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**Water Resources Optimization by Using Geographical Information Systems (GIS) and Sensors**

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**Abstract**

Technologies such as satellite remote sensing in combination with semantic sensor web and geographical information systems (GIS) can be used innovatively by water authorities to obtain information in real time about water use, to track and forecast the level of rivers and to identify new sources of fresh water. Web-enabled sensors and communication networks provide an opportunity for water stakeholders to obtain information in near real time about physical and environmental variables such as temperature, soil moisture levels and rainfall. Smart metering technologies can also provide individuals, businesses and water companies with information in near real time about their own water use, thus raising awareness about usage, locating leakages and offering better control over water demand.

This paper highlights the latest developments in optimizing water resources utilization by using state of the art Information technology applications in various parts of the world.

**Key words**: Rivers, lakes, dams and reservoirs 3D mapping, urban environment and impact assessment, urban hydrology, urban management and modeling.

1. **Introduction**

Water use efficiency can be increased by two ways, either by increasing yield or by saving water. Water use efficiency is affected by a number of factors like climatic conditions, edaphic factors, nature of plant and agronomic practices. There are various techniques to increase water use efficiency in the rain fed ecosystem. Many options to improve water use efficiency are available and the target is to produce more biomass with minimum possible amount of water. ICT can bring enormous benefits to water authorities in mapping and monitoring natural water resources, as well as in forecasting river flows and giving advance warning of water-related emergencies such as flooding. In particular, smart metering technologies will play an important role in measuring water consumption in real time, identifying leaks at the consumer level and making consumers more conscious about their water usage. The scope of the ITU–T Focus Group on Smart Grid could well be extended to include water-metering technologies. With developments in plug and play sensors, the semantic sensor web, the geoweb, geographical 3D modelling and mobile communications, this field has great potential for water authorities, and there could be new areas of standardization work for ITU–T Study Group 16 in collaboration with other standards bodies such as the Open Geospatial Consortium (OGC), the World Wide Web Consortium (W3C) and the Institute of Electrical and Electronics Engineers (IEEE). ITU–T Study Group 5 (Environment and Climate Change) could work closely with, for example ISO and the Water Footprint Network (WFN) to look into developing model standards that enable countries to understand how their water management policies affect both their water and energy

footprints.

1. **Potential benefits of integrating ICTs in water and sanitation projects:**

Below are some of the potential benefits of integrating ICTs in water and sanitation projects:

1. Reduces the duration and costs of monitoring and inventory activities. Accurate data and information management systems are a precursor for sound management and decision support systems. ICTs can help make data transfer more efficient, reduce manual data errors, and increase the frequency of monitoring due to relative cost effectiveness. For example, in Liberia the use of [FLOW](https://www.youtube.com/watch?v=MdRDROpc8Ao), an open source mapping software, allowed for the mapping of over 10,000 water points in less than six months in 2011 and supported the preparation of a national WASH sector investment plan from 2012 to 2017. In Liberia, a traditional paper based survey would take at least one year with no guarantee on the quality of data collected.
2. Improves efficiency gains of water service providers. ICTs can enable shortened response time, reduce travel distance and maintenance costs, optimize operations (production costs, energy efficiency etc.) and improve quality of service. The establishment of the Senegalaise Des Eaux (SDE) supervision cockpit for urban water supply in Senegal has contributed to increased network efficiency from 69% to 80% within 10 years. In Benin, an ICT based platform (mWater) facilitated access to financing for service providers through documentation of historic data on technical and financial operations permitting financing of investments by local commercial Banks.
3. Improves collection rates of water service providers through ICT based-payment systems. Some of the most common ICTs adopted by utilities are e-payment systems which offer payment facilitation and increased reliability in billing and payment recovery, reduced administrative and payment transaction costs, and improved revenue collection. The Kiamumbi Water Trust (KWT) in Kenya established an M-PESA payment system in December 2010, enabling 550 households to settle their monthly water bills via mobile phone. In the first month, 42% of customers had transitioned to the mobile payment channel, rising to 59% by month four.
4. Ensure better services to the poor. Mobile phones, especially, are particularly well placed to serve the development needs of the poorest and most vulnerable populations. They represent a widespread and relatively low-cost communication option for rapid information transfer and service facilitation whilst eliminating prevalent issues of distance and time. In Kenya, Jisomee Mita is an application that enables water consumers to use a mobile phone to query and receive current water bills, at a frequency of their convenience.
5. Strengthens citizen voice and accountability framework. ICTs can be used to promote public participation and create a system of transparency and accountability. MajiVoice, a platform for communication between citizens and utilities, was successfully tested in Nairobi and enabled complaints rose from 400 to over 4,000 per month and 94% of submitted complaints closed up from 46% in initial months.
6. **Major roles for ICT in water management**

**Mapping of water resources and weather forecasting**

* Remote sensing from satellites
* In-situ terrestrial sensing systems
* Geographical information systems
* Sensor networks and Internet

**Asset management for the water distribution network**

* Buried asset identification and electronic tagging
* Smart pipes
* Just in time repairs/Real time risk assessment

**Setting up early warning systems and meeting water demand in cities of the future**

* Rain/Storm water harvesting
* Flood management
* Managed aquifer recharge
* Smart metering
* Process knowledge systems

**Just in time irrigation in agriculture and landscaping**

* Geographical information systems
* Sensor networks and Internet

1. **NASA providing training program on water resources and disaster management**

The launch of several Earth Observation (EO) sensors from advanced satellites provides world-wide continuous measurements on various hydrological components which are essential input data for hydrological modeling. The data gaps due to lack of on-the-ground monitoring of water resources around the world are now available using satellite acquisition. Thus, satellite products and sophisticated computational techniques for the management of water can play an important role in present and future of water resources. The satellite remote sensing for hydrological applications includes, but not limited to rainfall (Global Precipitation Measurements (GPM) and Tropical Rainfall Measuring Mission (TRMM); Soil moisture (Soil Moisture Active Passive (SMAP) and Soil Moisture Ocean Salinity (SMOS); Actual Evapotranspiration (Surface Energy Balance System); Mapping Evapotranspiration with Internalized Calibration (METRIC) and Surface Energy Balance Algorithm for Land (SEBAL); Groundwater level monitoring by Gravity Recovery and Climate Experiment (GRACE). Using satellite data and GIS, water bodies such as rivers, lakes, dams and reservoirs can be mapped in 3D. The spatial water availability maps can be generated. The concerned authorities can use the information for identifying the sites or regions that need effective protection and management and decisions can be made regarding the sustainable management of water resources in the identified regions. The GIS can be used effectively for this purpose to combine different hydro geological themes objectively and analyze those systematically for demarcating the potential zone. There are several urban applications where satellite based remotely sensed data are being applied, namely; urban sprawl / urban growth trends, mapping and monitoring land use / land cover, urban change detection and updating, urban utility and infrastructure planning, urban land use zoning, urban environment and impact assessment, urban hydrology, urban management and modeling.

1. **Conclusions**

Using drone [technology](http://www.scidev.net/sub-saharan-africa/enterprise/technology/) could cut labour and costs spent in collecting data for maize breeding by at least ten per cent . With increased demand for better seeds to adapt to [changing climate](http://www.scidev.net/sub-saharan-africa/environment/climate-change/), breeders have turned to unmanned aerial vehicles (UAVs) - drones for precise gathering of [data](http://www.scidev.net/sub-saharan-africa/enterprise/data/) from the field to enable more efficient maize breeding in most of Southern Africa. The use of drones to collect data may be an efficient way if you look at large acreages.

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