

# Sustainable Water Resources Management using Water Rights Database System in Ghana

Francis Kwadade-Cudjoe

## ABSTRACT

*This study examines Sustainable Water Resource Management (SWRM) using Water Rights Database System (WRDS). The study explores the WRDS of the Water Resources Commission (WRC), Ghana, as a case study, for regulating and managing water resource. It looks at the functions, strengths and weaknesses of the WRDS; the assistance of the Invoicing Database Sub-System (IDSS); and the need to incorporate Quality Management Assurance (QMA) into the WRDS. Water Resource Management (WRM) has been a bane to most countries, albeit, not excluding the developed ones. The Board of the World Bank therefore, taking cognizance of the Rio Earth Summit of 1992, initiated plans in 1993 for a framework to contain the myriads of problems associated with WRM. The WRDS has been successfully implemented, used for capturing data, regulating and monitoring the water resource of Ghana, and generating management reports for decision-making activities.*

**Keywords:** Water resources management, database, sustainability.

## INTRODUCTION

The Government of Ghana in December 1996 enacted the *Water Resources Act 522* to establish a *WRC* to regulate and manage the utilization of water resources in Ghana (Parliament of the Republic of Ghana, 1996). Consequently, the then Ministry of Works and Housing (MWH) in 1997 commissioned the *Water Resources Management Study (WARM)* to find ways to facilitate *WRC*'s responsibility of regulating and managing Ghana's water resources on a sustainable basis (MWH, 1998). The *WRC* was subsequently, formed in 1998 and commenced operation in 1999. The organization has adopted integrated, cross-sectoral and catchment-area approach to *WRM*. With this new approach to tackling *WRM* problems, emerged the *Integrated Water Resources Management (IWRM)* plans and strategies, based on the particular environment or prevailing conditions. Accordingly, representatives of the stakeholders within the water sector constitute the board of *WRC*, and are using river-basin (land around a large river with streams running down into it) approach to managing the water resource of the country. There are 4 operating departments within *WRC*. These are: Administration/Finance, Policy/Regulation, Engineering/Planning, and Information Management. Some of the basins established by *WRC* (2006b) are:

- i. Densu (Eastern Ghana): used to be the most-stressed basin, mainly from

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- urbanization, pollution and land-degradation;
- ii. White Volta (Northern Ghana): for trans-boundary co-operation and joint management of shared water resources with Burkina Faso; and
- iii. Ankobra (Western Ghana): pressing mining activities on the resource and environment degradation (WRC, 2006b).

The WRC has a mission to regulate and manage the sustainable utilization of water resources and to co-ordinate related policies by combining the core competencies, effective participation, and monitoring as well as awareness creation for socio-economic development of Ghana (WRC, 2006c). The organization's vision is 'Sustainable Water Management by All and for All'. The values are: teamwork, honesty, Hardwork, punctuality, transparency, being responsible, and respect for others (WRC, 2006c). In achieving the above, WRC's activities include:

- i. Generating, collecting, collating, storing and disseminating information on water;
- ii. Allocating, monitoring and granting of water use permit;
- iii. Initiating and coordinating the development of water regulations, and
- vii. Setting up appropriate river-basin management structures (WRC, 2006c).

The Water Resources Commission (WRC) has developed a Water Right Database System (WRDS) for its core-activities of regulating and managing the river basins in Ghana. An Invoicing Database Sub-System (IDSS) has also been developed from the WRDS, and since 2004 a national water register has been published annually from the database system. The central objective of this study is to evaluate the use of the Water Rights Database System (WRDS) in Sustainable Water Resources Management (SWRM); and the need to incorporate Quality Management Assurance (QMA) into the WRDS. However, the following questions raised to guide the study.

- i What are the functions of the WRDS, its strengths and weaknesses?
- ii What is the assistance of the Invoicing Database Sub-System (IDSS) to the WRDS? and
- iii What benefits would be derived from incorporating QMA into the WRDS?

Approximately 97.5 per cent of water on earth is salty, and of the 2.5 per cent of freshwater, about 70 per cent is frozen in polar icebergs. Less than 1 per cent (about 0.007%) of the world's freshwater is readily accessible for direct human use (WHO, 2001). No wonder about 3.4 million people, mostly children, die annually from water-related diseases (WHO, 2001). However, in Ghana, the country is fairly endowed with water resources, but the present availability of 3000m<sup>3</sup> per capita per annum is decreasing due to rapid population growth. Nevertheless, the cost of exploiting new water supplies is rising sharply, particularly the cost associated with abstraction and transferring water from rivers and lakes to distant places (MWH, 1998).

It is therefore important finding sustainable management practices to this scarce commodity in Ghana, especially where technology can assist. Furthermore, to strategically regulate and manage this scarce resource efficiently and effectively is of paramount importance for the good-health of the citizenry.

### **Water Resources Management (WRM)?**

Problems involving WRM are critical as mostly the aged; women and children are the vulnerable. The World Bank therefore, in April 2005, formed a strong Water Resources Management Group (WRMG) to deliver a working paper on the growth development of Water Resource and how to champion the efficient use of water resource, dynamics of water for growth poverty alleviation (Grey and Sadoff, 2006). This was sequel to the earlier meeting by the International Conference on Water the Environment (ICWE) in January 1992, where water experts meeting in Dublin, Irel saw the emerging global water resources picture as critical, therefore, set out four guiding principles for action at local, national and international levels. The four guiding principles are:

1. Fresh water is a finite vulnerable resource, essential to sustain life, development and the environment. So, the effective management of water resources deemed a holistic approach, linking water uses across the whole of a catchment area or groundwater aquifer;
2. Water development management should be based on a participatory approach, involving users, planners and policy-makers at all levels. This involves raising awareness of the importance of water among policy-makers and the general public, where decisions are taken at the lowest appropriate level, with involvement of users in the planning and implementation of water projects;
3. Women play a central role in the provision, management safeguarding of water. So, the pivotal role of women as providers users of water guardians of the living environment requires positive policies to address women's specific needs to equip empower them to participate at all levels in water resources programs;
4. Water has an economic value in all its competing uses should be recognized as an economic good. Within this principle, it is vital to recognize first the basic right of all human beings to have access to clean water sanitation at an affordable price. Managing water as an economic good is an important way of achieving efficient equitable use of encouraging conservation protection of water resources (ICWE, 2016).

Globally, some organizations (both private public) the civil society have consequently, taken up the challenge to work on WRM issues to solving problems of countries affected. Unfortunately, literature on WRM is very scanty. However, for this study, the literature review would, hopefully highlight the *what, when, where, how* and *why* of WRM?

### **Database Resource Management Review**

Databases are generally helpful, especially where they contribute to the processing and managing of specialized tasks. Databases may be developed for general use (purchased *off-the-shelf* - at the counter), in-house or by a contractor for a specific functional task. Business Process Re-engineering (BPR) is one of the areas, where specialized databases are recommended for achieving dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed to maximize value-added content of businesses, thereby enhancing their competitive advantage (Hammer, 1990).

### **Models for Designing Databases**

There are 3 main models for designing databases – Hierarchical, Network and Relational Database Management System (RDBMS) - but the latter gives the best relationship among the data elements, for example, one-to-one and one-to-many relationships. It is therefore, the recommended approach for developing databases (Institute of Information Technology, 1996; Brookes, Grouse, Jeffery and Lawrence 1982).

### **Water Resource Database Systems (WRDS)**

Few authors and institutions have done research and/or developed databases for Management Information System (MIS) in *WRM*, rendering the environment devoid of the needed literature. One of the few institutions operating in *WRM* is the Environmental Software and Services – ESS (2007), which has developed an optimization database system for *SWRM* - (basin-based). The ESS database system looks at *WRM* issues in the areas of identification, definition and classification of problems, using decision-support systems (DSS). According to the ESS (2007), water is a key resource in the Mediterranean Region, and therefore, its efficient use and allocation are paramount to sustainable development, especially in the coastal zones of the South and East, which are undergoing fast economic development, land use and demographic change.

The overall aim of the ESS is to develop, implement, test, critically evaluate, and exploit an innovative, scientifically rigorous yet practical approach to *WRM* to increase efficiencies and reconcile conflicting demands (ESS, 2007). The most important elements of *WRM* databases are those designed to solve conflicting demands of water, and also being able to handle individual demands efficiently. The Demand-Management approach of the database system is therefore, vital for *WRM* (UN Habitat, 2002). Liu and Stewart (2004) also discuss object-oriented Decision Support System (DSS). Activities and actions involve modeling for multi-criteria decision-making in natural resource management (including water), and for efficiency and effectiveness of the system. Demand-Management is vital to enable a balance in the use of the resource, where the water available for supply would be able to meet the demand required (UN Habitat, 2002).

### **Methodologies for Designing Management Information Systems (MIS)**

Eppler and Mengis (2002) review literature in various domains to examine the theoretical basis of *information overload* discourses by analyzing, comparing various contributions (as well as impact), and to highlight current research deficits and future directions. The term *information overload* is often used to convey the *simple notion of receiving too much information* (Eppler and Mengis, 2002). Researchers across various disciplines have found that the performance of an individual correlates positively with the amount of information individual receives, up to a certain point. If further information is provided beyond this point, the performance of the individual will rapidly decline (Chewing and Harrell, 1990 cited in Eppler and Mengis, 2002). The information provided beyond this point will no longer be integrated into the decision-making process and *information overload* will be the result. Therefore, it can be implied (reasonably assumed) that *information overload* is not desirable too, in databases developed for *WRM*. However,

detecting the point where the *information overload* sets-in, would not be easy for both the developer and user. Unfortunately, the researchers, including Eppler and Mengis (2002) did not provide/include this vital point in their research, and therefore, making the detection of *information overload* very difficult. Kvasny and Richardson (2006) reflecting on the development of Critical Research in Information Systems (CRIS), state that during the 1990s, critical research entered an initial period of establishing legitimacy in information systems research through robust theoretical and philosophical analysis. CRIS therefore, enhances understanding, use and implementation of information technologies and information systems. CRIS is increasingly relevant for several issues, especially on global issues, such as digital inequality, social exclusion, and the strategic location of information technology services by trans-national corporations exploiting low pay, poor conditions or cheap raw materials (Kvasny and Richardson, 2006; Hamel, Doz and Prahalad, 1989; Ohmae, 1989). Therefore, a well-developed *WRM* database system, based on *CRIS* approach, with a DSS, and taking cognizance of Demand-Management plans, and not conveying ‘*information overload*’ is highly recommendable.

Unfortunately, and seriously left out of the databases or the methodologies listed above, is the importance of *Quality Management Assurance (QMA)* of the resource, which could measure the sustainability of the resource, in terms of quality. *Water Quality Management Assurance (WQMA)* therefore, is the practice of managing the way fresh water is maintained to make sure it is kept at a high standard. This is distinct from *Water Quality Control (WQC)*, the practice of checking the quality status of fresh water, to make sure it is of a high standard (Hornby, 2000); this is currently being practiced by the Water Resources Commission (WRC). Nevertheless, the quality system improvement concerning the procedures, processes and resources needed to implement quality management might be established (Zhang, 1997); however, the monitoring of *QMA* of the resource is equally important (as a preventative measure) for designing effective databases for *WRM* (Osekre, 2006), as the likelihood of the quality (of the resource) deteriorating through use is high. In Ghana, some of the critical issues of *WRM* relate to the under-listed areas:

**Inadequacy of water cycle data, caused by:**

- a. Serious national weaknesses in the assessment of water balance components, and
- b. Gaps in the available time series data, especially during the 1981–1983 drought affecting both hydro-meteorological and hydrological sectors (EPC, 1991); and

**Problems of Water Management**

- a. *Negative impacts of water management*, e.g. land use – the *WARM* study reports that catchment degradation, where soil erosion is a prime result of land degradation, from increased human activities is rampant in Ghana. This occurs from land-use practices of bushfires, lumbering, fuel wood harvesting and over cultivation from the agro-ecological zones. Catchment management through, e.g. soil and water conservation, and tree planting are therefore, critical in Ghana (MWH, 1998);



- b. *Water pollution* – water is one of the means by which waste as a by-product of socio-economic development process is disposed of. Disposed waste finds its way into surface and groundwater bodies. Also, inappropriate use of land, which leads to erosion, creates water quality and sedimentation problems;
- c. *Disposal of domestic and municipal wastes* – the capacity to handle household and municipal garbage deteriorated except in the capital, where a program of assistance from the Federal Republic of Germany helped to contain a serious situation. Disposal is by incineration or by land filling. In the coastal areas, the garbage find their way into the sea usually through lagoons where polluted waters are used by downstream settlements; and
- d. *Disposal of effluents* - the major industries discharge effluents into water bodies without treatment (EPC, 1991).

### **How Ghana approached WRM**

Technologically, the *WRDS* currently caters for only the regulation of the *WRC*'s mandate, but not the management of the resource. The idea of using the *WRDS* is a good starter for tracking the activities of the commercial users of the resource, and thereby regulating and monitoring them. However, the database should equally include data for monitoring and auditing the *IWRM* plans/strategies initiated by management for reclaiming/maintaining the resource. This approach could help solve a lot of the problems being encountered; the 3rd Research Questions takes care of this. This is vital for the nation, due to the fact that a lot of water-borne and water-related diseases are rampant in the country. A good *WQMA* policy would help to eradicate this canker of water-borne diseases prevalent in most rural settlements, where potable water is not available, but groundwater through bore-holes. Socio-economic inputs on settlers along the banks of the river basins when captured periodically into the system could help to effectively monitor/audit the management activities on the resource.

### **Water Resource Stakeholders**

The 'institutional principle' deals with stakeholders of *WRM* issues (country and trans-boundary activities) - (World Bank 2005). The *WRC* is managed by commissioners (board) of stakeholders in the water sector, with most having their activities impinging on the *WRC*'s. The Danish International Development Agency (Danida) supported the activities of the *WRC* with an integral component of a 5-year (2004–2008) Water Supply and Sanitation Program Sector (WSSPS) II facility (Niras-Danida, 2004). The strategic elements of the component indirectly supported the *WRC* through the Water Resources Information Services (WRIS) institutions, namely: Water Research Institute (WRI) - groundwater and water quality monitoring; Hydrological Services Department (HSD) - river systems monitoring; and Ghana Meteorological Agency (GMA) - rainfall and evaporation monitoring. These are data-generating Organizations within the water sector of Ghana. Other stakeholders are: The Ghana Water Company Limited (GWCL) and Irrigation Development Authority (IDA) - potable (drinking) and freshwater (irrigation) water supply agencies respectively.

They abstract fresh-water for their operations, and are therefore, customers to WRC; the Community Water and Sanitation Agency (CWSA) - peri-urban and rural water supply for the country through the operation of borehole/groundwater use of water; the Environmental Protection Agency (EPA), Mineral Commission (MC) and the Forestry Commission (FC) - partners with the WRC in managing the environment of Ghana; and Volta River Authority (VRA) - in charge of the Volta Lake/River from which the country generates its hydro-electric power (WRC, 2006a). Some of the trans-boundary stakeholders in partnership with the WRC include: the *Direction Générale de l'Inventaire des Ressources Hydrauliques (DGIRH)* of Burkina Faso - facilitating the process towards a more equitable and sustainable international WRM of the Volta Basin, and the World Conservation Union (IUCN) project - improving trans-boundary coordination, management and Water Governance in the Volta River basin, commonly known by its French acronym, *PAGEV (Projet d' Amélioration de la Gouvernance de l'Eaudans le Bassin de la Volta)* - (PAGEV, 2005). With a population growth rate of 2.5% per year, the basin is continually becoming stressed as a result of human activities (PAGEV, 2005).

## METHOD

To enable a good exploration of the WRDS, a sampling strategy of convenience and quota was used for the research. By this strategy, senior members selected from convenient Departments within the WRC were interviewed in-depth, using semi-/unstructured methods and questionnaire, to gather the necessary data for the research (Blaxter, Hughes and Tight, 2001). By this approach the major and sub-questions set for the research were achieved. The data so collected was subjected to qualitative (grounded theory) and quantitative (descriptive and cross-tabulation, using a statistical modeling package, 'SPSS for Windows') analyses – (Blaxter, Hughes and Tight, 2001). As the research was to evaluate the use of the WRDS in WRM in Ghana, a thorough investigation was adopted, necessitating more open and closed questions for collecting the primary data (Morgan and Smircich, 1980). See Appendix 2 for the Questionnaire.

A sample of 10 out of 14 senior members of the Organization was used for the research. This gives a sample framework of 71.4%, which was assumed to be quite good for the study. The primary data so collected was triangulated against data from the systems and operations manuals written for the database software. The face-to-face interactions (semi-/unstructured interview), between the researcher and the respondents uncovered a lot of rich qualitative primary data, as the respondents led the interview and therefore, volunteered a lot of information (Blaxter, Hughes and Tight, 2001; Daft, 2003; Coulson-Thomas, 1993). Secondary data was collected from the annual reports of WRC, water stakeholders in Ghana, newspapers, libraries, and database systems for WRM.

The data complemented the primary data gathered, and was subjected to qualitative and quantitative analyses. Though the secondary data was helpful, however it produced a longer time on learning the objectives of the research as compared to the primary data (Bishop, 2007). The grounded theory approach was adopted for the analysis because

*WRM* is not extensively researched, and as such, a thorough analysis of coding to identify the categories of data and their properties was needed. This produced inductive and deductive results that were used for making interpretations.

## RESULTS AND DISCUSSION

The primary bio-data gathered indicates that 60% of the respondents were male while 40% were female. This gave a ratio of 3:2, indicating a fair distribution of the gender used for the study. The respondents were senior members of the WRC, indicating a high-level source of the primary data, and therefore giving the research the needed importance and reliability. Majority of the respondents were in the age-group 21-30 years while 30% were in the 40 and above age-group; unfortunately, 31-40 years age-group was not covered by this research. The 70%, age-group 21-30 respondents being young indicates a better future for WRC. The 30% respondents in the over 40 age-group would surely mentor the younger 70% for a brighter future of the Organization. Of course, this would only be possible if the younger senior members would be willing to stay and work for WRC, and not change jobs for better remuneration. Triangulating the primary data with the secondary revealed that the *WRDS* developed for the WRC was implemented in June 2001 (WRC, 2001).

Some of the objectives of the database system are to:

- i Design a custom-made database system to capture the data collected on water users in Ghana;
- ii Produce the necessary reports required from the system to effectively manage the resource; and
- iii Produce a simple and workable database for use by the WRC (WRC, 2001).

The custom-made database captures water-rights data into the system to efficiently/effectively manage the water resource of Ghana (WRC, 2001). The *WARM* study enjoined the WRC to identify water resource users and make them apply/contribute in the form of annual charges for the management of the resource (MWH, 1998). In order therefore, to keep comprehensive and reliable information on the users, a database system was developed for the effective regulation and management of the resource. Hence, the *WRDS* is a computerized database system to regulate and monitor the activities of users of the resource.

### Features of the *WRDS*

The *WRDS* has been developed in Microsoft-Access and Visual Basic. It is made up of tables, schema forms, queries and reports. There are 19 data-tables constituting the table view; 13 data capturing media forming the schema form view; 10 queries for the query view and 3 reports for the report view (WRC, 2001).

### Processing data on the *WRDS*

The Table 1 (see Appendix 1) indicates that 70% of the respondents are familiar with the database, while 30% are not familiar. 70% of staff familiarity with the database makes it important for accomplishing the following tasks/activities: report generation is the most



popular (40%), data capturing (30%), database maintenance (20%), and water regulation (10%) (Table 2). The 70% respondents who are familiar with the database attest to the fact that it meets their needs (Table 3). It is therefore, not surprising that 100% of the respondents (including those not familiar with the database) know the objectives/functions of the WRDS (Table 4). The functions given by the respondents are: water monitoring (40%) is the most popular, report generation (30%), water regulation (20%) and for analysis (10%) (Table 5 and figure 1). Furthermore, 60% of the respondents are aware that system manuals have been written for the WRDS, while 40% cannot tell (Table 6); and again 70% are aware of operations manual for the WRDS, while 30% cannot tell (Table 7).

### **Comparing the Activities and Functions of the WRDS**

Juxtaposing the functions supplied by the respondents against the activities the respondents scored for the database indicates that 'Water Monitoring' is not a popular activity with the respondents who really use the database. Rather, 'Report Generation' appears in both responses for activities and functions of the database. 'Report Generation' (40%), which is the most popular activity the database is used for by the respondents, is also the 2nd most popular function. It has a mean frequency of 35%  $[(40+30)/2]$  usage when the activities and functions are combined, and therefore, the most popular activity/function the software is being used for.

### **Limitations of the WRDS**

Table 8 reports on the limitations of the system; 80% vouched for no limitation, while 20% responded for limitations. The 20% gave the limitations as 'few staff use it' and 'not fully operational' (Table 9). When probed further for why 'the database is not fully operational', it was revealed that it is currently not interactive, but rather being used as *stand-alone* (installed separately on different computer machines without any communication between them). The connection between the 2 limitations above is immediately established, as from the foregoing, not all the staff would have access to the database, and therefore, only 'few staff use the software'. However, this interactive problem is seriously being addressed by the WRC.

### **The Benefits of the WRDS**

All the respondents testified to the benefits of the WRDS (Table 10); they gave the benefits as: report generation (47%) is the most popular, water monitoring (27%), water regulation (20%), and flexibility of use (6%) (Table 11 and figure 2). For the 3rd time, the respondents' view on the WRDS produced 'Report Generation' as the most important/popular benefit, and with the score of 47%. There is 'no lie' therefore, that management of the WRC has been using the database system in generating reports for decision-making activities. Apart from the functions where 'Report Generation' came 2nd from the respondents, it has featured as the most important or popular in both the activities and the benefits the database is mostly used for. This shows that the database has been generating the necessary reports for management's decision-making activities.

### **Success of the WRDS**

Finally, for the success of the WRDS, 90% scored for 'successful' while 10% scored for 'very successful' (Table 12). From the above, there is no gainsaying that, the database is very useful for the Organization.

### **Invoicing Database Sub-System (IDSS)**

Triangulating the primary data with the secondary revealed that the *IDSS* developed for the *WRC* was implemented in March 2003. The database system has been developed to collect, store, process and print quarterly invoicing information on registered water users in Ghana. To develop an effective system to meet the needs of the *WRC*, a menu comprising series of processing tasks has been designed for the above system. The *IDSS* has been developed in Microsoft-Access and Visual Basic. It is user-friendly and very easy to operate (*WRC*, 2003). The Information Technology Department has also designed pre-printed forms for printing the invoices. The Accounts Department therefore, monthly and/or quarterly, generates the invoices that are sent to the water users informing them of their indebtedness to the *WRC*. Useful information on registered water users are transferred from the *WRDS* to the *IDSS* for the processing of the invoices.

### **Assistance of the *IDSS* to the *WRDS***

The respondents' familiarity with the database was only 20% for 'Yes' and 80% for 'No' (Table 13). The activities the database is used for as provided by the 20% are: 'invoice preparation' (13%), and 'tracking no-payment users' (7%) (Table 14). The 20% attested that the *IDSS* meet requirements - Table 15. Though the use of the database is not popular within the *WRC* (as only 20% responded for familiarity); however, 50% of the respondents scored the assistance of the *IDSS* to the *WRDS* as 'Important'; and surprisingly, the other 50% respondents scored the assistance as 'Strongly Important' (Table 16), signifying the usefulness of the invoicing database for generating revenue for the *WRC*. The high success (50% as 'Important' and 50% as 'Strongly Important') scored by the respondents for the invoicing database is not strange, despite the low patronage. This is so, because financial databases are normally restricted for use, except the Accounting Department. Controls put on such databases are therefore, important, so as to prevent fraud. The assistance of the *IDSS* to the *WRDS*, and then its contribution generally to *SWRM* is therefore, very important. The effective revenue mobilization by an Organization, such as *WRC* is very crucial to achieving its mandate. The revenue generated would enable the *WRC* to undertake its numerous projects/tasks of regulating and managing the country's water resources in addition to meeting its other costs.

### **Benefits to be derived from incorporating 'WQMA into the *WRDS*'**

The respondents' answers to the question 'what do you know/understand by *WQA*' were laudable despite the fact that most of them were hearing the term for the first time. The answers that emerged from the categorization (of responses) are: 'ensuring good quality status of the resource' (46%), 'ensuring sustainability of the resource' (31%), 'managing

tasks/activities for good quality of the resource' (15%), and water quality management framework (WQMF) (8%) (Table 17 and Figure 3). The first three answers seem alike, since they convey the message of 'managing tasks/activities to ensure good quality of the resource for sustainability'. The 4th answer was 'water quality management framework (WQMF). This is a lead to the next question; unfortunately, it scored the least, 8%. As a matter of fact, socio-economic data is one of the inputs required for WQMF. It was not a surprise therefore, that all the respondents scored 'Yes' for the question 'can socio-economic data on water users measure *WQA*'? (Table 18). The explanations given by the respondents as to how socio-economic data may be used for measuring *WQA* are: living standards are related to water cleanliness (60%); the environment determines quality of life (20%); data is indicator for measuring the pressure/condition of the resource (10%); and WQMF requires socio-economic inputs (10%) (Table 19 and figure 4). All the respondents replied 'Yes' to the question 'Is *WQA* relevant for *SWRM*'? (Table 20).

Furthermore, when the question was posed 'what contribution can it provide'? The answers received from the respondents were: measure/prevent quality degradation (45%); ascertain whether the *IWRM* plans are okay for managing the resource (45%); and serve as an auditing tool for *IWRM* plans for better results (10%) (Table 21 and figure 5). All the responses are very good, and point to the fact that *WQA* is really relevant for *SWRM*. Finally, when the respondents were asked 'does the *WRDS* incorporate *WQA*'? They all answered 'No'. As all the respondents were in favour of the relevance of *WQMA* to *SWRM*, the concept can be investigated further to determine the socio-economic parameters/inputs needed for monitoring and managing the sustainability of the resource.

### **Quantitative Test (using a statistical modeling package)**

Using a quantitative test, SPSS to further determine the relevancy of *WRDS* to regulate and manage *WQMA* of water resource leads to Cross Tabulating 'Is water quality assurance relevant for *SWRM*' against 'What contribution can *WQA* provide'. The outcome was (Yes) '*WQA* is relevant for *SWRM*', as it can be used to 'measure/prevent quality degradation' (scoring 4), 'audit management plans for better results' (scoring 4), and possibly 'ascertain whether the *IWRM* plans are okay' (scoring 2) (Table 23). The above quantitative analysis indicates the usefulness of incorporating *QMA* into the *WRDS* for the holistic regulation and management of the resource to render a *SWRM* for the country.

The results of the findings from both the qualitative and quantitative analyses (social constructivism and positivism respectively) point to the interpretation that incorporating *QMA* into the *WRDS*, would enlarge the scope of the database system. The *WRDS* therefore, would become holistic, versatile and provide the synergy for management to monitor the regulation, manage and sustain the resource (Bryman and Bell, 2007). The findings are also good enough to answer the 3 main research questions, and thereby achieving the central objective of the research. There is the need for further research on the socio-economic parameters needed for monitoring the *WQMA* framework, and development of the necessary database systems. These are however, beyond the scope of this project.

## CONCLUSION AND RECOMMENDATIONS

The *WRDS* has been successfully implemented in the *WRC*, and as at September 2015, 266 freshwater users have been registered in the country and, with 107 drilling license users. The findings revealed that management of the *WRC*:

- i. Is familiar with the *WRDS* of the organization,
- ii. Mostly use the database to generate management reports for decision-making activities, capturing data, regulating and monitoring the resource, and
- iii. See the database as successful (90% successful and 10% very successful).

However, as a limitation, it was found out that the database is currently not interactive, and being used as a *stand-alone* and therefore, few staff have access to it. This is however, seriously being corrected by the *WRC*. The *IDSS* produces the invoices for billing the water users. The database is mostly used by the Accounts Department to generate monthly and/or quarterly invoices for the regulation and management of the resource. The success of the database is very high (despite its controlled use), and assists greatly the *WRDS* in generating revenue for achieving the *WRC*'s mandate. *WQMA* is a concept, which is supposed to use socio-economic inputs (on water users) to monitor the *IWRM* plans and strategies for managing the river basin. It would also serve as an internal audit of the *IWRM* plans/strategies.

The successful completion, implementation, live running of the *WRDS* at the *WRC*, is a testimony for effective teamwork in the Organization. Effective teamwork embraces commitment, communication, empowerment, creativity openness (Capozzoli, 2006), but when group dysfunctional behaviour prevails, it leads to schedules slipping, cost over-running, output quality diminishing project failing (Kloppenborg and Petrick, 1999). *WRM* is quite a new concept of regulating managing river basins. As a new concept, therefore not researched much, getting the right literature for extensive review was very difficult. This has reflected in the literature on Ghana's *WRM*, with most of them written in the 1990s. This gives an opportunity for those in the water environment to research extensively, which would create a niche for them. The *WRDS* has been successfully implemented at the *WRC*; there is the need to incorporate water quality management (*WQM*) of the resource into the *WRDS*.

**Table 1:** Water Rights Database (*WRDS*): Familiarity with *WRDS*

Options	Frequency	Valid Percent	Cumulative Percent
Yes	7	70	70
No	3	30	100

*Source:* Survey, 2015

**Table 2:** *WRDS*: Activities *WRDS* is used for

Activities provided	Frequency	Valid Percent	Cumulative Percent
Capturing Data	3	30	30
Generating Reports	4	40	70
Maintenance	2	20	90
Water Regulation	1	10	100

*Source:* Survey, 2015

**Table 3:** WRDS: Did WRDS meet requirements

<b>Options</b>	<b>Frequency</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
Yes	7	70	70
No	0	0	70

*Source:* Survey, 2015

**Table 4:** WRDS: Knowing of Objectives/Functions

<b>Options</b>	<b>Frequency</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
Yes	10	100	100
No	0	0	100

*Source:* Survey, 2015

**Table 5:** WRDS: Objectives/Functions of WRDS

<b>Functions</b>	<b>Frequency</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
Water Monitoring	8	40	40
Water Regulation	4	20	60
Report Generation	6	30	90
For Analysis	2	10	100

*Source:* Survey, 2015

**Table 6:** WRDS: Availability of system manual

<b>Availability</b>	<b>Frequency</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
Yes	6	60	60
No	0	0	60
Can't Tell	4	40	100

*Source:* Survey, 2015

**Table 7:** WRDS: Availability of operations manual

<b>Availability</b>	<b>Frequency</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
Yes	7	70	70
No	0	0	70
Can't Tell	3	30	100

*Source:* Survey, 2015

**Table 8:** WRDS: Limitations/Weaknesses of the WRDS

<b>Options</b>	<b>Frequency</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
Yes	2	20	20
No	8	80	100

*Source:* Survey, 2015

**Table 9:** WRDS: List limitations of the WRDS (the 20% -Yes at Table 8)

<b>Limitation</b>	<b>Frequency</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
Few staff use it	1	10	10
Not fully operational	1	10	20

*Source:* Survey, 2015

**Table 10:** WRDS: Benefits/Strengths of the WRDS

<b>Options</b>	<b>Frequency</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
Yes	10	100	100
No	0	0	100

*Source:* Survey, 2015



**Table 11:** WRDS: List benefits of WRDS

<b>Benefits</b>	<b>Frequency</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
Water Monitoring	4	27	27
Water Regulation	3	20	47
Report Generation	7	47	94
Flexibility of use	1	6	100

*Source:* Survey, 2015

**Table 12:** WRDS: Describe success of the WRDS

<b>Options</b>	<b>Frequency</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
Strongly Unsuccessful	0	0	0
Unsuccessful	0	0	0
Uncertain	0	0	0
Successful	9	90	90
Very successful	1	10	100

*Source:* Survey, 2015

**Table 13:** Invoicing Database Sub-System (IDSS): Familiarity with IDSS

<b>Options</b>	<b>Frequency</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
Yes	2	20	20
No	8	80	100

*Source:* Survey, 2015

**Table 14:** IDSS: Activities IDSS is used for (the 20%-Yes at Table 13)

<b>Activities</b>	<b>Frequency</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
Invoice preparation	2	13	13
Tracking non-payment users	1	7	20

*Source:* Survey, 2015

**Table 15:** IDSS: Did IDSS meet requirements

<b>Options</b>	<b>Frequency</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
Yes	2	20	20
No	0	0	20

*Source:* Survey, 2015

**Table 16:** IDSS: Describe assistance of IDSS to WRDS

<b>Options</b>	<b>Frequency</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
Strongly unimportant	0	0	0
Unimportant	0	0	0
Uncertain	0	0	0
Important	5	50	50
Strongly important	5	50	100

*Source:* Survey, 2015

**Table 17:** Water Quality Assurance (WQA): Meaning of WQA

<b>Meanings Provided</b>	<b>Frequency</b>	<b>Valid %</b>	<b>Cumulative %</b>
Ensuring good quality	6	46	46
Managing for good quality	2	15	61
Ensuring sustainability	4	31	92
Quality management framework (WQMF)	1	8	100

*Source:* Survey, 2015

**Table 18:** WQA: Can socio-economic water-users data measure WQA

Options	Frequency	Valid Percent	Cumulative Percent
Yes	10	100	100
No	0	0	100

Source: Survey, 2015

**Table 19:** WQA: If Yes, explain (from Table 18)

Explanations provided	Frequency	Valid %	Cumulative %
Environment determines quality of life	2	20	20
Living standards relate to quality of life	6	60	80
Indicator for measuring condition of water	1	10	90
WQMF requires socio-economic inputs	1	10	100

Source: Survey, 2015

**Table 20:** WQA: Relevance of WQA to Sustainable Water Resources Management

Options	Frequency	Valid Percent	Cumulative Percent
Yes	10	100	100
No	0	0	100

Source: Survey, 2015

**Table 21:** WQA: If Yes, provide the contributions it can give

Contribution provided	Frequency	Valid %	Cumulative %
Prevent quality degradation	5	45	45
Ascertain whether IWRM plans are okay	5	45	90
Audit management plans for better results	1	10	100

Source: Survey, 2015

**Table 22:** WQA: Does WRDS incorporate WQA

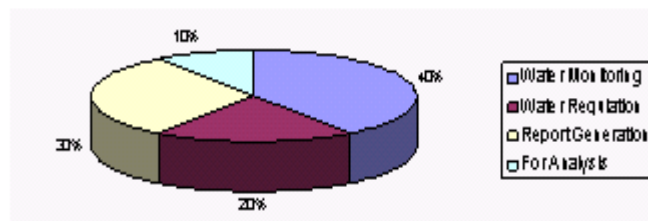
Options	Frequency	Valid Percent	Cumulative Percent
Yes	0	0	0
No	10	100	100

Source: Survey, 2015

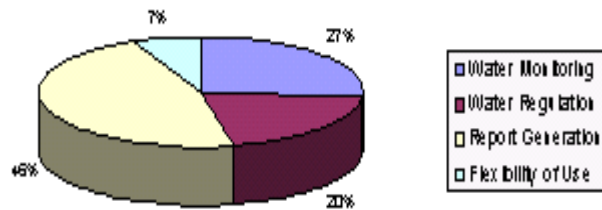
**Table 23:** What Contribution can WQA Provide

	Measure/Prevent Quality Degradation	Ascertain whether the IWRM plans are okay	Auditing of Management Plans for Better Results	Total
Water Quality Assurance is Relevant for SWRM	4	2	4	10
Total	4	2	4	10

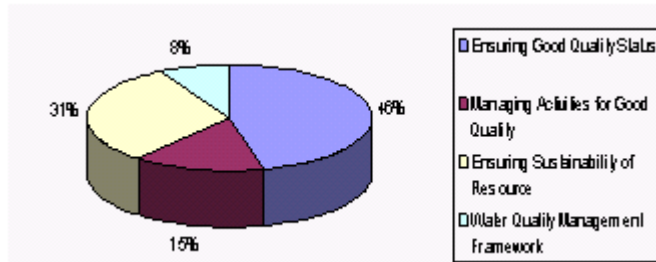
Source: Survey, 2015



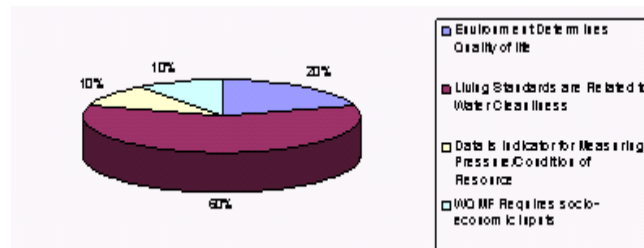
**Fig. 1:** Functions of the Water Rights Database System



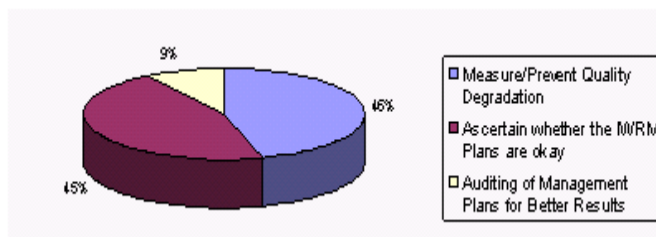
**Fig. 2: Benefits of Water Rights Database System**



**Fig. 3: Understanding of Water Quality Assurance**



**Fig. 4: Why Socio-economic data on water users can measure Water Quality Assurance**



**Fig. 5: The contribution of 'Water Quality Assurance' to 'Sustainable Water Resources Management'**

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