SENSORS FOR WATER MONITORING FOR IMPROVED ON FARM WATER MANAGEMENT

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ABSTRACT

Sustainability of agriculture is important in the context of Climate Change, soil degradation and scarce water resources. The existing irrigation management practices by farmers are not sufficient in improving water use efficiency and water productivity. The solution may be found in accessing and making use of real time information in water management decisions. The paper presents pilot initiative of WALAMTARI under ClimaAdapt project, on use of smart technology for obtaining real time information and establishing decision support system. Low cost sensors were developed and used in the field area for field channel water flow information and on-farm water and environmental parameters. Technology options for data acquisition, processing and decision support system are identified. For on-farm water monitoring the ultrasonic sensors was used with RBC Flume for water inflows and outflows. For measuring the water in the fields ultrasonic sensors fitted to Bowmen water tube are used. Other parameters measured are temperature and relative humidity. The lessons learnt from the pilot on research, innovation and capacity building activities can together create enabling conditions for change management through policy advocacy and scaling up.

Keywords: Smart Technologies, Low cost sensors, Bowmen water tube, RBC flume

1. INTRODUCTION

Climate change is having a profound effect on the environment, especially on the quality and availability of water resources. It will have significant impact on agriculture, which is climate sensitive. One of the main concerns in agriculture is the reliability and quality of water supplies owing to erratic monsoons, climate variability, extreme weather events and rising temperatures, which increases evaporation. Therefore, farmers, researchers and policy makers are increasingly concerned about the potential impacts of climate change on food security.

Proper water management is crucial for paddy cultivation practices of System of Rice Intensification, which involves alternate wetting and drying of paddy fields, direct seeding of rice, and machine transplantation. ClimaAdapt program, which is being implemented in Andhra Pradesh, Telangana and Tamil Nadu states of India with the support of Norwegian Institute of Bio-Economy (NIBIO), focused on developing a basket of climate smart agriculture options for improving adaptive capacity in agriculture and water sectors. This paper is based on initiatives taken up by the Water and Land Manabement Training and Research Institute (WALAMTARI), Hyderabad, under ClimaAdapt project. It discusses the use of sensors for monitoring and increasing canal and on-farm WUE.

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2. WATER USE EFFICIENCY

Almost 70% of all available freshwater is used for agriculture globally. Irrigation schemes in many parts of the world are performing well below their full potential (World Water Commission, 2000). It is regognised that deficiencies in management and related institutional problems, rather than technology of irrigation, were the chief main reasons of poor performance of irrigation systems" (ICID, 1992). Many management and institutional problems are self-created that could be minimized or eliminated with proper designs and operational instructions (Burt, 1999).

The National Action Plan on Climate Change (NAPCC) on climate mitigation and adaptation identified eight National Missions (NWM, 2011). For agriculture sector, national missions on agriculture and water are important. An important aspect in this context is water use efficiency (WUE): 'The National Water Mission recommends for improvement of WUE by 20%' (GOI, 2012).

There is growing urgency for more efficient utilization of water. At the farm level, there is a need for a dependable water supply that is flexible in frequency, rate, and duration. As part of improving water use efficiency, water management strategies should consider not only resources but also demands (Plusquellec, 2002).

2.1 Smart Technologies for Water Use efficiency

Good water management practices will increase yields, improve crop quality, conserve water, save energy, decrease fertilizer requirements, and reduce non-point source pollution**.** Information is most critical to decide on exact amount of water required by a crop in a given climatic condition and for effective design and management of irrigation system, irrigation scheduling, etc.

Sensors provide a better solution in accurate level measurements and automatic processing of water levels. Use of sensors would ensure using right amount of water as appropriate to season, and climate and weather conditions (Crabit *et al,* 2011). Proper scheduling can avoid over watering and excessive runoff. There are many advantages of using smart technologies over the conventional methods.

Table 1. Advantages with smart technologies

Particulars	Conventional Irrigation	Smart Irrigation Technologies
System	It is a supply based system with a fixed schedule, where watering schedule involves specific run-times and days regardless of the season or weather conditions	It is demand based system with a focus on climate and weather condition. Watering is done when required and that too in right amount of water.
Wastage	Large amount of water is wasted.	Very little chance of water wastage.
Productivity	Don't consider the plant productivity which is not based on efficient irrigation.	Consider all the aspects of plants related to water irrigation. It is based on efficient irrigation.
Operational convenience	Existing systems are not reliable due to not giving importance to operational aspects.	Can be controlled manually or automatically without physical presence at the system or field.

Soil moisture measurement is one of the best and simplest ways to get feedback to help make improved water management decisions. The soil monitors can be used to measure soil water content, which through calibration can estimate field moisture capacity. These data are accessible via telemetry, including cell phones. The soil probes send out an electronic signal that will call in every 15 minutes, if desired, though the system can be set to any time interval default.

2.2 Methodology and Approach

The pilot focuses on creation of Canal Network Flow Monitoring System (CNFMS) under Climate Cell, ClimaAdapt Project, at WALAMTARI. This included sensors and instrumentation lab to develop and install of sensors, software development to process and analyse information, decision support system, monitoring and control centre with dissemination facility. i.e., A comprehensive system to monitor the canal systems and on-farm parameters using sensors, Remote terminal Units (RTU), and Information and Communication Technology. It enables canal network flow management through creation of stages / nodes in a canal network. The system will facilitate receiving daily water availability, flows and release information; on-farm information at designated points; weather parameters from established systems; and other environmental parameters like Air Temperature, Relative Humidity, Sunlight hours, etc. The information thus captured would be disseminated automatically to designated authorities in specified formats through state of art Information and Communication Technologies, apart from getting stored in a central database.

2.3 Initiatives on WUE under ClimaAdapt Project

Information collected using manual measurements is less accurate; and may not represent the real time situation. There is, thus, a need for developing an error-free system with less human interference using mobile technology and GIS. ClimaAdapt program has taken up a pilot initiative for automatic measurement (by using low-cost sensors) of water flows in canals, soil moisture content on-farm, ambient air temperature and relative humidity. It would help in rolling out services to various stakeholders involved in the system such as farmers, members of farmers' organizations, Irrigation and agriculture engineers and scientists. For this purpose, Water User Associations (WUAs) in Kondrapole village DC-4, Miryalaguda Cirlce, Nalgonda District, Telangana state and Kavuru village, DC-21, Lingamguntla Circle, Guntur District, Andhra Pradesh state were selected

2.4 Key components of the pilot initiative

The pilot activities are aimed at identification/ innovation of suitable technology options, conduction of studies at field level, capacity building- awareness, on data collection, processing, analysis, establishing monitoring and reporting system linked to decision support system. The envisaged system would have sensors, instruments, gauges and devices for capturing real-time information on stage and water flows, and stage and water levels all along the water *distributory systems* from source to the field. On-farm systems for monitoring the water use in the fields would assess water usage by the primary stakeholders. The temperature, relative humidity and soil moisture sensors would provide information for crop management and field level activities. In other words, pilot involves developing a comprehensive system for information collection and use to help in water management decisions. The activities under the pilot are:

(a) Identifying technology options (Conducted market scan on sensors in regard to availability, suppliers, price, etc)

(b) Developing low cost sensors (Sensors were developed using Arduino microcontroller for water levels (ultrasonic), temperature, relative humidity and soil moisture)

(c) Capacity building (Exposure visits for the irrigation department officials on existing systems and modern canal control systems). Identified nodes in canal network for installing sensors to monitor water flows)

(d) Control centre (Control centre is being established at Climate Cell for centralised processing of real time information received from the various locations across the project area)

(e) Decision support system (DSS) (DSS calibrates physically based, numerical models, to better understand the water systems and forecast scenarios)

	
Ultrasonic sensors for water level	Temperature and relative humidity sensor
	
Soil Moisture sensor	Arduino Uno Microcontroller
	
GSM Board for sending SMS	12V Battery

Fig. 1. Componets of sensors assembly

2.5 Strategic interventions:

The pilot has initiated strategic actions for developing total system (see table below). These actions have led to test run and/or put in place sub-parts (individual parts) of envisaged system; and created enabling conditions for graduation to next level.

Table 2. Strategic interventions

S.No.	Parameter	Number
	Proto types developed	30
	Micro processors / Controllers	30
	Baseline data collected (no. of WUAs)	2
	No of trainings organised	10
	No. of exposure visits organised	2
	No. of people trained	200
	Sensors installed	20
	Software	Developed

2.7 Assessing sensors and instruments:

Historically, wireless sensor networks have mainly addressed military applications. However, in recent years, many civilian applications, such as managing inventory, monitoring product quality and monitoring disaster zones have emerged. The sensor is more reliable and cost effective when compared with manual operations. The sensor has to be physically compatible with its intended applications; and its selection depends on field (physical) condition, accuracy of operation, technical issues, application constraints and availability of budget.

2.8 Developing and Installation of sensors:

The available sensors were tested to reach a conclusion about the right trade-off of complexity and cost against usability and expected benefits. The pilot has developed two proto types: (i) TWEET for water level, temperature and relative humidity; and (ii) CLICK for soil moisture, temperature and relative humidity. The system is based upon Arduino microcontroller platform, an open-source electronics prototyping board. Arduino development environment, is an open source language and development tool. The code is simple and does not need support of an underlying operating system.

The cost of production was one-fifth to one-tenth of the average market price. The sensors were placed in the canals and on-farm at the project areas. Sensor was located where it is safe and convenient to install and access information.

Fig. 2. A tweet sensor installed in the field for measuring water level and flow, soil moisture, temperature and relative humidity with solar power, Kondrapole village, Miryalaguda area, Nalgonda, Telangana

2.9 Ongoing initiatives: Canal and on-farm water use efficiency studies

Information is being collected on weather, water levels at different points, surface and ground water, soil and crop aspects for using down to distributaries, WUAs and farmer level. It may be noted that data were collected from weather stations, reservoirs, and canal off take points on regular basis. In addition, soil monitors were installed to measure percentage of moisture in the soil; and was accessed through GSM modules. The Bowmen tubes fitted with ultrasonic sensors were installed in paddy fields for measuring water depths.

i) The pilot will need to graduate from information collection to data processing and decision support system. Toward this end, different aspects were studied and identified hardware and software modules for establishing a decision support system; and to bring pilot initiatives to a logical conclusion and take up initiatives for scaling up.

ii) Besides hardware and software systems, the following operational systems are also established.

(a) Visual data capturing: The images are captured through cameras in the form of photos and videos. Apart from the data collection, the photos and videos would be useful for continuous visual monitoring of the field situation. The images can also be analyzed through software for calculating water levels. Images can also be used for crop coverage too. Remote sensing imageries are useful for depicting current status of water flow in the canals.

(b) Data communication: Standard options like satellite (VSAT), telephone and cell phone are used for connectivity of the systems and data flow configuration. Wifi, blue tooth allows an alternative communication path, while a MicroSD could enhance the storage size for vast data archiving.

(c) GSM: GSM digital cellular network is used for transmission of SMS messages from sensors to the control centre. It can be controlled through UART and simple AT commands.

3. CONCLUSIONS

Irrigation managers are constrained by the lack of real time information. The pilot was implemented in recognition of the need for real time information on various aspects, which control and influence the water delivery and utilization regimes. It is assumed that real time data would help water mangers/users in tracking transmission/conveyance losses; and taking decisions for improving water use efficiency, instantly.

Technologies can be used innovatively by water authorities to obtain information in real time about water use, to track and forecast the water level in reservoirs and flows in rivers. The pilot initiative has applied Information and communication technologies (ICTs) for automation of information collection and processing, and linking it to a decision support system. In terms of technology, low cost sensors were adopted and test-run for monitoring water flows in two project areas, in Telangana and Andhra Pradesh states. In addition, hardware and software options were identified for data communication, processing and information visualization.

The capacities of engineers, farmers and other stakeholders were built, thus making available human capability and support system required for implementing this pilot initiative. Traditional system may pose challenges in implementing this system. The following are precondition for implementing pilot:

i) Suitable shutters to be provided for operation of sluices and to be maintained regularly with watch and ward for avoiding damages.

ii) Exploring possibility of providing water meters at field level for supply of water as per actual requirements

iii) Involving farmers in irrigation management to ensure judicious use and equitable distribution by building on traditional systems like WARABANDI system

iv) Involving the farmers and Water User Associations in measuring water flows and planning water releases at canal and reservoir level.

v) Adopting rotational water supply as irrigation scheduling

vi) The efforts are also needed to bring changes in farming practices to complement technology in achieving water use efficiency. For example, practices like micro-irrigation, and in rice cultivation - Alternate Wetting and Drying (AWD), Machine transplantation, System of Rice Intensification (SRI), direct seeding, and crop rotation as well as ID crops may be promoted. There should also be extension with a focus on creating awareness among the farmers about efficient use of water as per crop requirement. The real time information to all the stakeholders is useful in :

vii) Adopting the irrigation scheduling water usage can be minimized

viii) Generating crop water demand and supply graphs and make use of the same while releasing water to canals.

ix) Predicting occurrence of rainfall in the future by using rainfall probability analysis

x) Adoption of visualization techniques for quick decision making and supervision of gates, meters and other field devices.

xi) Water delivery would be equitable and also economical

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