Development of Point Source Water Systems an Alternative to Urban and Suburban Water Needs for Integrated Water Resources Development and Management in Ghana

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Abstract:

On the basis of the 2010 population census, urban/suburban population of Ashanti region in Ghana represents about 51% of the total population of the region with an annual growth rate of 3.4%. In recent times the demand of water supply from the Owabi and Barekese headworks has increased manifold due to ever expanding urban/suburban communities and increased pollution levels in traditional sources of supply viz; hand -dug wells, streams and springs. Available evidence indicates that only 59 percent of urban residents have access to improved drinking water. The inadequacies in urban water supply are felt disproportionally by suburban communities. And in areas served by the approved utility company, water service is erratic and increasingly unreliable. The deliberate policy of the government in the early 90's to improve access to potable water in rural areas through point source supply systems via boreholes have seen an increase in access to potable water from the 90's till now. Thus a similar policy to the solution of urban/suburban water needs lie in the adoption of point source water systems: through an integrated water resources development and management techniques and sound regulatory policies on private point source water providers. Point source water systems are not only economical but feasible for the dispersed suburban communities in Ashanti Region.

Keywords: *Integrated water resources development and management, Governmental structure, Policy, Improvement, Sector Wide Approach, Globalization, Urbanization, Population, Point Source Water Systems, Housing Developers.*

1: Introduction

Urbanization and urban sprawl in particular, naturally affects groundwater and water resources in urban areas and its vicinities. Figures from the World Bank suggest that about 1.1 billion people today do not have access to safe drinking water. With increasing demand, better management of our water resources is urgent if we are to avoid severe water crisis. After many years of independence Ghana is still confronted with water shortages as a nation. Water shortage in Kumasi and other urban areas of Ghana has become a practice. Water problems are not confined to the urban centers only; the rural areas are also feeling the pinch and there is a little doubt that the future will bring increasing stresses on water supplies across the nation. The population of the urban areas to name a few, Kumasi, Accra, Tema and other regional capitals has since increased about four-fold after independence with Accra, the capital city of Ghana being the most populated followed by Kumasi, but there has not been a corresponding expansion of water treatment facilities and municipality/metropolitan base managed groundwater supply system to meet the increasing population so there are always the problem of water rationing in Kumasi and parts of the regional capitals where the population have increased substantially (2010 population census).

For community managed small town systems, the recommended amount of water use per capita, per day is 60 lpcd for people with access to household connections and 20 lpcd for people getting water from standpipes. In addition, industrial and commercial demand is assumed to be 10-20 percent of the domestic demand and physical losses are assumed to be 8-10 percent (10-15 percent in case of rehabilitated pipelines) (CWSA, 2004). The current approach tends to favour small scale Point-Source Water Systems (BOREHOLES AND RAIN WATER HARVESTING) to provide a primary protected source where people can collect clean water. This options target the most affected, enhance health, and contribute to development and productivity and merit far greater priority for rapid implementation.

Supply limitations envisaged here comprises of the following factors; increased urbanization; poor performance of water reservoirs, most of which use in-line booster pumps; illegal connections; inability to operate cost recovery; management challenges inability to carryout expansion due to low tariffs and erratic power supply. Thus the present paper aims to 1) create the awareness and improve understanding of emerging Point Source Water Systems and Rainwater Harvesting and 2) to incorporate the development of PSWS in integrated watershed development programs for sustainable supply of drinking water.

2: Groundwater Resources

Ghana is dendritically drained by three major river systems. These are the Volta, the South-western and the Coastal River systems. They, respectively, cover 70%, 22% and 8% of the area of Ghana. The Volta River system consists of the Red Volta, Black Volta, White Volta and the Oti Rivers. The basin formed by the Volta River system is shared with Cote d'Ivoire, Burkina Faso, Mali, Togo and Benin. The South-Western River system comprises the Bia, Tano, Ankobra and Pra Rivers. The Bia River basin is shared with Cote d'Ivoire and the lower reaches of the Tano Rivers forms the boundary between Ghana and Cote d''Ivoire. The coastal River system consists of several river basins along the Gulf of Guinea (Atlantic Ocean). They include the Kakum, Amissa, Ochi-Nakwa,Ayensu and the Densu Rivers. The total annual runnoff of Ghana is estimated at 54.4 billion m^3, of which 38.3 billion m^3 is accounted for by the Volta River system (WARM, 1998). The annual runoff from Ghana alone is 39.4 billion m^3, which is 68.6% of the total annual runoff.

The Volta, the South-Western and Coastal systems contribute 64.7%, 29.2% and 6.1%, respectively, of the annual runoff from Ghana. The occurrence of groundwater in Ghana is associated with 3 main geological formations (Fig.1). These are the basement complex, comprising crystalline igneous and metamorphic rocks; the consolidated sedimentary formations underlying the Volta basin (including the limestone horizon); and the mesozoic and cenozoic sedimentary rocks (Figs. 2, 3 and 4). The basement complex and the Voltain formation cover 54 percent and 45 percent of the country respectively. The remaining 1 percent consists of mesozoic and cenozoic sediments. Groundwater occurrence in the basement complex is associated with the development of secondary porosity as a result of jointing, shearing, fracturing and weathering. The depths of aquifers are normally between 10 m and 60 m, and yields rarely exceed 6 m^3/hr. In the mesozoic and cenozoic formations occurring in the extreme south eastern and western part of the country, the aquifer depths vary from 6 m to 120 m. There are also limestone aquifers, some of which are 120 m to 300 m in depth. The average yield in the limestone aquifers is as high as 180m^3/hr. The quality of groundwater resources in Ghana is generally good except for some cases of localised pollution and areas with high levels of iron, fluoride and other minerals. Salinity in certain groundwater occurrences is also found especially in some coastal aquifers.

2.1. Aquifer Characteristics

Typical values of some aquifer parameters in some geological formations are shown in Tables 1 and 2. The range of the overburden thickness in the Tertiary is 38-90m and 10-21m in the highly weathered granites of the high rainfall areas in the country. The overburden is mainly clayey and quite often underlain by the weathered rocks which constitute the aquifers.

The transmissivity values indicate that, in the Buem and Dahomeyan formations, the aquifers are quite good. The Dahomeyan formation, yield up to 13m^3/h but has highest failure rate of drilling also (Table 2).

Table 1. Information and aquifer characteristics of mechanized boreholes in some geological formations (Dapaah-Siakwan and Agyekum, personal comm.)

Geological Formation	Yield (m^3/h)		Transmissivity (m^2/s)		Overburden Thickness (m)		Aquifer Zone(m)
	Average	Range	Average	Range	Average	Range	
Buem	18	12.0-25.5	4.0x 10^{-4}	0.97-7.01x10^{-4}	10	8.3-14.5	16-30
Granite	11.1	4.5-15	2.2x10^{-4}	0.41-7.62x10^{-4}	15.1	10-21	21-61.3
Dahomeyan	13	4.5-35	2.9x10^{-3}	0.12-9.65x10^{-3}	15.4	4-26	14-65
Tertiary	7.1	3.8-21.1	1.1x10^{-4}	0.01-2.51x10^{-4}	70.2	38.1-90.1	38-90

Table 2. Handpump borehole yields and failure rates data in Ghana (after Dapaah-Siakwan and Gyau-Boakye, 2000; Darko, 2001)

<table>
<tr><th rowspan="2">Geological Formation</th><th rowspan="2">Percentage Coverage (%)</th><th colspan="2">Yield (m^3/hour)</th><th colspan="2">Depth (m)</th><th rowspan="2">Failure Rate (%)</th></tr>
<tr><th>Average</th><th>Range</th><th>Average</th><th>Range</th></tr>
<tr><td>Buem</td><td rowspan="7">54</td><td rowspan="2">9.2</td><td rowspan="2">0.72-24.3</td><td rowspan="2">44</td><td rowspan="2">21-146</td><td rowspan="2">12</td></tr>
<tr><td>Togo</td></tr>
<tr><td>Granite</td><td>4</td><td>0.3-36</td><td>37</td><td>13-152</td><td>22</td></tr>
<tr><td>Upper Birimian</td><td>7.4</td><td>0.45-23.6</td><td rowspan="3">54</td><td rowspan="3">16-187</td><td rowspan="2">24</td></tr>
<tr><td>Lower Birimian</td><td>12.7</td><td>0.41-29.8</td></tr>
<tr><td>Tarkwaian</td><td>8.7</td><td>1-23.2</td><td>17</td></tr>
<tr><td>Dahomeyan</td><td>2.7</td><td>1-3</td><td>39</td><td>22-122</td><td>64</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>Upper Voltaian</td><td rowspan="3">45</td><td>8.5</td><td>1-9</td><td rowspan="3">42</td><td rowspan="3">22-355</td><td rowspan="2">44</td></tr>
<tr><td>Middle Voltaian</td><td>6.2</td><td>0.45-9</td></tr>
<tr><td>Lower Voltaian</td><td>8.5</td><td>1-9</td><td>45</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td>Cretaceous - Tertiary</td><td rowspan="3">1</td><td>3.9</td><td>1-5</td><td>142</td><td>19-305</td><td>64</td></tr>
<tr><td>Cretaceous-Recent</td><td>15.6</td><td>4.5-54</td><td>68</td><td>36-108</td><td>22</td></tr>
<tr><td>Alluvium</td><td>11.7</td><td>1-15</td><td>-</td><td>-</td><td>33</td></tr>
</table>

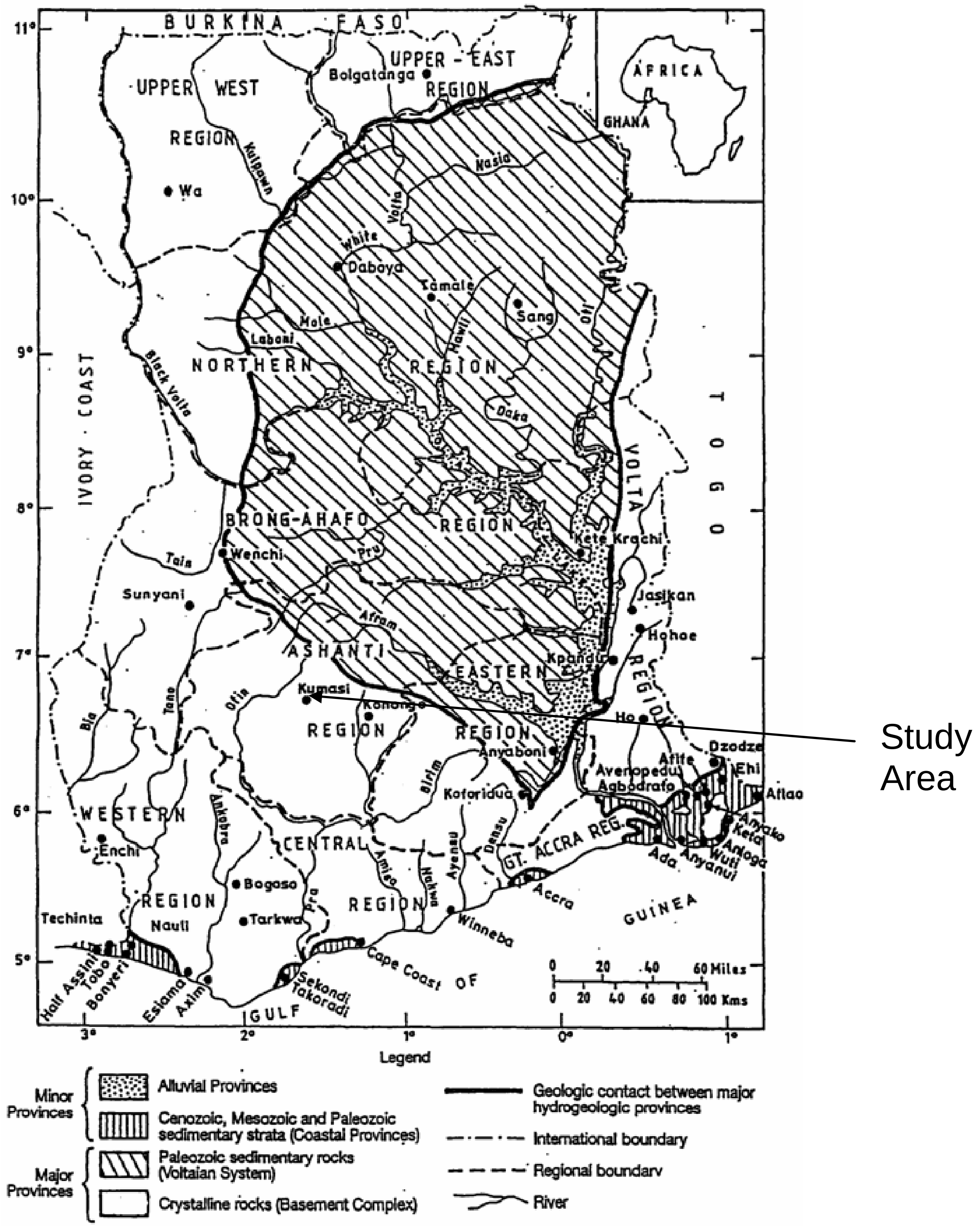

Fig 1. Hydrogeological provinces and river systems of Ghana (Geological Survey of Ghana 1969).

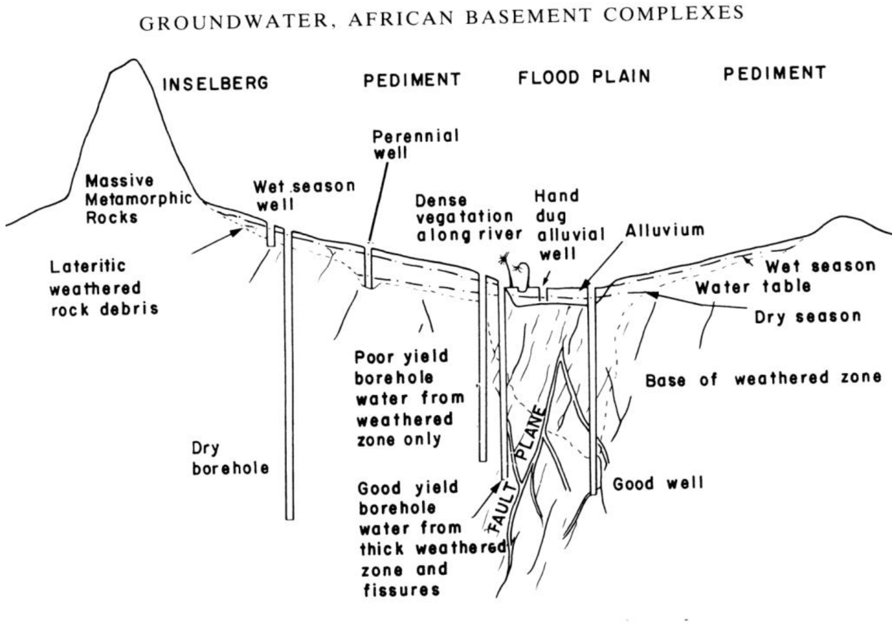

Fig 2. Diagramatic basement complex hydrogeolgy

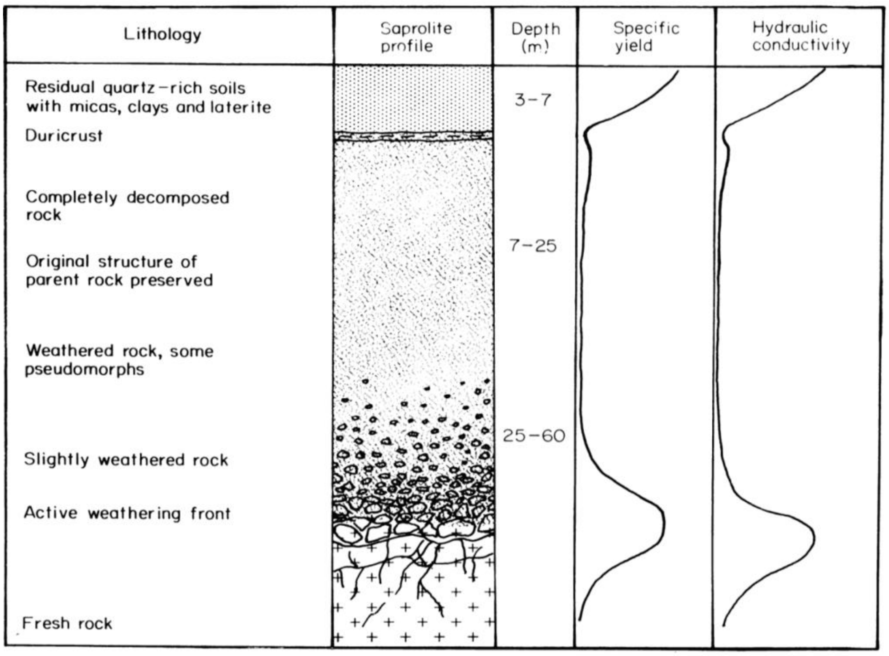

Fig.3. Major aquifer profiles depicting a typical saprolite profile over the crystalline Basement Complex in Central Africa. The variations in specific yield range from 10^{-1} to 10^{-5}, while the hydraulic conductivities are in the order of 10^{-2} to 10m/day.

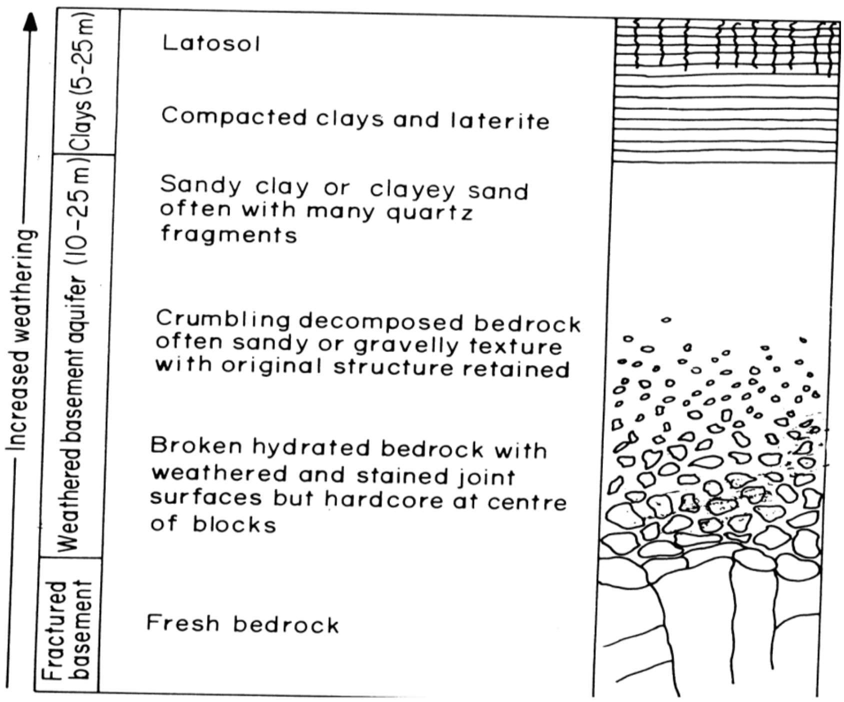

Fig.4. Typical profile of weathered basement aquifer

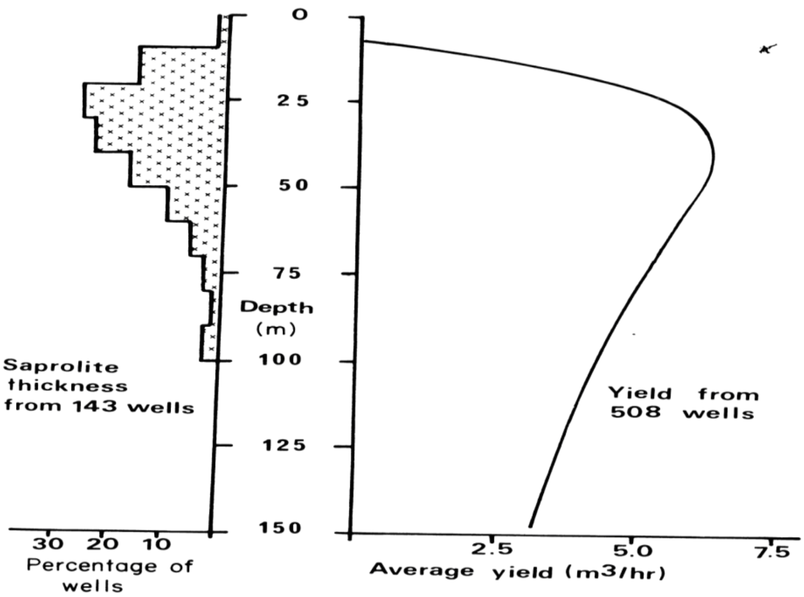

Fig.5. Saprolite thickness and average yields from wells drilled in the African and post-African surfaces in Tanzania.

Typical pump and recovery test curves in the study area have Static Water Level values in the range 4.69-20.65m, Dynamic Water Level 15.39-31.45m, Drawdown values in the range 10.7-10.8m, Yield values between 70-90 l/m and Specific Capacity values in the range 6.48-8.41 l/min/m. Water quality parameters in Kumasi, the study area mostly conforms to the international water quality standards by the WHO.

3: Current Water Resources Management Plan

Ghana has since the mid 1990's, been implementing a string of reforms in the water sector aimed at enhancing the efficiency of the production and utilization of water. These reforms have culminated in the institutional re-alignment of key institutions in the sector.

The summarized integrated water resources management approach being implemented in Ghana at the river basin level and national level is given in the following flow diagrams:

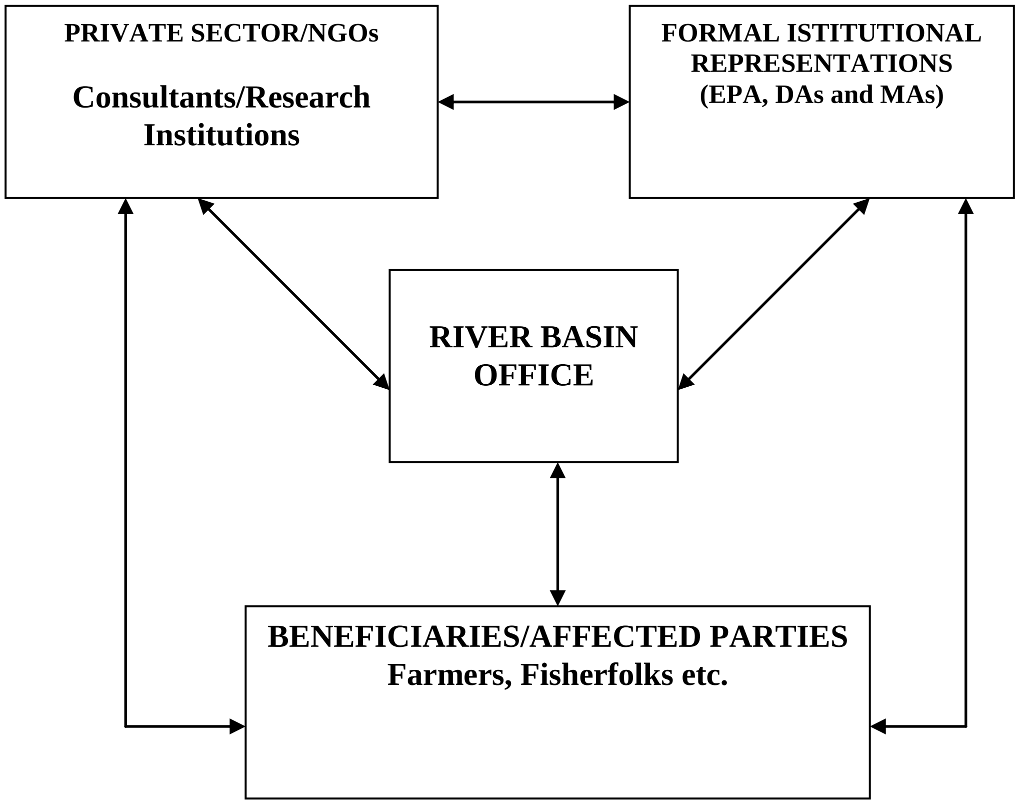

Fig.6. Institutional framework at the river basin level (source: adapted from Water Resources Commission, 1999, EPA-Environmental Protection Agency, DA-District Assemblies, Municipal Assemblies)

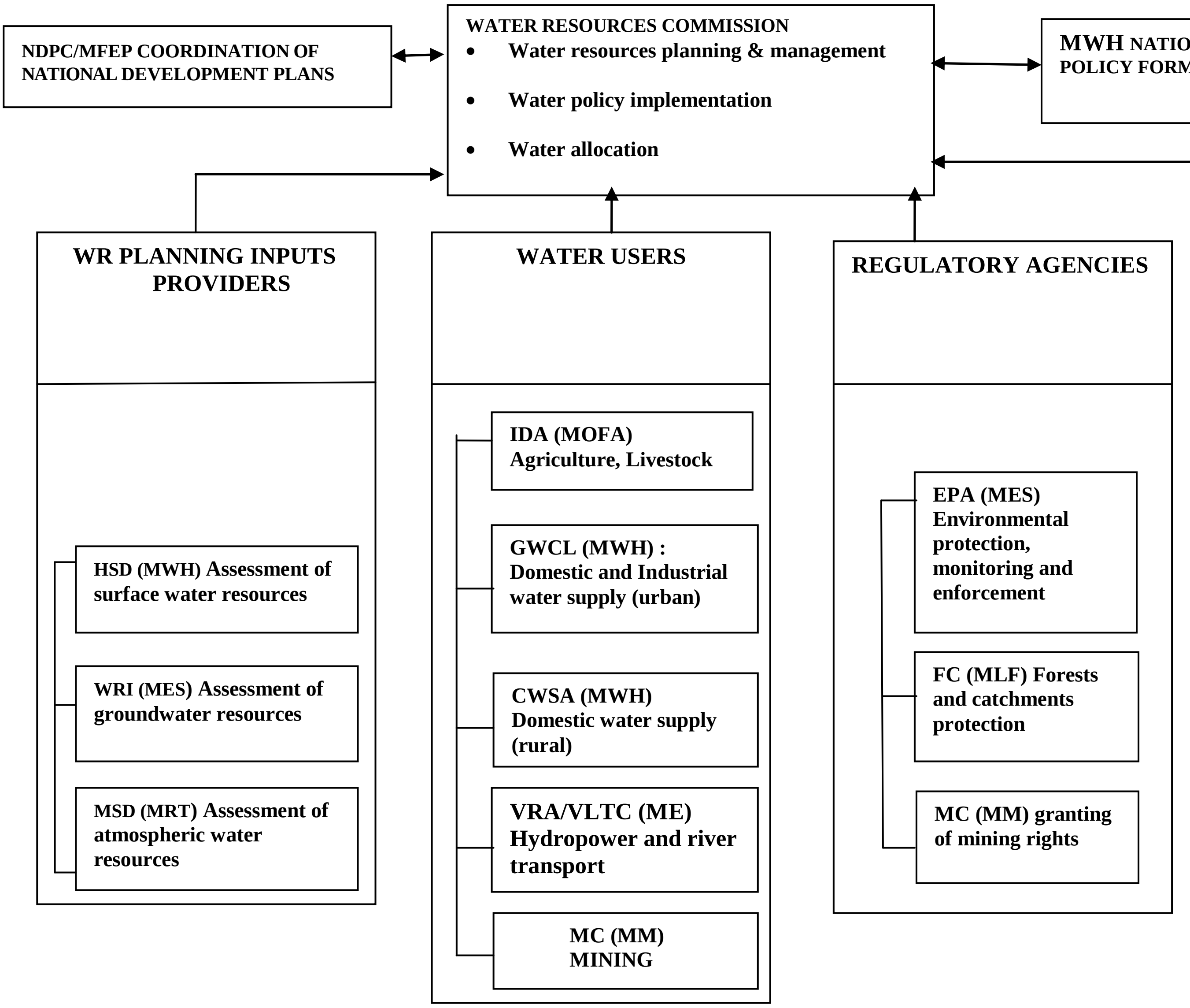

Fig.7. Institutional framework for IWRM in Ghana: Key Actors in Water Provision, Policy Regulations and Management (source: Water Resources Commission, 2000)

The proposed model (fig.8) seeks to add and highlight the current institutional framework at the river basin level and the need for the development and exploitation of point source water supply systems (boreholes and rainwater harvesting) in urban and suburban areas to augment water supply in times of water shortages from the usual Ghana Water Company or Community Water and Sanitation Agency.

These point source water supply systems are to be managed locally in liaison with the river basin offices. In this case information is shared (fig.8) with the aim of sustainable development and managing of water resources with a scientific approach.

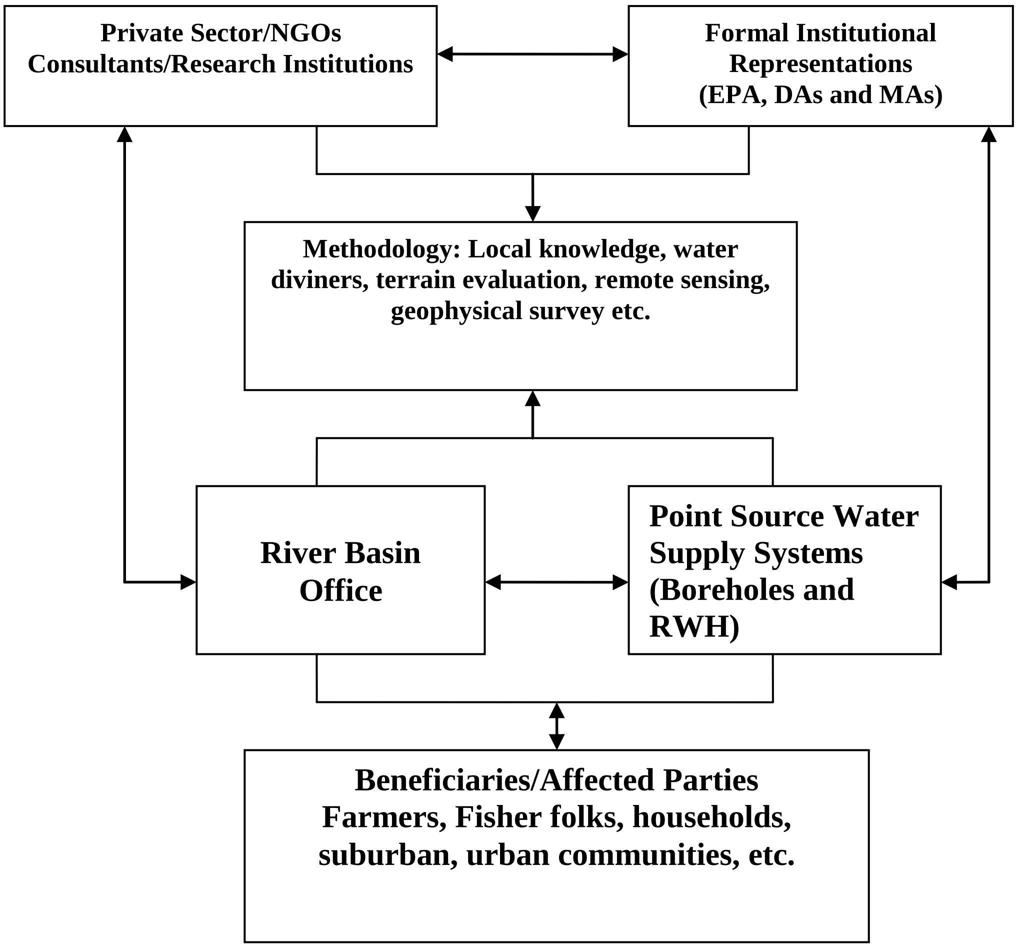

Fig.8. Proposed model for water resources management and distribution

The use of a combination of techniques such as local knowledge, water diviners, terrain evaluation, remote Sensing, hydrogeochemical surveys, geophysical survey is required to provide the necessary understanding of the geology, hydrology and geochemistry in study areas to develop the few freshwater resources (ground/surface water and RWH). Pertaining to this study, geophysical surveys were undertaken. The electrical resistivity method/technique was used where geophysical data was obtained to identify formations, presence and depths to the groundwater table in study area for possible development and exploitation.

Table 3. Legal enhancements for setting up major water-related agencies (source: Ministry of Works and Housing, Ghana, 1998)

Institution	Responsible ministry	Legal enactment
Meteorological Services Department	Communications	Administrative
Hydrological Services Division	Works and Housing	Administrative
* Water Resources Research Institute	Environment, Science and Technology	NLCD 293 of 1969
* Institute of Aquatic Biology	Environment, Science and Technology	NLCD 293 of 1969
Irrigation Development Authority	Agriculture	SMCD 85 of 1977
Ghana Water and Sewerage Corporation	Works and Housing	Act 310 of 1965
Volta River Authority	Mines and Energy	Act 46 of 1961
Volta Lake Transport Company	Transport and Communications	Registered under Company Code of 1970
Environmental Protection Agency	Environment, Science and Technology	Act 490 of 1994
Forestry Commission	Lands and Forestry	NRCD 239 1974

***Two institutions now merged as Water Research Institute**

4: Discussion

The Ghana Water Company at present manages about 82 urban water supply systems covering approximately 10 million or 40% of the country's population. The water supplies for the remaining 60% of the population are nonetheless catered for by the Ghana Community Water and Sanitation Agency. Yet the two institutions are unable to meet the water supply needs of the expanding populace. However, the problem can be overcome if more point source water systems (boreholes and rain water harvesting) are explored and managed locally on sustainable basis in urban and suburban areas to augment the already in place Ghana Community Water and Sanitation Agency and Ghana Water Company to make up for the shortfalls in water supply due to increasing population and urbanization. The proposed model aimed to enhance the delivery of adequate and the substantial supply of potable water to households in the ever increasing population and urbanization. So that, water supplies in the cities, metropolis and municipalities will become regular. This will help in a long way, such that school children especially, women and children in general will have time for themselves and to study in a way that they will no longer spend time in long queues and carrying buckets and gallons to fetch water at far distances when water shortages are experienced. The proposed method of integrated water resources development and management: is based on decentralized system involving the municipalities, cities, districts and localities. The various municipalities and cities should be given autonomy to form and manage their own water supply systems and given the authority to oversee the running of their water systems. Similar boards and local public water supply agencies can be formed at the district, community and local levels. If the everyday management of the water system is performed by people in the locality, there will be some efficiency in the water delivery in the area. Added to the municipal systems are the rural water supply systems, which consist mainly of shallow boreholes fitted with hand pumps, hand-dug wells, streams (permanent and ephemeral), springs, and ponds.

Obviously, there is no simple solution to the nation's growing water problems. Although the decentralization may help improve the water management problems, it also poses its own set of challenges which may need to be addressed through careful planning.

4.1. Conclusions

- There are two different cities in each urban area in Ghana, the well serviced city occupied by the rich few and the poorly serviced city occupied by everyone else
- Potable Water abstracted from Boreholes is an emerging option to meet domestic water supply
- Local initiatives for abstraction exist and development of groundwater supply is feasible over many urban areas within the metropolis
- Groundwater yields varies from locality-locality as a result of changing geology, geomorphology and several other complex factors
- Expert advice should be sought to ensure quality water is sited in groundwater potential zones.
- Borehole sitting should be incorporated in the design of new settlements to preserve hydrologically sensitive areas which serve as sources of supply and recharge to groundwater aquifers.
- Rainwater harvesting (RWH) should become an integral part of government policy in water resources development and management.

Most municipal and metropolitan water systems require the infusion of capital for major improvements and expansion to meet the ever-increasing populations. This has come about as a result of a lack of innovation and integrated comprehensive planning on the part of city and utility planning managers. The WRC should be encouraged to prepare, have or come out with short term plans, that is, 3 or maximum every five years based on population projections. Such a plan should include, at a minimum, our current sources of supply, current water usage, and sources being considered to meet any future projected needs without any adverse effects on the environment. Groundwater is used extensively in the rural areas on the other hand not like how it is used in the urban and peri urban centres to augment our reliance on surface water. Although, some well to do individuals and companies are able to afford to drill their own boreholes, the majority of the people are unable because of the high cost involved in sinking a borehole. This should be approached scientifically so that the adverse effects of over drawing groundwater can be monitored and controlled. A well scientifically coordinated groundwater and surface water resources development and management involving the various communities can lead to facilities and conservation programs for the expansion of water systems to meet current and future water demands to accommodate population growth.

IWRM implementation is still at its formative stage in Ghana. The creation of WRC in 1996 was a significant step taken by the government to address the diffused state of functions and authority in water resources management in Ghana. WRC is learning from the experiences gained in other places in Africa and elsewhere in the world, and should be encouraged to use pilot studies to develop appropriate tools to ensure sustainable water resources management and delivery to the people. The lessons from pilot studies will be replicated in other urban and peri urban areas in the country, taking into account of the differences in industrial development, cultural traditions and natural resources of each area. This implies that the approach to planning, monitoring and enforcement will have to be adapted to the actual situation on the ground.

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