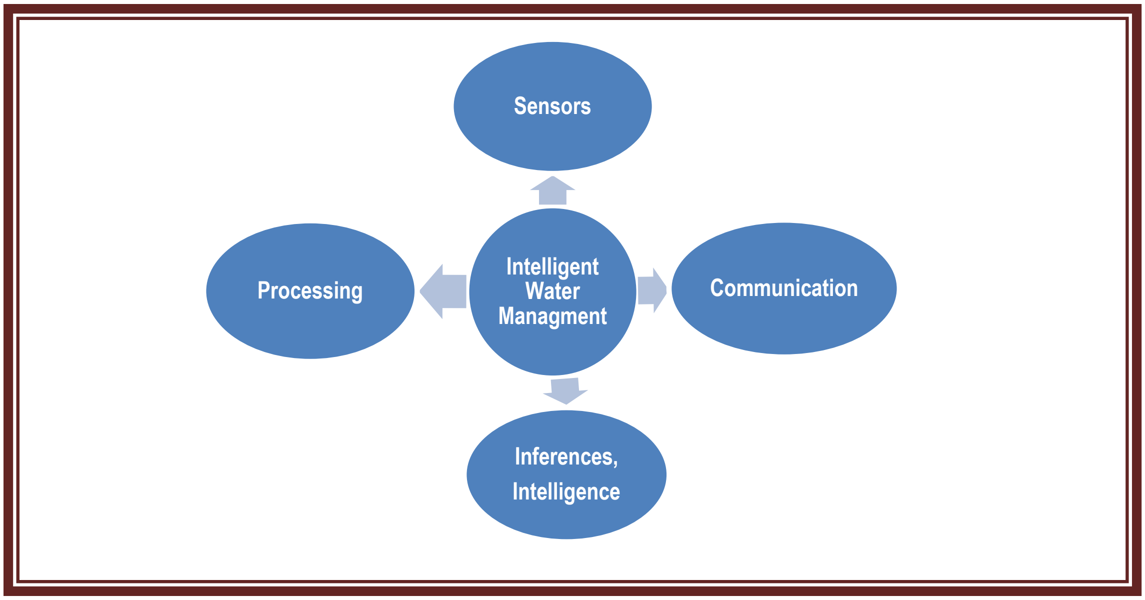

Figure. 2

Sensor's block: This block includes the various sensors installed, the edge electronics (IOT device) programmed to acquire, store and transmit data. Different sensors shall be deployed in the network as per required features. Pressure sensor and Ultrasonic sensors for water level finding, flow meter sensor (electromagnetic, fluidic and the ultrasonic) to find the water consumed, temperature and current sensor for motor monitoring, solenoid valves and motors for auto control of water flow. Water Quality sensors - There are a set of parameters to be acquired like Ph, turbidity, chlorine concentration, conductivity using different sensors for detecting quality and pollution level. Similarly, for leak detection, overflow management and maintenance of water network a set of valves (scour, sluice etc.) and sensors are installed in the distribution network.

The sensor block communication between the sensor and edge IOT depends on whether they are in a single housing or apart. Zigbee or UART is used when the sensor and the edge IOT module are apart and remote. In case of single housing, the connection will be direct (wired) connectivity and use RS485, TTL, direct wiring, Modbus, Mbus etc. based on the IOT chosen.
The sensor block data transmission to cloud happens through one or two hops (gateways). Data from sensor block to the gateway, different wireless protocols could be used like Zigbee, WSN or UART, Bluetooth, LoRaWAN or Wi-Fi. The decision to choose one over the other depends on the distance between the source and destination elements, cost, power consumption, network availability and data rate needed. Zigbee is low power, short distance and long battery life option. LoRa is used as a wide area network technology and LoRaWAN is a low power, wide area networking (LPWAN) protocol based on LoRa Technology. Long Range Wide Area Network is primarily designed for long-range, battery-operated wireless IoT devices. Narrow Band (NB) IoT protocol is specifically designed for networks that require low bandwidth to support massive connection density. IWMF al-
.

Communication block: The data needs to be transmitted from sensors to intermediate gateways and finally to cloud. The data from cloud or the gateways, is accessed by different stakeholders from their device. There are a number of communication protocols and standards available to choose from based on a number of factors to address the challenges of each hop.

lows use of one or more of these protocols, the internet and mobile GSM/GPRS (2G/3G/5G) network for implementing the IWM.

Processing Block – This includes the edge processing IOT at sensor end, the processing IOT unit at gateway or data collectors and the processing unit at the server. The collector and the cloud server shall have the required electronics and software to process and generate the inferences/decisions and knowledge to deliver complete functionality. These processing units consists of IOT functional blocks like a microcontroller, data acquisition modules, communication modules, cloud computing modules, user interface to various devices, battery management and rest of the blocks like RAM /ROM to store and execute the software and firmware. The software for handling these functional blocks plus code to address user interface, security, user friendly application features and other best practices are also part of this block.
Intelligence Block – This block consists of advance processing hardware and software modules for data analytics, AI and ML modules for implementing the features

ISSN 2229-5518

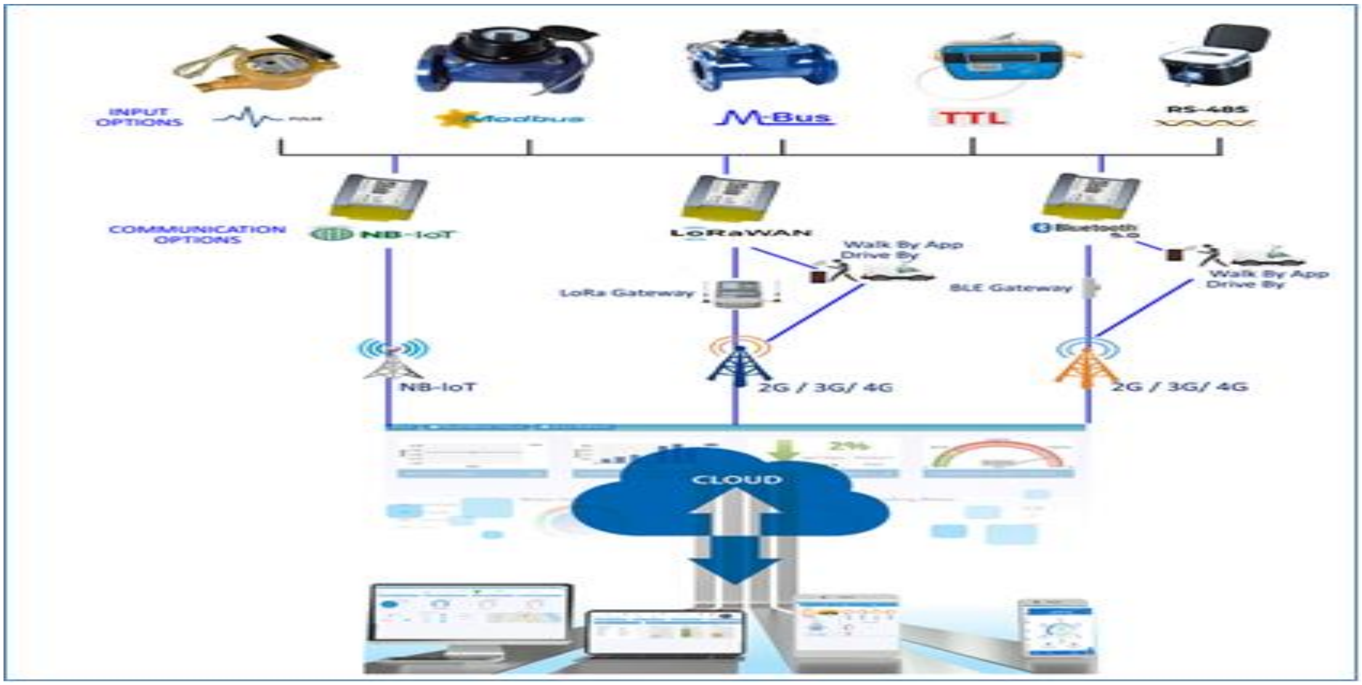

Figure. 3

A typical IWM implementation

For a geographical area identified for implementation, the existing infrastructure and minimal smart metering implementation (if any), shall be studied along with the current statement of work (features, cost, timelines) and a tailored IWM solution shall be defined and implemented.
The IWM solution shall facilitate upgradation of current implementation to a value-added intelligent proposition seamlessly. The USP of IWMF based IWM is that we could start with a bare minimum feature set and added more features in a phased manner. This would help in getting a solution in place sooner and grow to next phase with learnings accumulated from day 1. There are a set of consumers (commercial buildings, individual houses, gated communities, etc.). Every leaf node consumer having a water connection will have a meter installed at its end to measure the water inflow. The automatic meter is equipped with sensor and electronics to acquire, record, and transmit to a data collector. Data Collector shall be for a group of leaf node consumers. It is an intermediate gateway. The data collectors shall transmit the data to a cloud server. The communication between the leaf nodes to data collectors shall be to facilitate remote access or walk-by or drive-by access. The above flow is common for all the features/sensors that are implemented. Depending upon features required, the related sensors need to be installed. The data collectors and cloud server shall be common to all the sensors. Sensors needs to be deployed at appropriate positions in the water network to tap the real time data .

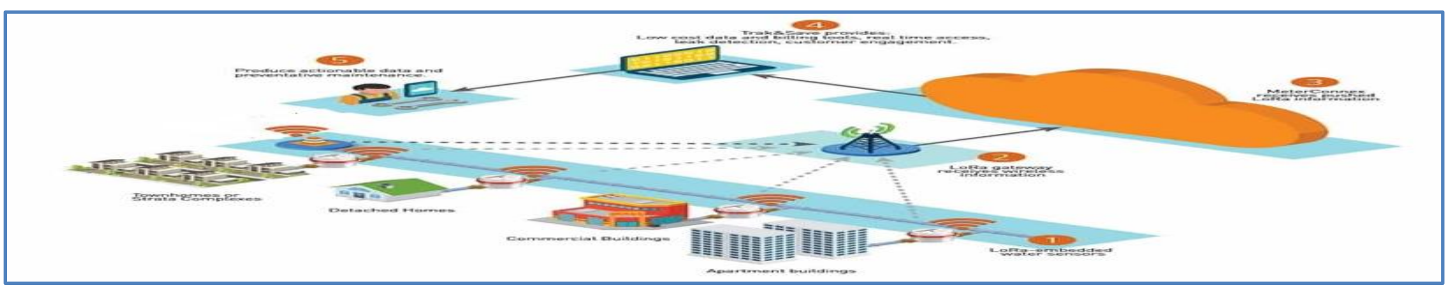

Figure 4

4. Facts and Figures from Implementations

Let us look at sample data from a few implementations which is a validation for smart water metering and management solutions. Every target group of this water eco system namely the end users, the service providers, the utilities provider, the government or other organizations / groups is benefited.

o use of water globally has increased by roughly six times over the past 100 years, and is expected to rise further.

o Available freshwater resources have declined by more than 20% per person over the past two decades, according to a 2020 report from Food and Agriculture Organization.

o By 2025, 1.8 billion people might reside in countries or regions with "absolute" water scarcity, experts have predicted.

o lack of clean water is estimated to be responsible for 80% of all illnesses in the developing world.

o India's water situation is dire: we constitute 16% of the world's population but possess only 4% of its freshwater resources. So, the urgency to work out solutions for India is more importa nt.

Looking at India specific data:

Karnataka) from the JJM site. The table has a lot of information embedded, detailing the

same is beyond the scope of this paper. But the takeaway is to know there is lots done and much more to be completed. Hence a strong case for IWM implementation at a faster pace.

Let's look at the problem-space data from different reputed global bodies and organizations. This gives a fair idea on the magnitude of the problem and hence urgency in implementing the solution.

o Compounding the scarcity, about 25%-40% of water in urban India is lost during distribution due to theft, leakages, and other faulty mechanisms, contributing heavily to the non-revenue water (NRW) of a utility.

o The average NRW in India is about 38%, just above the global average range of 30% to 35% reported by the World Bank.

o Promptly detecting and fixing leakage is crucial because a leaking faucet generates 4,000 drops of water, roughly equal to one liter. In a larger context, thousands of gallons of water could go to waste.

JJM program shows the GOI's understanding of the problem. GOI is trying to implement solution in a time bound manner. There is much to be done, see below data (State wise table and Karnataka district level data of

Table 1. State wise PWS (Piped Water Source) and FHTC (Functional Household Tap Connection) Coverage State - All State, Category - All Districts

			Villages without PWS			Villages with PWS				
S. No.	State	Total No. of Villages	No. of Village	No. of households (without FHTC)	No. of house holds (with private connections)	No. of Village	Total No. of households	No. of Households (with FHTC)	No. of villages having 100% FHTC	No. of villages having < 100% FHTC
1	Andaman & Nicobar Islands	266	0	0	0	266	62037	62037	266	0
2	Andhra Pradesh	18578	803	78602	0	17775	9490600	5991152	3684	14091
3	Arunachal Pradesh	5509	872	20946	0	4637	208578	151520	2920	1717
4	Assam	25335	5211	498584	0	20124	6052836	2462339	3419	16705
5	Bihar	39036	199	66784	0	38837	16629864	15963549	34514	4323
6	Chhattisgarh	19682	6163	975350	0	13519	4030712	1403269	275	13244
7	Dadra & Nagar Haveli and Daman & Diu	96	0	0	0	96	85156	85156	96	0
8	Goa	378	0	0	0	378	263013	263013	378	0
9	Gujarat	18191	0	0	0	18191	9177459	8904967	16518	1673
10	Haryana	6803	0	0	0	6803	3096792	3096792	6803	0
11	Himachal Pradesh	18150	1	236	0	18149	1727282	1646791	15719	2430
12	Jammu & Kashmir	6887	11	1031	0	6876	1834159	1062940	1122	5754
13	Jharkhand	29604	11961	1522101	0	17643	4599448	1382534	667	16976
14	Karnataka	28335	152	12453	0	28183	10105767	5566410	4329	23854
15	Kerala	1578	0	0	0	1578	7068652	3034498	37	1541

ISSN 2229-5518

			Villages without PWS			Villages with PWS				
S. No.	**State**	**Total No. of Villages**	**No. of Village**	**No. of households (without FHTC)**	**No. of households (with private connections)**	**No. of Village**	**Total No. of households**	**No. of Households (with FHTC)**	**No. of villages having 100% FHTC**	**No. of villages having < 100% FHTC**
16	Ladakh	250	0	0	0	250	42757	23645	26	224
17	Madhya Pradesh	51548	11366	1481273	0	40182	10525501	5242454	5894	34288
18	Maharashtra	40327	2393	358879	0	37934	14212508	10293234	13197	24737
19	Manipur	2556	0	0	0	2556	451566	332213	416	2140
20	Meghalaya	6491	1501	93262	0	4990	537040	253000	1523	3467
21	Mizoram	686	17	1369	0	669	132643	89011	203	466
22	Nagaland	1499	85	11549	0	1414	365737	181740	327	1087
23	Odisha	47293	12919	1139214	0	34374	7718182	4548363	9242	25132
24	Puducherry	246	0	0	0	246	114908	114908	246	0
25	Punjab	11974	0	0	0	11974	3426043	3423759	11933	41
26	Rajasthan	43364	13977	2364813	0	29387	8203990	2848130	1596	27791
27	Sikkim	439	6	771	0	433	131109	90948	86	347
28	Tamil Nadu	12525	0	0	0	12525	12489128	6769756	2777	9748
29	Telangana	10450	0	0	0	10450	5386962	5386962	10450	0
30	Tripura	1176	0	0	0	1176	741945	397696	35	1141
31	Uttar Pradesh	97568	52743	10773975	0	44825	15653730	4404790	5467	39358
32	Uttarakhand	15041	216	24865	**0**	14825	1469553	976660	2670	12155
33	West Bengal	39179	15463	3966099	0	23716	12035599	4777906	3649	20067
	Total	601040	136059	23392156	0	464981	168071256	101232142	160484	304497

Table 2. Karnataka State: PWS (Piped Water Source) and FHTC (Functional Household Tap Connection) Coverage.

District wise PWS and FHTC Coverage										
State - KARNATAKA, Category - All Districts										
			Villages without PWS			Villages with PWS				
S. No.	**District Name**	**Total No. of Vil-lages**	**No. of Vil-lage**	**No. of house-holds (without FHTC)**	**No. of households (with private con-nec-tions)**	**No. of Village**	**Total No. of house-holds**	**No. of House-holds (with FHTC)**	**No. of vil-lages having 100% FHTC**	**No. of vil-lages having < 100% FHTC**
1	Bagalkote	641	3	1023	0	638	333679	241514	181	457
2	Ballari	282	3	407	0	279	202920	96535	35	244
3	Belagavi	1215	0	0	0	1215	852433	488737	258	957
4	Bengaluru Rural	889	1	270	0	888	208636	33802	0	888
5	Bengaluru Urban	692	3	17	0	689	317262	54427	2	687
6	Bidar	637	1	930	0	636	313952	141777	93	543
7	Chamara-janagara	677	2	531	0	675	251336	181816	138	537
8	Chikkabal-lapur	1487	8	676	0	1479	246911	54866	5	1474
9	Chikkama-galuru	1013	9	873	0	1004	240389	134714	96	908
10	Chitra-durga	1359	10	1991	0	1349	378992	185151	50	1299
11	Dakshina Kannada	366	1	350	0	365	333834	266596	64	301
12	Davangere	696	0	0	0	696	259439	170096	207	489
13	Dharwad	353	0	0	0	353	204187	197385	284	69
14	Gadag	317	0	0	0	317	200113	196709	300	17
15	Hassan	2303	22	414	0	2281	431179	195484	380	1901
16	Haveri	697	0	0	0	697	294578	219412	379	318
17	Kalaburagi	859	0	0	0	859	456182	215088	38	821
18	Kodagu	297	1	265	0	296	135670	91607	69	227
19	Kolar	1522	3	129	0	1519	271842	60721	3	1516
20	Koppal	577	0	0	0	577	305419	243579	73	504
21	Mandya	1402	1	260	0	1401	396068	311820	114	1287
22	Mysuru	1198	8	582	0	1190	499093	253900	136	1054
23	Raichur	979	1	26	0	978	362097	239954	302	676
24	Rama-nagara	846	1	7	0	845	231111	161859	188	657
25	Shivamogga	1539	15	992	0	1524	308422	214381	496	1028
26	Tumakuru	2596	8	241	0	2588	564687	209127	42	2546
27	Udupi	246	0	0	0	246	247188	156342	16	230
28	Uttara Kannada	1246	49	2368	0	1197	283719	124269	231	966
29	Vijaya-nagara	319	1	56	0	318	277589	77396	1	317
30	Vijayapura	620	0	0	0	620	464370	224496	108	512
31	Yadgir	465	1	45	0	464	232470	122850	40	424
	Total	**28335**	**152**	**12453**	**0**	**28183**	**10105767**	**5566410**	**4329**	**23854**

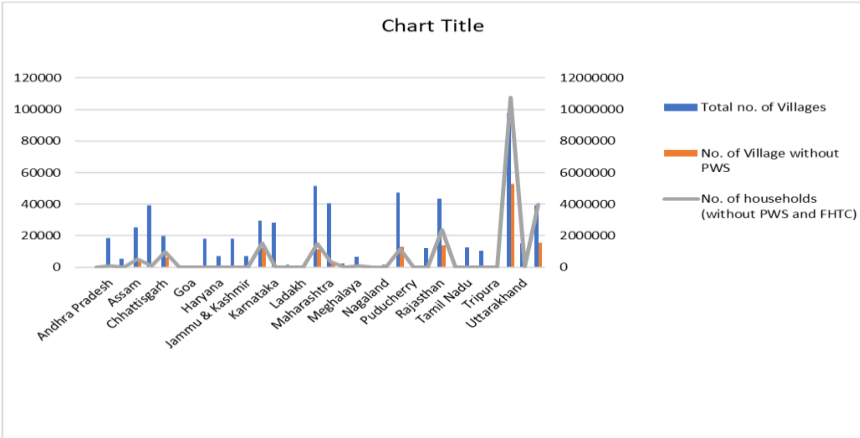

Figure 5. State wise PWS (Piped Water Source) and FHTC (Functional Household Tap Connection) Coverage Graph.

The smart water metering solution plus AMI, addresses the basic issues to a large extent. Let us look at a few implementation data:
A. Implementation at Bangalore city, see column in green in **Table-3** below [7]

B. Implementation in town, Shirpur Warewade Shirpur Warwade (in Dhule the north of Maharashtra) See column in green in **Table-3** below [9]

Table 3. Comparative Analysis of Proposed model with the state-of-art models.

Factors	**Pre smart meter**	**Smart meter implementation**	**IWMF based IWS (Proposed Architecture)**
Water Intake	12 million liters, No control on water consumption	8 million liters, Reduced by 33%	Expected to be further reduced
Bill generation time	2 months	Reduced to 1/3rd of pre-smart meter	Automatic, at preset periods
Tracking Consumption	Very difficult process, approximate data, excess water usage	Needs special effort, still approximate data with better accuracy	Automatic, continuous data available and exact data
Revenue collection	Huge deficit	100%	100% plus saving huge operational cost
Ease of Maintenance	Customer complaints, error prone reading delayed billing etc.	Improved response and efficiency	High customer satisfaction and error free metering, easy scalability of features
Ease of deployment	Difficult	Reduced difficulty	Very easy
Reliability	Low	Medium	High

The direct reflection of the need for smart metering solutions reflects in the business forecast of the smart water meter market too as we can see the numbers below:
Smart Water Metering Market size surpassed USD 1.5 billion in 2021 and is expected to grow at a CAGR of over 23% during 2022 to 2028. The industry demand is set to cross 92,043.3 by 2028[Ref - 6] The growing awareness toward the efficient use of water resources coupled with rising concerns for non-revenue water reduction will augment the industry scenario.

6. The IWMF value-add and the expected outcome

As of now, world over, the solutions are built for a specific implementation. Meaning, except for the sensors. there are as many implementations as projects. Hence the benefits of a well-engineered system design are not reaped as yet in this field. The current implementations seem to meet the requirement but the kind of road to be covered globally still, there is a need for something more. The smart metering infrastructure and technology – IOT, software and hardware need to be engineered. The AMI has to be maintainable, reusable, reliable and a faster turnaround time. This is where IWMF proposes a pioneering framework. IWMF is designed to build IWS by configuring the requirements and choosing a set of components from IWMF. The reliability, maintainability, faster deployment, quick turnaround time and ease of project execution, reduces the overall cost and time by 30 %. This is the USP of IWMF.

6. Pros and Cons, USP of IWMF

The proposed framework in this paper shall be a game changer and shall be a foundation for years to come. It is cost effective, reconfigurable to any geographical area, for any size, easily implementable and maintainable solution by design. and This framework shall be implemented and demonstrated in an area identified and expanded to other areas in phases. There is no disadvantage per say but the non-recurring cost could be slightly higher initially, but the ROI will be many folds higher. Hence a buy-in by the decision-making stakeholders is the key. A pilot implementation shall be taken up to demonstrate the solution.

References:

1. Global Biodiversity Outlook (GBO), a flagship publication of the Convention on Biological Diversity (CBD).
2. UNITED NATIONS SECRETARY-GENERAL'S PLAN: WATER ACTION DECADE 2018-2028 report
3. Towards a smart water city: A comprehensive review of applications, data requirements, and communication technologies for integrated management
Martin Oberascher, Wolfgang Rauch, Robert Sitzenfrei * Unit of Environmental Engineering, Department of Infrastructure Engineering, University of Innsbruck, Technikerstraße 13, 6020 Innsbruck, Austria
https://doi.org/10.1016/j.scs.2021.103442 2210-6707/© 2021 The Author(s). Published by Elsevier Ltd.
4. Smart Water: A Service-Oriented and Sensor Cloud-Based Framework for Smart Monitoring of Water Environments. Remote Sens. 2022, 14, 922.
Citation: Mezni, H.; Driss, M.; Boulila, W.; Ben Atitallah, S.; Sellami, M.; Alharbi, N
https:// doi.org/10.3390/rs14040922
5. Smart water consumption measurement system for houses using IoT and cloud computing Henry Fuentes · David Mauricio https://doi.org/10.1007/s10661-020-08535-4
6. 6. https://www.gminsights.com/industry-analysis/smart-water-metering-market
7. https://bengaluru.citizenmatters.in/apartment-smart-water-meters-adoption-67687
8. https://www.frost.com/frost-perspectives/world-water-day-india-tackling-water-utility-issues-with-smart-water-meters/#:~:text=The%20smart%20water%20meter%20market%20in%20India%20is%20forecast%20to,begun%20implementing%20smart%20water%20meters.
9. https://www.kamstrup.com/en-en/customer-references/water/shirpur-warwade
10. https://ejalshakti.gov.in/