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Emerging Technologies for Water Conservation and Sustainable Development

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Abstract—

Evolution of life and its sustenance on our planet has been possible due to the availability of water. Out of total water available in our planet only 2.5 per cent is fresh water and thus needs to be conserved for the plants and animals to survive for centuries. SMART technology basically refers to the use machine-to-machine technology for resolving problems without interference of operators and has the potential to play very important role to conserve water and sustainable development. Importance of water conservation has been realised by India way back in 1974 and considerable progress has been made by implementation of awareness campaign, rain water harvesting, ground water recharging, sprinkling, drip irrigation, use of greywater etc. With the use of SMART technology, sustainable development can be achieved using atomiser, soil moister sensor, flush with saving, low flow showerhead, dry sanitation, leakage sensor, automatic pump controller, sensor based water tap, automatic water tap etc. To achieve the aim of water conservation and its sustainable development it requires a combined effort of Govt. policies, strategies and public private partnership coupled with SMART technologies to maintain its sustainable development.

Keywords— ***Green Technology, rain water harvesting, ground water recharging, sprinkling, drip irrigation, atomiser, soil moister sensor, flush with saving, low flow showerhead, dry sanitation, leakage sensor, automatic pump controller, sensor based and automatic water tap.***

I. INTRODUCTION

Ours is the only planet where water and oxygen are available together causing evolution of life and its sustenance for millions of years. Till date no other planet in the solar system and beyond has been found to have both and thus the presence of life could not be established. The scientist community noted with great excitement when presence of water was reported [1] in an earth like planet named Proxima b which is just 4.25 light-years away from us. The planet is orbiting Proxima Centauri - a red dwarf star in our closest neighbouring star system. Earlier, non availability of oxygen and other unfavorable factors could not make the breakthrough of establishing human colony on the surface of moon. NASA has confirmed evidence of water in mars as found by Mars Reconnaissance Orbiter [2]. The excitement was again rose when mars expedition Curiosity Rover brought out the evidence of a stream of sorts in Mars that would have been active in the past. ISRO scientists are hoping to determine the quantities of water available in Mars that will help scientists around the world [3].

Evolution of life and its sustenance on our planet has been possible due to the availability of resources, called natural resources. As the name suggest the resource is available naturally. The plants and lives on this earth are blessed that both water and oxygen are available here. In fact, ours is the only known planet in this universe that has these two important resources and thus life. Two third of earth surface is submerged in water. But this is not potable and conversion of sea water into fresh water is not economically viable. Out of total water available in our planet only 2.5 per cent is fresh water. Out of this 2.5 per cent, approximately 68 per cent is locked into glaciers and icecaps [4]. This amount of water needs to be conserved for the plants and animals to survive for centuries. This would not be an overstatement that water is the most precious resource on the earth and hence sustenance of living beings.

Rapid misuse and improper storage coupled with population explosion has caused scarcity of water globally. Mawsynram village in Cherrapunji of Meghalaya State of India created world record in the year 1861with average annual rainfall of 22987 mm. 150 years later it reduced to 11430 mm per year. Presently this village, once famous for highest rainfall in the world is facing water scarcity in dry season [5] is probably the best example of consequences of not conserving natural resources.

Self-Monitoring, Analysis and Reporting Technology abbreviated as SMART is a technology which has the capability to monitor itself by obtaining feedback from the system and takes action as per the system requirement. This is technology was initially applied in computer hard disk drives (HDDs) and solid-state drives (SSDs) [6] to detect and report on system reliability, with the intent of enabling the anticipation of hardware failures. The rising demand for improved technologies and the growing investment in the research and development of the same have catapulted SMART machines to the forefront of the global industrial sector.

Application of SMART technology basically refers to the use machine-to-machine (M2M) technology for resolving problems and taking corrective measures without interference of operators. SMART machines include robots,

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self –driving cars and other cognitive computing systems that are able to make decisions and solve problems on their own [7]. Machines and tools have become more user friendly in the last decades mainly due to availability of latest technologies in open market and through e-commerce which has ensured availability at the doorsteps. These states of the art machines ensure high accuracy even at high speed when performing repetitive tasks for a considerable period of time [8]. Additionally, deploying SMART technologies across industries significantly reduce the chances of errors that may cause wear and tear of components, human fatigues and over confidence and casual attitude. SMART technologies have the potential to play very important role to conserve water and sustainable development.

International Institute of Sustainable Development (IISD), Canada in their report, also known as the Brundtland report [9] has defined sustainable development as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainable Development Policy & Practice is a knowledgebase tracking intergovernmental activities to implement the sustainable development agenda under the aegis of International Institute of Sustainable Development (IISD) [10]. UN Summit on Sustainable Development held at New York on 25 Sep 2015 [11], Sustainable Development Agenda has been adopted. This includes a set of 17 Sustainable Development Goals (SDGs) to end poverty, fight inequality and injustice, and tackle climate change by 2030. Conservation of natural resources comes under the agenda of climate change.

With wide accessibility of SMART technology, time is ripe to apply the same to conserve our natural resources for sustainable development.

II. NATURAL RESOURCES

The natural resources are categorized as primary and secondary resources. Earth's primary resources which are available on the surface of the earth consist of soil, oxygen, water and sun light. On the primary resources live the plants and animals and together they maintain the ecosystem. Prevention of soil erosion, maintenance of water and oxygen level is also because of ecosystem. Hence, to a large extent, ecosystem and primary resources are complementary to each other. As a result of these combinations, the life goes on in this planet.

Secondary resources, available below the earth's top surface are fossil fuel and natural gas which has been the product of primary resources with the passage of time. Secondary resources are important for development of society, to make the life progressively developed and make it more and more comfortable. Non availability of secondary resources definitely makes life very difficult and one has to look for alternatives. But, non availability of a single component of primary natural resources will throw the ecology out of gear and its cyclic effect will have direct impact on the life, threaten to destroy it in no time. Alternate of primary resources are not available and hence for our sustenance we have to ensure its judicious use. Out of these, we probably cannot control sunlight, but for sustainable development we can definitely impact on the remaining natural resources by preventing its misuse.

III. WATER ON EARTH AND ITS CONSUMPTION

Water, one of the major components of primary natural resources which is available in plenty in our planet like oxygen. In fact, the water to land ratio of the globe is three is to one. However, this is one of the major reasons that it is the most misused resource amongst all the natural resources. It is to some extent unknowingly due to lack of awareness of majority of people. But to a large extent, the misuse is due to the habit of mankind that anything available in abundance can be used carelessly. However, drought affected areas is various part of the world are the testimonies of the havoc caused due to scarcity of water. Hence, it is to be considered as burning issue to conserve water and application of SMART technologies to consume less water and stop misuse to achieve the same result.

In addition to use of water for agriculture, industry and commercial sectors it is directly consume by all living beings of this planet. Human water consumption depends upon geographical location, climate, traditions, urban or rural set up and above all personal habit. A survey has revealed [12] that the daily average water consumption in a village of Haryana was found to be 117 ltr per person per capita per day and washing of clothes consumes the highest amount of water. According to Code of Basic Requirements for Water Supply, Drainage And Sanitation (*Fourth Revision*) published by Bureau of Indian Standard [13], a minimum of 70 to 100 ltr per head per day may be considered adequate for domestic needs of urban communities in India, apart from non domestic needs as flushing and sanitation requirements.The WHO handbook [14] has laid down the emergency scale of water consumption (Table 1) per head per day in tropical climate.

IV. PRESENT SCENARIO OF WATER CONSERVATION

A considerable progress has been made in last decade to conserve earth's water by way of reducing its misuse, wastage and return the water to its subsoil by rain water harvesting. Alliance for Water Efficiency, Chicago, USA has initiated SMART Water Application Technology (SWAT) [15]. The SWAT project is an international utility/irrigation industry initiative to achieve efficient use of surface water by employing new irrigation technology. In this regards SWAT identifies the scope, researches and promotes technological innovations and related management practices. SMART irrigation controllers are a new technological innovation and have garnered national attention. There is tremendous interest in the potential of these devices to improve irrigation water management. Led by the Irrigation Association (IA), USA in partnership with leading water purveyors, the SWAT process also includes industry professional associations and irrigation equipment suppliers. A SMART irrigation system [16] can realize 30 to 65 percent water savings over traditional timer-based systems, although they can cost about 15 percent to 50 percent more. However, the first step to start the conservation process is the awareness to save water from misuse and wastage. Since it

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contributed significantly towards the loss of surface water, all other methods may follow from low cost to high tech methods. Present water conservation scenario in India is discussed in the following paragraphs.

Table I Emergency Scale of Water Consumption

Purpose	**Consumption (Per ltr per day)**	**Variables**
Drinking	2.5 to 3	Climate and individual habit
Hygiene, Sanitation	2 to 6	Social & cultural norm
Cooking	3 to 6	Food type, social and cultural norms
Total	7.5 to 15	

A. Awareness –

Aggressive awareness campaign to save water from its misuse and wastage has been undertaken through print and electronic medium, film strips, also in the form of slogans, posters and road shows. There are some catchy and innovative slogans which have generated interest amongst the masses. Some of these slogans are [17] "Save Water Save Life", "jal hai to kal hai", "Conserve Water, Conserve Life", "If you don't know importance of water conservation, ask a thirsty man", etc.

B. Rain Water Harvesting –

For conservation of water rain water harvesting is gaining popularity. Rain water harvesting is one of the most effective methods of water management and water conservation. It is the term used to indicate the collection and storage of rain water at surface or in sub-surface aquifer, before it is lost as surface run off. It is then either preserved for subsequent use or returned back to the sub-surface using simple technology (Fig. 1). However, at individual level, its implementation is limited in urban scenario. High cost of land forces people to settle in multi-storeyed complexes where storage space is at premium to implement rain water harvesting [18] at individual level. Rainwater harvesting methods are site specific and hence it is difficult to give a generalised cost. But first of all, the major components of a rainwater harvesting system - rain and catchment area - are available free of cost. A good proportion of the expenses would be for the pipe connections. By judiciously fixing up the slopes of roofs and location of rainwater outlets, this could be brought down considerably. However the cost varies widely depending on the availability of existing structures like wells and tanks which can be modified and used for water harvesting [19]. It is estimated that for large scale rain water harvesting, the per-capita investment goes down. It has been noticed [20] for Panchsheel Park in Haryana that about 1000 residents pooled in Rs 4.5 lakh to harvest more than 170 million ltr of water annually. Centre for Science and Environment, Delhi [21] estimates that merely capturing the rain water and run off on 2 per cent of India's land area could supply 100 ltr of water per person per year.

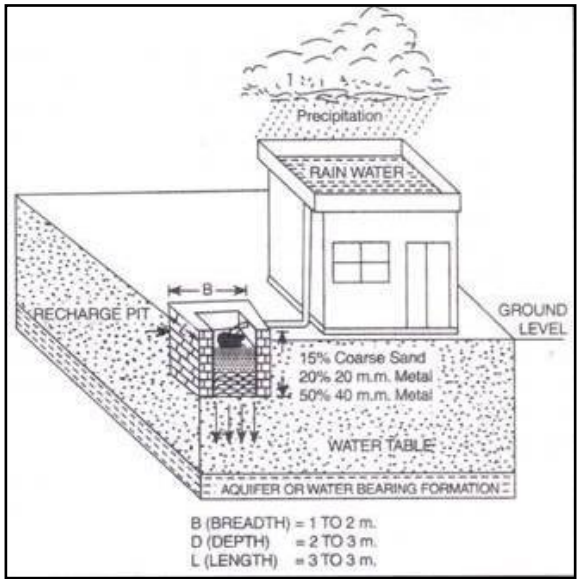

Fig. 1 Rain Water Harvesting
(Source: http://cdn.yourarticlelibrary.com/wp-content/ uploads /2013/12/clip_image00244.jpg)

C. Ground Water Recharging –

This is advanced method of rain water harvesting by way of artificial recharge to ground water. In this process the ground water reservoir is augmented at a rate exceeding that under natural conditions of replenishment. The collected water is stored and pumped in a separate pipe distribution. This is a very useful method for a developing country like India in reducing the cost. This is also useful to meet the demand of treated water and economising the treatment plants operation, maintenance and distribution costs.

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D. Sprinkler –

Sprinkler irrigation and drip irrigation have the potential to play a crucial role in conserving scarce water resources in dry areas. By ensuring the economy of use, drip irrigation and sprinkles can save anywhere between 30 to 60 per cent of water [21]. Additional benefit of sprinkler and drip irrigation is to apply water soluble fertiliser more optimally by mixing it with the water supplied to the plant. Other benefits are reduced weed growth and soil erosion. However, fairly good water quality is necessary to prevent clogging due to sedimentation. Hence it needs to be ensured that muddy water is not fed to the system. Sprinkler is a self driven accessories attached at the end of water distribution pipe placed on the field. This is a combination of water jet and reaction turbine packed in sprinkler head. At the delivery end of the pipe, the water passes through a jet which increases its velocity. The jets are mounted on a set of reaction turbine blades which causes the jets to rotate in the opposite direction due to reaction force. The combined effect is availability of water with adequate velocity which also revolves on the axis perpendicular to the ground surface. There are various types of sprinkler heads. Certain types apply water more efficiently than others. Rotary spray heads deliver water in a thicker stream than mist spray heads, ensuring more water reaches plants and less is lost to evaporation and wind. For all categories the water is sprayed of the top surface of the soil and ensured even watering and moreover it does not consume power from external source as it uses the energy of water for rotation while spraying. Sprinkler system is useful for field crop.

E. Drip Irrigation –

In this form of irrigation also called micro irrigation, water is supplied to the plant from the top in droplet form. The water drips slowly to the roots of the plant either onto the soil surface or directly onto the root zone. The system requires a network of valves, pipes and drippers. The water moves through gravity feed and hence it is most suitable in hilly areas [22] and widely used in north eastern hilly states of India. This system is very successful in orchards and plantation crops but not useful in field crops because of the fact that the drip system hinders routine field practices. The drip system is generally more efficient than conventional sprinklers, because it delivers low volumes of water directly to plants' roots, minimizing losses to wind, runoff, evaporation, or overspray Drip irrigations systems use 20 to 50 percent less water than conventional pop-up sprinkler systems. By installing the system around trees, shrubs, and gardens in place of a conventional sprinkler system annual saving of water can save up to 110 Kltr [23]. The draw backs of the systems are, relatively high initial cost, needs a certain amount of technical skills, system degradation due to continuous exposure in high sunlight resulting in frequent replacement of components [24]. Hence, a realistic cost benefit analysis would be deciding factors for implementation of the system.

F. Use of Greywater -

Used water from bathroom sinks, showers, tubs, and washing machines known as greywater. Greywater may contain traces of dirt, food, grease, hair, and certain household cleaning products but it is free from germs as it has not emanated from the toilet. It gives a dirty appearance, but it is a safe and its ingredients act as fertilizers to the plants and thus act as a good source of irrigation [25]. However, if it is released into rivers, lakes, or estuaries, its nutrients become pollutants. In addition to saving water, reusing greywater keeps it out of the sewer or septic system, thereby reducing the chance that it will pollute local water bodies. The easiest way to use greywater is to pipe it directly outside and use it to water ornamental plants or fruit trees. Greywater can also be used to irrigate vegetable plants as long as it doesn't touch edible parts of the plants. In any greywater system, it is to be ensured that the detergent and soap do not contain boron or chlorine bleach as these are potential health hazards to human beings.

V. SUSTAINABLE TECHNOLOGIES

Sustainable technologies are nothing but eco-friendly green technologies combined with SMART technologies. This is to make our present lives easy and comfortable and at the same time favourable for sustainable development. It is also called environmental healing technology because it reduces eco-damages by the by-products created due to the use technologies. India is the second highest populated country with one of the highest growth rates in the world [26]. Uneven distribution of population and unplanned use of water will become a huge challenge for our future generation. The quality and quantity of natural water is declining exponentially due to water pollution and uncontrolled consumption. Due to fast urbanization and conversion of agricultural land into residential and industrial plots, the ground water level is also receding fast. Some SMART technologies for water conservation and sustainable development are soil moisture sensors, low flow showerhead, atomiser, dry sanitation, leakage sensor, automatic controller etc. These have been brought out below.

A. Soil Moisture Sensors –

Watering the field by measuring the amount of moisture in the soil and tailoring the irrigation schedule accordingly can be done by using Soil Moisture Sensors [27]. The Kit is an easy to install add-on to any standard irrigation system that directly links the irrigation controller [28] to the land moisture requirements. Program the controller to water every day that irrigation is allowed, and the soil moisture sensor will do the rest.

B. Low-flow Showerhead –

It is the showerhead that allows 7.5 ltr per min or less water to pass through [29]. There are two basic types of low-flow showerheads: aerating and laminar-flow. Aerating showerheads mix air with water, forming a misty spray.

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Laminar-flow showerheads form individual streams of water. For humid climate, laminar-flow showerhead is preferred as this does not create as much steam and moisture as an aerating one.

C. Atomiser –

This is an attachment used in kitchen which restricts flow rates in an inexpensive method. Some atomisers are fitted with shut-off valves that allow stopping the flow of water without affecting the temperature. The water being used at mist form, M/s Kickstarter, one of the renowned manufacturers [30] claims the saving of water by 98 percent without compromising the cleaning quality.

D. Flush with Saving –

A low-flush toilet (or low-flow toilet or high-efficiency toilet), is a flush toilet that uses significantly less water than a full-flush toilet [31]. Low-flush toilets use 4.84 ltr or less per flush as opposed to 6 ltr as in case of a conventional toilet. It is available in two models; single-flush model and dual flush model typically use less than 6 ltr for the full flush and 4.5 ltr for a reduced flush. There are plenty of dual-flush toilet options available, which use 6 ltr per flush for solids waste and less [32] for liquids waste.

E. Dry Sanitation –

It is defined as the disposal of human waste without the use of water as a carrier. Often the product is then used as fertilizer [33]. In developed countries, dry sanitation toilets were initially designed for use in remote areas for practical and environmental reasons. However, increasing environmental awareness has led to some people using them as an alternative to conventional systems. In developing countries they can be a low-cost, environmentally acceptable, hygienic option. With dehydrating toilets, the urine is diverted away and the faeces collected in a chamber(s). Lime, ash or soil is added each time. When full, it is sealed and after some months the product is used as [34] fertilizer or buried. Examples are the Vietnamese double vault toilet [35], which has been used widely in Vietnam since 1954, and adapted models in Mexico and Guatemala. With composting toilets [36], the faeces are broken down by bacteria and fungi. Other organic matter such as coconut husks, straw or vegetable scraps are added. Temperature, airflow and moisture content are all carefully controlled to maintain aerobic conditions. Excess urine is drained away or evaporated [37]. Examples are the SIRDO, a prefabricated Mexican toilet [38], the Swedish Malthus and prefabricated and homemade Pacific Island [39] versions.

F. Leakage Sensor –

A considerable amount of water is lost through leakage ranging from droplets to flow through cracks. Be it in the domestic households or in industrial sector, any loss of water is loss of vital resourced. A dripping tap can waste 15 ltr of water a day, or 5,500 ltr of water per year. SMART technology is available in the form of Automated Leak Detection System or ALDS [40]. The small equipment fits into the main water valve has a built in thermodynamic sensor that measures the flow of water under normal condition. For leakage, it senses the difference in flow pattern. An error signal is generated to operate a servo motor to further close the main water valve. It thus stops the water loss due to continuous leakage. Once the leakage is rectified, the sensor is put in re-set condition for to resume its work.

G. Automatic Pump Controller –

Use of storage tank placed at the highest point of a house or placed atop of an independent tower is very common site for smooth supply of water. The tank is filled by pumping water available in a shallow storage at the base or sub-soil water is pumped up using submersible pump. The pump is switched on or off by an operator deputed for the same to do it in a fixed time intervals.

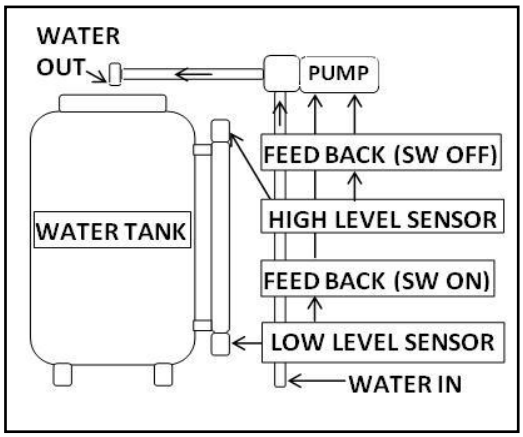

Fig. 2 Automated Pump Controller Systems

However, if the water is finished before stipulated time, there is no solution but to face the crisis. Also, there would be overflow of the tank if water consumption has gone low and the pump runs for stipulated period of time without a check on the water level. An automated pump operating system is devised to dispense with the requirement of

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operator (Fig. 2). This is a sensor based system which senses the low and high water level of the tank and switch ON or OFF the pump. This system automatically ensured steady flow of water without over flow and crisis.

H. Sensor Based Stop Valves-

Sensor based stop valves are very useful to save water in public urinals. These are generally used in the toilets of airports and malls in metro cities. The water flows on the urinals only when it is being used. It stops automatically as the user moves away from the sensor. It consumes only 10 percent of the water which otherwise would have used for continuous flow of water. However, presently it is not cost effective for use in all public toilets.

I. Automated Roadside Tap –

Wastage of municipality water in India through the road side tap is very common feature. More than 50 percent water is lost if the taps are either broken or stolen and the loss is recurring if not stopped. Sensor based stop valves as generally found in the toilets of airports cannot be fitted at the roadside in India as it would be stolen in no time. Tap with timer or spring loaded stop valve as used in Indian Railways appear to be the solutions to prevent such losses till our awareness is adequate to prevent theft of sensor based taps.

VI. CONCLUSIONS

Every drop of water prevented from wastage is the same amount of water conserved. It shows a bright future for water conservation wherein the school students are actively involved in the campaign *save water, save future*. Parth Gupta, a 10th standard student in Bharatpur, Rajasthan, India [41] offered ten easy tips to save water. These are; turn off the tap while brushing the teeth and take shower of shorter duration (saving @ 6 litre of water per min), place a cistern displacement device in the toilet to reduce the volume of water used in each flush, use washing machine and dishwasher in full load, fix a dripping tap, install a water butt to your drainpipe and use the water collected to water your plants, clean your car and wash your windows, water your garden with a watering can rather than a hosepipe (a hosepipe uses 1,000 ltr of water an hour), mulching the plants (with bark chippings, heavy compost or straw) and watering in the early morning and late afternoon will reduce evaporation and also save water, invest in water-efficient goods and services, install a water meter.

Importance of water conservation has been realised by India way back in 1974 and Indian Institute of Soil and Water Conservation was established [42]. The institute is progressing pioneering work in the field of soil erosion appraisal, water conservation, watershed hydrology and management. Water is an absolute necessity of life, it can sustain biodiversity. Water has been used everywhere from daily activities to construction and even for transportation. First life ever evolved in water. Water conservation involves reducing the usage of water and recycling of waste water for various purposes such as cleaning, irrigation and manufacturing. Hence, water conservation is most important for us and if do not conserve the water today we become responsible for the difficulty to be faced by our younger generation and too difficult a problem will be confronted by our future generation. Factors such as climate change will further increase pressures on natural water resources. To achieve the aim of water conservation and its sustainable development it requires a combined effort of Govt. policies, strategies and public private partnership coupled with SMART technologies to maintain its sustainable development. An adult human can live only seven days without drinking water. In this scenario as human beings we have to save water in spite of its present availability so that spare water can be conserved for others.

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