Sector	Water Resources
Subsector/ Category	Planning
Technology	Ground water mapping and modelling
Scale of Application	National
Availability	This technology has matured in the global marketplace. The US Geological Survey(USGS)is a major developer of hydrological models since the 1960's and provides a wide range of models depending on the degree of sophistication required. For example, MODFLOW was built in the 1980's by the USGS and it continues to evolve as one of the most widely used ground water simulation models. NASA also provides a Global Change Master Directory (GCMD)on a wide range of models.

Technology Characteristics

Introduction

In Guyana, hydrologic data are lacking throughout the country, particularly since the late 1960's when data collection decreased dramatically. Drier conditions will have an impact on ground water recharge and water quality. Already, saline intrusion is a problem in some aquifers. With a growing demand on surface water for agricultural and industrial needs, the monitoring and management of ground water is becoming an increasingly important issue. According to estimates by the FAO, the internal renewable water resources (IRWR) are estimated at 241 km^3/year with groundwater resources at 103 km^3/year. According to AQUASTAT data, roughly 90 percent of the population is concentrated within the coastal area and thus all residents of the coastal area depend wholly on groundwater supply to meet their domestic needs, with the exception of Georgetown, which utilizes about 10 percent of surface water from the EDWC conservancy.

Because of the abundant surface water resources, sparse population, and lack of suitable aquifer-forming rock types, interior locations have only a limited number of wells. Overall, water supply sources for the entire country are about 178 ground water wells and 8 surface water sources (WRA, 1998). The Intermediate savannahs and hinterland used a mixture of surface and groundwater. In Guyana many businesses that use large quantities of water have their own wells to meet their needs. These include the bottling of beverages, water, other manufacturing and food processing industries (FAO, 2015).

To understand how ground water works and the risks posed by increased extraction, hydropower generation and climate change, there is a need to monitor and determine the long-term viability of ground water resources (WRA,2009). There is a need to generate/update data on well inventory and characteristics, such as, pumping rates and piezometric heads. Groundwater mapping and modelling is a highly technical and intensive process. Observation wells are created or existing wells are equipped with data logging instruments. Modern data loggers are battery/solar powered and can store water quality data, which can be then be downloaded and used in mapping and models. Groundwater mathematical simulation models, such as MODFLOW exist in several versions, are open sourced and can run on Microsoft systems.

Institutional /Organizational	The Ministry of Agriculture, Hydro-meteorological Services is the institutional authority for ground water resources. The Hydromet also collaborates with the Guyana Water Inc.
Adequacy for Current Climate	This technology is not climate dependent. However, it is a useful tool that will provide significant benefits for ground water management. The climate parameters such as rainfall and temperature are basic inputs to the program of groundwater modelling. Climatological data must be adequate and reliable. The results of groundwater flow predictions obtained with the computer model is a very important source of information for decision makers.
Size of Potential Beneficiary	The general public will benefit from this technology directly and indirectly, including, water managers, lecturers, researchers, householders, industries and farmers.
Disadvantages	• Require specialized skills in GIS technology and modelling; • Need to keep updated with models and training; • Lack/inadequate training may cause loss of interest in the technology; • High operating cost at the beginning; and • May diffuse slowly.
Endorsement by experts	The USGS (USA) is a leading provider of hydrologic and geochemical simulation models since the 1960's. USGS models are widely used to predict responses of hydrologic systems to changing stresses, such as, increases in precipitation or

	ground-water pumping rates, as well as to predict the fate and movement of solutes and contaminants in water (TNA FS). In the Caribbean Region, through the CARIWIN project, three pilot countries have benefited from training and capacity building in Integrated Water Resource Management, which include the testing, developing and disseminating new tools and information products including, hydrological data and measurements, flood analysis, climate change, watershed and groundwater modelling, GIS and water resources, hydrometeorology and water quality.
Capital Costs	
Cost to implement/Operate/Maintain	*Implementation:* • High investment cost, which would include, preparation of observation wells, data logging equipment, computers, open source or software license, procurement of expert/consultancy services for training; and • Many of the software developed by the USGS for ground, surface and water quality modelling, for example, MODFLOW are available for free download. *Operation/Maintenance:* • Training, ongoing data collection, security for observation wells/ equipment, procurement of software updates
Development Benefits – direct/indirect benefits	
Adaptation benefits	• Groundwater modelling technology application is actually derived from existing water scarcity as a result of climate change impact. Therefore, it is very important to have this projection model on water resource in order to better manage the available water; • Will build capacity to make recommendations on, risks, well locations, rates of extraction etc. based on scientific assessments; • Protection of aquifers: Aquifers are very convenient sources of water because they are natural underground reservoirs and can have an enormous storage capacity, much greater than even the largest man-made reservoirs. Many aquifers are also able to offer natural protection from contamination, so untreated groundwater is usually cleaner and safer than its untreated surface water equivalent;
Economic benefits	• Employment opportunities for technical experts and community support workers; • May spur investment in ground water assessment and protection services; and • Generate investment in enterprises such as small-scale hydropower, domestic water supply, food production etc.
Social benefits	• Increased awareness of the status of ground water resources and the impact of a changing climate on water resources; • Communities can use data to plan for water management; • Improve water access and supply; and • Reduce hardship on vulnerable groups of water carriers, such as, women, children and the elderly.
Environmental benefits	• Promote water security; • Strengthen capacity to monitor ground water resources; • Prevent ground water contamination and excessive extraction; • Reduce subsidence and salinization; and • Promote ecosystem health.
Local Context	
Status of Technology	This technology is non-existent in Guyana.
Market potential	Modelling technology has become a very important tool in natural resource assessments. This technology is advanced and is widely used by governments,

	universities, scientific institutions and service providers. It has significant market potential in the provision of expertise and services. Can inspire more extensive research in in the future.
Acceptability to stakeholders	Has high acceptability among all water users as a result of its potential to provide quick and efficient results. Considering the gap in hydrologic data, this technology will provide much needed updated information on the status of ground water in the country, which can be used to make informed decisions for water management in the future.
Opportunities and Barriers	*Opportunities:* • Can contribute to the establishment of a water resource information system; • Strengthen capacity to monitor ground water and make predictions; and • Significantly strengthen planning for water resource management and development programs. *Barriers*: • Lack of institutional skills to deploy the technology; • High initial investment cost; and • Cost to retain technical staff and sustain this technology.
Time Frame	Medium to long term.

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