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ENVIRONMENTAL IMPACTS OF ENERGY PRODUCTION

The case of Volta River Authority (VRA)-Ghana

Master's Thesis in

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ABBREVIATIONS

CCGT	Combine Cycle Gas Turbine
DSS	Decision Support System
DDT	Dichloro-Diphenyl Trichoro-ethane
ECG	Electricity Company of Ghana
GLOWA	Global Change for Water Cycle
GRIDCo	Ghana Grid Company
GVP	Government Volta Project
GWP	Global Water Partneship
IPPs	Independent Power Producers
IWRM	Integrated Water Resources Commission
JICA	Japan International Cooperation Agency
LVB	Lower Volta Basin
MW	Megawatts
MRP	Mines Reserve Plant
NEDCo	Northern Electricity Distribution Company
OEC	Observatory of Economic Complexity
REED	Real Estate and Environmental Department
SONABEL	Societe National D'electricite du Burkina Faso
TAQA	Energy in Arabic, Abu Dhabi National Energy Company
UAE	United Arab Emirates
US	United States
VBRP	Volta Basin Research Project
VRA	Volta River Authority
VRB	Volta River Basin
WRC	Water Resources Commision
WRIS	Water Resources Information System
WHO	World Health Organization

APPRECIATION

Anything that has a beginning surely has an end under the sun, this journey has not been without ups and downs but as long as the creator lives, we shall always be sustained.
I would like to express my sincerest gratitude to my supervisor, Professor Jussi Kantola of Industrial Management Department of the University of Vaasa for his encouragement and support during my studies at the University.
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ABSTRACT:

In this research, the discussion is centered on the construction of the Akosombo dam on the Volta River by the Volta River Authority (VRA) of Ghana and its impacts on the immediate environment and the ecosystem, the effect on the people living in the catchment area and their sources of livelihood.

In terms of both its operations and expansion in the power production activities, the initial project was only the hydro-power generation, which later on expanded to include a number of other sources of energy production. This expansion covers a period of approximately six decades, from 1963 to 2014.

The review of literature consists of five areas such as, Important Environmental Considerations catered for by the Volta River Authority (VRA), Environmental Concerns associated with the individual phases of the project, Steps lacking in the implementation method with respect to the Environmental concerns, Socio-economic cost of the Environmental concerns associated with the project and Remedial Strategies with their effectiveness.

The research methodology consists of five main headings such as Research Design, Data Collection, Sample and Population, Analysis and Limitations of the study. This research is a mixed-method study because, while the literature constitutes the basis for both the discussion and the main argument which is qualitative, the provision of an empirical evidence base is also quantitative.

The findings are divided into three main areas which are as follows; Presentation of the systematic literature review, Analysis towards classification of the research objectives and Analysis of findings in the light of the two main Environmental Theories.

KEY WORDS: Energy, Environment, Production, Impact, Volta River Authority

1. INTRODUCTION

This chapter takes a considerable look at the relationship between Energy and Environment. How these two entities interconnect to have effect on the daily activities of humanity.

1.1. Energy and the Environment

Energy is the food the modern world runs on as it fulfils the needs of both the massive urban and industrial sectors which have both expanded rapidly over the recent past and both of which have a huge appetite for energy. Towards fulfilling the massive needs of these sectors, both traditional and renewable energy sources are being exploited, where the former include the fossil fuels like coal, oil and natural gas, the latter however include wind energy, solar energy and also thermal, nuclear and hydropower generation. It is important to understand that the environment suffers at the hands of both the conventional and renewable methods of energy production; though the conventional are considered more dangerous as compared to the renewable methods because of the threats of global warming and greenhouse effects et cetera. However, the renewables also exercise an adverse impact upon the environment and the surrounding communities in a more indirect and subtle manner (Panwar, Kaushik & Kothari, 2011; and Botkin, Keller & Rosenthal, 2012).

1.1.1. Introduction to the Case Study-Volta River Authority (VRA)

Volta River Authority (VRA), the leading power generation company in Ghana and the property of the Government of Ghana, was established by an Act of the Ghanaian parliament in 1961. Volta River Authority (VRA) is considered significant because of two important reasons: firstly, it uses a combination of hydro, thermal and solar means to produce power; and secondly, the produced power is not only destined for domestic utilization but is also exported to other neighbouring countries in the West African subregion. The domestic production of power by the Volta River Authority (VRA) amounts to approximately 61 percent of the total energy capacity in the country which is man-

aged by the Electricity Company of Ghana (ECG) in order to fulfil the energy requirements of both the mining industry, urban and industrial sectors. The exported power which amounts to 39 percent of the total power produced by the Volta River Authority (VRA) is supplied to the Republics of Benin and Togo via Communauté Electrique du Benin (CEB); and to Burkina Faso through SONABEL (Agbemabiese & Byrne, 2005; and Sarpong, 2005).

Table 1. International share in Volta River Basin

Country	Area of Volta River Basin (km^2)	% of basin	% of country in the basin
Benin	17098	4.10	15.2
Burkina Faso	178,000	42.65	63.0
Cote d'Ivoire	12,500	2.99	3.9
Mali	15,392	3.69	1.2
Togo	26,700	6.4	47.3
Ghana	167,692	40.18	70.0

(GWP, 2017)

It is important to note that Volta River Authority (VRA) has constantly been evolving since its establishment. In terms of both its operations and the expansion in the power production activities, as the initial project just included the hydro-power generation, which later on expanded to encompass a number of diesel powered plants; and at a later stage, included a few wind energy farms, solar energy farms and also a thermal power production facility. This expansion can be mapped over almost six decades i.e. from 1963 to 2014 (Johnson, Howell & Evered, 2015).

1.1.2. The Environmental Impacts of VRA in the Volta Region of Ghana

Volta River Authority (VRA) was principally established by the Government of Ghana towards the supervision of the construction of the Akosombo Dam on the Volta River and the further development of the power generation potentials of its facilities. As part

of this aim, the designs, plans, organization and implementation of the resettlement strategy for the population segments and communities both in the main river basin area and also on the riverside, was also made part of the responsibilities of the Volta River Authority (VRA). Once Akosombo Dam was completely constructed in 1964, the Volta Lake was formed, which today is one of the largest fresh water reservoirs in the whole of Africa. The Lake covers an area of around 3300 square miles or 8500 square kilometres, with a perimeter of 3000 miles or 4800 kilometres long; enjoys a storage capacity of 153,000,000,000 cubic meters or 124,000,000 acre-feet of water; and constitutes 3.6% of the total land mass of Ghana (Figure – 1) (Al Wahaibi & Ross, 2014). Below is figure 1. which shows the Volta Lake on the map of Ghana.

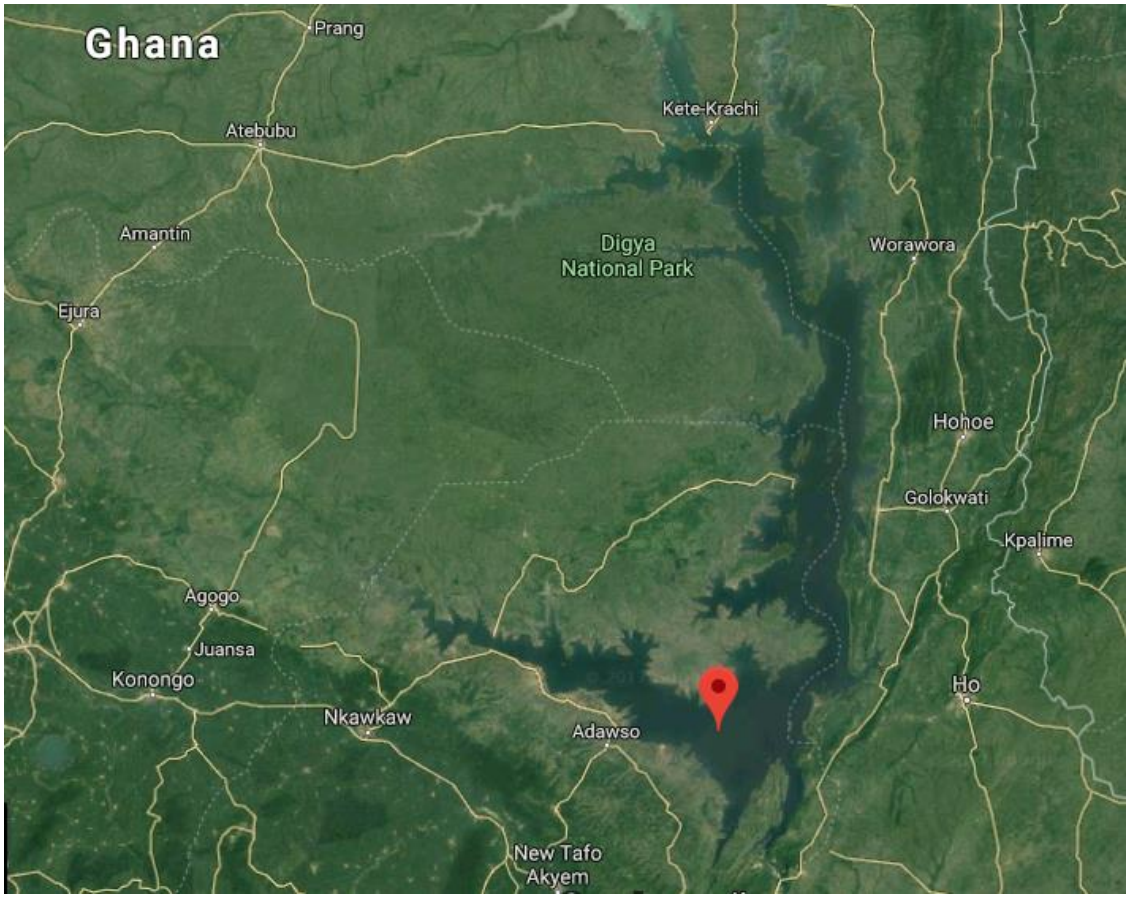

Figure 1: Lake Volta (Google Maps, 2018)

Since its establishment, Volta River Authority (VRA) has been criticized because of two important reasons: firstly, though the setting up of the Authority was principally

aimed at socio-economic development of Ghana, an evidence of this achievement has been found lacking and secondly, the power production operations by the Volta River Authority (VRA) have had significant adverse impact on the environment and surrounding communities. This adverse impact can be observed mainly in two dimensions, these are; the negative effect upon the local agriculture and ecosystems owing to both the reduction in the flow of the river water because of the construction of the Kpong and Akosombo Dams and also owing to the geographical disturbance (Biney, 2010); and in the form of the prevalence of infections and diseases in the riverside communities, especially amongst children (Abukari, 2010).

In the above context and with respect to the impact of the Volta River Authority (VRA) on the surrounding communities, De Wet (2006) is of an opinion that the implementation of the Volta River Authority (VRA) project led to a serious human resettlement issue, which because of its immense scale, could not be managed efficiently by both the Government of Ghana and the Volta River Authority (VRA). Similarly, highlighting the disease-related impact of the Volta River Authority (VRA), Steinmann et al. (2006) mention that the construction of the Akosombo Dam (Figure 2 bellow) and the formation of the Volta Lake have caused a phenomenal increase in the water-borne diseases in the area. This increase was observed in cases of both the river blindness or onchocerciasis and also the bilharziasis or urinary schistosomiasis and is because amongst the transmission vectors of disease for Onchocerciasis, the Simuluim damnosum or the black fly thrives in the fast flowing waters of the Volta River; while snails, which are the transmission vector of bilharziasis or the urinary schistosomiasis, treat Lake Volta as their natural habitat. Bellow is figure 2. which shows the Akosombo dam where majority of Ghana’s electricity supply is derived?

Figure 2: Akosombo dam (Multiconsult, 2019)

With particular reference to bilharziasis or the urinary schistosomiasis, Yirenya-Tawiah et al. (2011) highlight that the disease is not new to the region as even prior to the Volta Lake's formation, it was present but with low endemicity; for instance, a 1961 survey found endemicity of only 5% amongst children. The later increase in the endemicity, for example went up to approximately 90% according to a 1964 to 1977 survey, this can be seen as the result of two main developments: firstly, the formation of the new lake allowed a rapid growth of the aquatic weeds, which are natural habitats of the aquatic snails; and secondly, the lake caused a mass migration of fisher communities from regions of high endemicity (Nilsson, 2009; and Girmay, 2006). According to Hart & Pitcher (2012), the development of Volta River Authority (VRA) and the formation of the Volta Lake also had a significant impact upon the complete natural environment, plant and animal ecosystems, atmospheric composition as well as the water chemistry. This environmental impact is considered to be the direct product of the immense size and huge water storage capacity of the Volta Lake, which is further aggravated due to amount of flood water required to replenish the reservoir.

A detailed examination of the Volta River Authority (VRA)'s impact upon the local ecology reveals that since its establishment, there has been a phenomenal increase in the population of aquatic weeds. These weeds for example water hyacinth, Pistia, Ceratophyllum and Vossia spp, are considered very harmful for the environment, primarily because of their being resistant to most of the herbicides and their long-life cycles. Furthermore, the aquatic Bulinus snails treat the underwater beds of Ceratophyllum as a natural habitat and as mentioned earlier, these snails are the primary transmission vectors of urinary Schistosomiasis. Vossia spp is also considered highly problematic due the presence of needle-like hair, it is quite difficult to remove these weeds or use them for cattle grazing. Similarly, the abnormal growth of water hyacinth poses an entirely different set of problems since it does not originate from Ghana. It originates from Burkina Faso and floats inn on the river surface, it threatens the Volta River Authority's (VRA) reservoir by greatly reducing the oxygen content in fresh water, while also causing a high degree of evapo-transpiration. Once these reasons are examined in totality, a highly negative impact on the fish population in the Volta Lake can be observed, which translates negatively for the fisheries sector (McCartney, 2009).

In addition to the environmental impacts already covered in the preceding paragraphs, the operations of the man-made facilities create yet another critical problem. Primarily, the problem of acid rain can be seen as the result of the emission of the greenhouse gasses from the thermal power generation plants, which exercise a highly adverse impact upon the environment. A significant example of this impact can be seen in terms of the abnormal increase in acid rains in Ghana in general and in the areas surrounding the Volta River Authority (VRA), in particular (Asante & Amuakwa-Mensah, 2014).

1.1.3. Research Problem

Agbemabiese & Byrne (2005) and also Rubin & Warren (2014) argue that VRA enjoys a high significance for the Ghanaian economy primarily because of the scale and scope of the power generation operations and infrastructure, which makes it unique in the region. This was the main reason that the project was primarily aimed at socio-economic development by the Government of Ghana and was thought to be the solution of many of the country's economic problems.

The economic significance of the Volta River Authority (VRA) can be identified in three separate dimensions. Firstly, The Volta River Authority (VRA) has a huge power generation capacity and potential, which fulfils and can meet the needs of both the existing and future urban and industrial sectors by way of guaranteed power supply, thereby boosting expansion and growth in these sectors. Secondly, Volta River Authority (VRA) was developed as a support to the agriculture sector in Ghana because of the project's ability to provide an elaborate irrigation network, which is able to sustain a growth in the sector. Thirdly, by virtue of the size of the Volta Lake and its environmental effects, especially in terms of the development and emergence of new fresh water ecosystems, an expansion in the tourism sector was also expected. All these factors combined were expected to usher in a new era of large-scale economic development in Ghana; however, experts believe that the adverse environmental impacts of the project nullified these aims and objectives and instead of boosting and supporting socio-economic development in Ghana, the Volta River Authority (VRA) caused a further decline (Rooney, 2007; Johnston & McCartney, 2010; and Hermann et al., 2012).

In 1952, a special Preparatory Commission was established by the Government of Ghana with Commander Jackson as its head towards undertaking the planning and design-

ing for the Volta River Authority (VRA) in a systematic and organized manner. This Commission took into consideration the actual location of the (VRA) along with upstream and downstream areas and carried out a detailed examination of various important dimensions such as economic factors, financial factors, technical factors, socio-cultural factors, environmental factors and public health factors, towards inclusion in the final strategy and plan on the Volta River Authority (VRA) (Miescher, 2014). Both Mettle (2011) and Decker (2011) have acknowledged efforts of the Preparatory Commission and appreciated the comprehensiveness of the recommended strategy for the VRA. However, the authors also point out that as the principal aim of the Government of Ghana behind undertaking the Volta River Authority (VRA) was power production, this aim available in the form of Volta River Authority (VRA) in terms of a cost-effective and cheap source of electric energy, was prioritized over all other considerations and factors. This biased prioritization and the neglect and disregard for other important social, economic and environmental factors ultimately became the main reason for the subsequent deterioration and degradation of the environmental and other socio-economic issues such as loss of livelihood and the destruction of plants and animals ecosystems.

Though the wrong prioritization seems to be the actual problem behind the wide scale of resettlement and human health issues and environmental problems linked with the Volta River Authority (VRA), a detailed examination of the situation highlights that the attribution was not that simple as there were other factors which were part in degrading the situation. For instance, Rodgers et al. (2007) identify some other significant causal factors to include: a marked lack of serious commitment on part of the Government of

Ghana to address the situation in the Volta River Basin; lack of attention on part of the Preparatory Commission towards incorporating and according preference to the voice of local communities during the planning and design stages; inadequate political will to address the situation at priority; non-availability of the huge financial resources required for the deployment of remedial strategies; inadequacy of the requisite administrative capacity; and the hurried nature of the work of the Preparatory Commission, which maintained a focus on completion of the project irrespective of the complexities. In addition to these problems, Martin & Van De Giesen (2005) also indicate that the problems in the Volta River Basin were a direct product and a reflection of the failure and inability of both the Government of Ghana and the Volta River Authority (VRA) of ensuring the implementation of all recommendations of the Preparatory Commission in the desired fashion and a distinctive failure on part of the planners and executors of the Volta River Authority (VRA) project to foresee and cater for all the possible issues related to the project.

The scope of the research problem thus includes, the perceived socio-economic significance of the Volta River Authority (VRA) for the Ghanaian economy in terms of industrial expansion and growth, agricultural development and tourism, the adverse environmental impacts of the Volta River Authority (VRA) project, the adverse health-related impacts of the Volta River Authority (VRA) project, the misplaced prioritization of the cheap and cost effective power production over all other considerations, and also the other significant causal factors including the lack of commitment on the part of both the Government of Ghana and the Preparatory Commission. It is expected that a detailed examination of all these factors will lead to an accurate determination of the extent to which the original socio-economic developmental aims behind the Volta River Authori-

ty (VRA) project have been actually fulfilled; along with an identification of the impact of a host of environmental, resettlement and public health problems upon the intended socio-economic development in Ghana. However, it is important to note that keeping in view the subject of research, a focus will be maintained upon the environmental problems linked with the Volta River Authority (VRA) and their subsequent impact upon the development.

1.2. Research Question

Considering the subject of the research and the scope discussed in the preceding paragraphs, some research questions have been identified as follows:

I. What were the significant environmental considerations catered for by the Preparatory Commission of the Volta River Authority (VRA)?

II. What have been the important environmental concerns associated with the individual phases of the Volta River Authority (VRA) project?

III. What steps were lacking in the implementation methodology of the Volta River Authority (VRA) project with reference to the observed environmental concerns?

IV. What has been the socio-economic cost of the environmental concerns associated with the Volta River Authority (VRA) project?

V. What was the solution after the manifestation of environmental concerns and its effectiveness?

1.3. Structure of the Thesis

This thesis has been divided into five chapters in all. After introducing the research subject along with a discussion on the research problem and background, the next chapter encompasses a detailed review of literature in the areas identified in accordance with the research questions. Chapter 3 introduces the research methodology in requisite detail; while Chapter 4 encompasses the presentation of findings and discussion. Towards the end, the discussion is concluded in a separate chapter.

2. LITERATURE REVIEW

After introducing the Volta River Authority (VRA) in accordance with the research questions, five important areas have been identified for the review of academic literature. These include: important environmental considerations catered for by the Preparatory Commission of the Volta River Authority (VRA); important environmental concerns associated with the individual phases of the (VRA) project; steps lacking in the implementation method of the Volta River Authority (VRA) with respect to the environmental concerns; socio-economic cost of the environmental concerns associated with the VRA; and remedial strategies and their effectiveness.

2.1. Introduction to various components of VRA

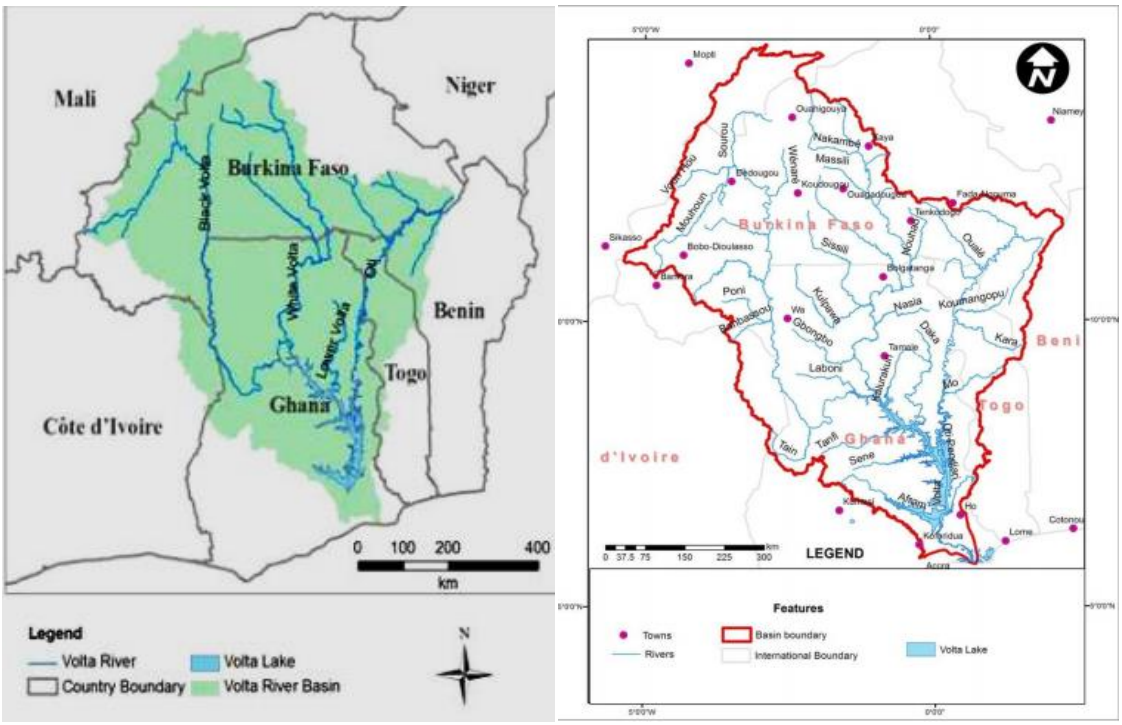

Figure 3: Volta Basin (GWP, 2017)

Though much has already been highlighted regarding the establishment of the Volta River Authority (VRA) in Ghana, it is important to mention that initially Volta River Authority (VRA) was mandated under the Volta River Development Act for the generation, transmission and distribution of electricity, however, in 2005, this Act was amended as part of the power sector reforms undertaken by the Government of Ghana.

Through this amendment, the mandate of Volta River Authority (VRA) was restricted to only the power generation, primarily in order to accommodate and attract independent power producers (IPPs) to the energy market in Ghana (Tackie & Adams, 2007). As a result of this new restriction on the Volta River Authority (VRA)'s mandate, both the transmission and distribution functions were separated and made the responsibilities of two independent entities through an act of Parliament. The Ghana Grid Company (GRIDCo) was made responsible for electricity transmission; and the Northern Electricity Distribution Company (NEDCo), was made responsible for the distribution of electricity in the Northern sector which constitutes the Northern Region, Upper East and West Regions, Brong-Ahafo Region and parts of Ashanti Region. Northern Electricity Distribution Company (NEDCo) acts as a subsidiary of the Volta River Authority (VRA), but also distributes electricity in the Volta Region. Electricity Company of Ghana (ECG) also became responsible for the distribution aspect (Brew-Hammond, 1997).

At present, Volta River Authority (VRA) is capable of generating 1,970 MW as part of its combined installed capacity; while employing the use of the hydropower and thermal power plants. As part of the hydro, two separate hydroelectric power generating units have been setup on the Volta River. Out of these two plants, there is one at Akosombo which has an installed capacity of 1020 MW, whiles the other at Kpong has an installed capacity of 160 MW (Kemausuor et al., 2011). It is also important to note that another hydropower facility, that is the Pwalugu Multipurpose hydro dam project with the total installed capacity of 48 MW, is in the planning phase and at present its feasibility studies are being prepared in consultation with the Mott MacDonald Ltd/Eviron Engineering Management Consult (Gyamfi, Modjinou & Djordjevic, 2015).

On the other hand, Volta River Authority (VRA) also has several thermal power facilities, the biggest of which is setup at Aboazde near Takoradi, which has a total installed capacity of 330 MW (Adaramola, Agelin-Chaab & Paul, 2014). Aboazde had another thermal plant called Megallan which was established in 2012 with an intended installed capacity of 132 MW, but operated for only two years and was closed down in 2014 be-

cause of a major technical fault with its turbines (Eshun & Amoako-Tuffour, 2016). In the thermal power generation category, a latest addition has been the result of a joint venture with an Abu Dhabi firm TAQA. This plant was commissioned in 2015 with a total installed capacity of 220 MW; however, through later incorporation of a combined cycle plant, its total installed capacity has now been increased to around 330 MW (Bekoe & Logah, 2016). In addition to these, there are several other thermal plants located at Tema, for example, Tema – I Thermal Plant, set up in 2008 with the total installed capacity of 110 MW; Tema – II Thermal Plant, set up in 2010 with the total installed capacity of 50 MW; Mines Reserve Plant (MRP), set up in 2008 with the total installed capacity of 80 MW; and another one located at Kpone Thermal Power Station (KTPS), which is a simple cycle plant with the total installed capacity of 220 MW (Adaramola, Agelin-Chaab & Paul, 2014).

In addition to the above mentioned thermal power facilities, Volta River Authority (VRA) is planning to convert the Tema plant into a combined cycle plant in collaboration with CENIT Power; while another Combined Cycle Gas Turbine (CCGT) Power Plant at Aboadze is being planned in collaboration with Globeleq (Eshun & Amoako-Tuffour, 2016).

In addition to traditional hydro and thermal power development, Volta River Authority (VRA) is also involved in renewable development towards ensuring security and diversity of the electricity supply and also enhancing environmental preservation and reducing emissions along with contributing towards the prevention of climate change. The Authority is already operating a solar power plant at Navrongo with the total installed capacity of 2.5 MW since 2012. The expansion of this existing plant in addition to the installation of two additional solar power plants at Lawra and Kaleo with a total installed capacity of 12 MW in collaboration with the Government of Ghana, are in the planning phase (Eshun & Amoako-Tuffour, 2016). Moreover, in the renewable sector and considering the availability of wind resources, Volta River Authority (VRA) is also

planning to establish four wind power generation plants at Akplabanya, Lekpoguno, Anyanui and Anloga in collaboration with private sector developers including El Sewedy and Vestas with a total installed capacity of 150 MW (Gyamfi, Modjinou & Djordjevic, 2015).

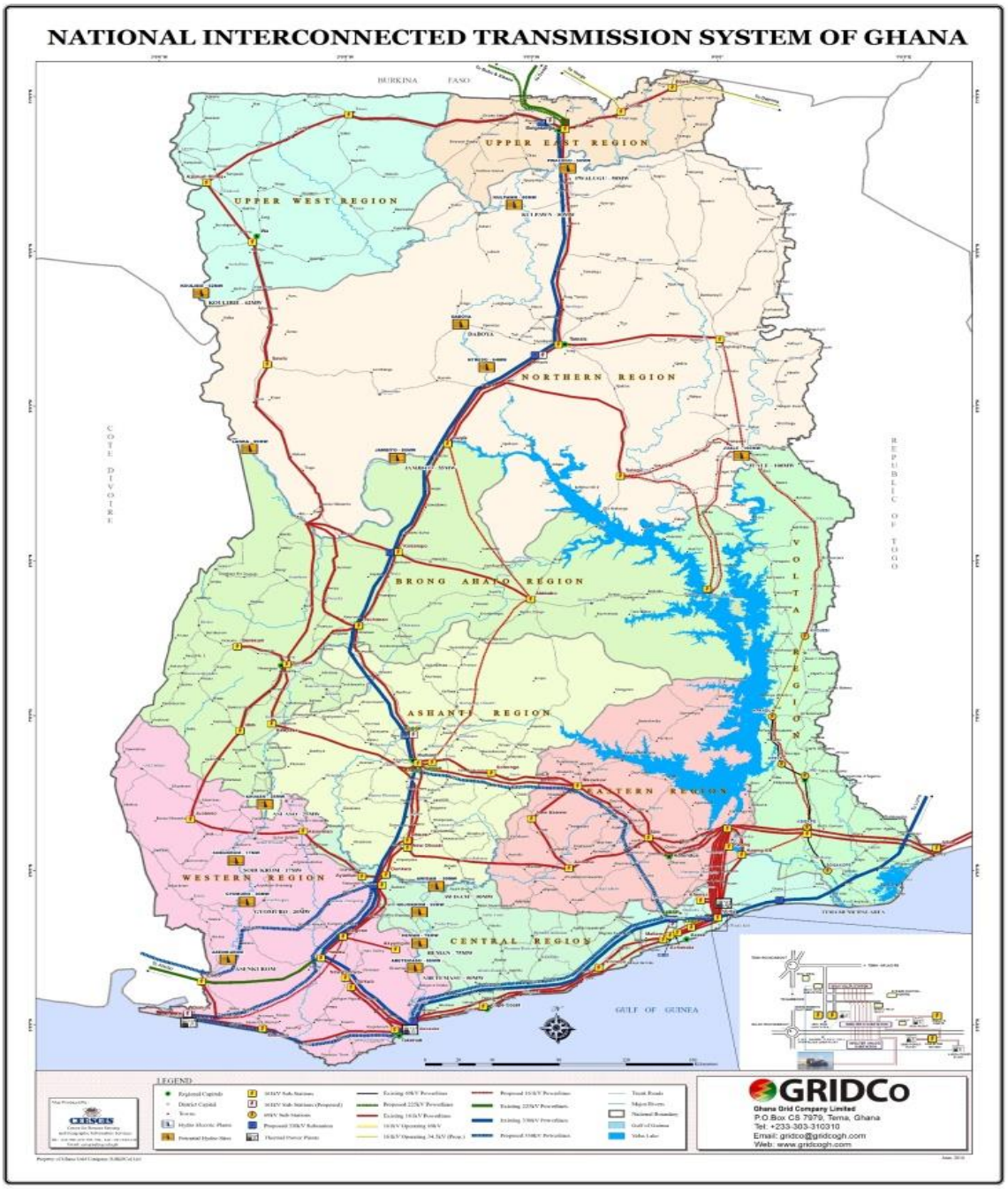

Figure 4: National Grid System of Ghana (Gridcogh, 2016)

The main or primary customers of the Volta River Authority (VRA) include both Northern Electrification Distribution Company (NEDCo) and Electricity Company of Ghana (ECG), while the secondary customers include commercial and industrial sectors for example the Diamond Cements, Akosombo Textiles and Aluworks; and several mining companies for instance Golden Star Resources Group, Goldfields Ghana Ltd., Newmont Ghana Gold Ltd. and AngloGold Ashanti (Foster & Pushak, 2011).

2.2. Environmental Considerations of Preparatory Commission of VRA

Adu-Aryee (1985) considers the implementation of Ghana Hydropower Project by the VRA as the most significant and economically important project in the history of Ghana. This is viewed as an indication of Ghana's economic progress. The reason for this opinion can be found in the multi-perspective nature of the project as the aims behind this undertaking included: power generation for the commercial, industrial and irrigation network; agricultural growth and development; advancement and growth in the industrial sector; and also the promotion of tourism (Johnston & McCartney, 2010).

Molle (2009) and Agyenim & Gupta (2010) highlight that because of the immense scope and economic potential of the Volta River Authority (VRA), its development was preceded by the designation of a Preparatory Commission in 1952 under the leadership of Commander R. G. A. Jackson. This Commission functioned for four years until 1956. Its primary tasks included examination of the project feasibility in the technical, financial and economic dimensions and the detailed assessment of the implications of the project for both the public health and socio-cultural aspects. It is also important to note that the Commission was setup for this examination and assessment of these factors in three main areas including both the actual site and the areas located behind and below the dam being proposed (Opoku-Ankomah et al., 2006). Scudder (1989) is of the view that the feasibility and environmental study recommended by the Commission was quite comprehensive as it encompassed a workable and effective strategy which was in the best of interests of the Ghanaian economy, environment and population. However, others such as Alhassan (2009) and Odame-Ababio (2003) are of the view that the work of the Commission was highly biased as it unduly prioritized the energy needs of Ghana over the environmental, public health and socio-cultural concerns. Before examining

these concerns, it is considered relevant to identify the important environmental considerations catered for by the Preparatory Commission of the Volta River Authority (VRA).

Table 2. Cropped Area and Food Production in Ghana from 2007-2009

Crops	Cropped Area (1000 ha)			Production (1000 MT)			Yield in 2009 (t/ha)
	2007	2008	2009	2007	2008	2009	
Maize	790	846	954	1,220	1,470	1,620	1.7
Sorghum	208	276	267	155	331	350	1.3
Rice/paddies	109	133	162	185	302	391	2.4
Cassava	801	840	886	10,218	11,351	12,231	13.8
Yams	324	348	379	4,376	4,895	5,778	15.2
Others	726	746	737	5,148	5,401	5,549	7.5
Total	2,958	3,189	3,385	21,302	23,750	25,919	7.7

(JICA, 2012)

According to Sarpong (2005), the Preparatory Commission of the Volta River Authority (VRA) gave consideration to various environmental, social and human factors as the incorporation of all these factors were highly essential and significant towards the principal objective of generating hydropower. In order to support the production of aluminium, Van Edig et al. (2001) indicate that the principal environmental concern was associated with the network of primary and secondary water channels, and the resultant quantum of water flow draining all areas of the Volta River basin. On the other hand, Samba & World Health Organization (WHO) (1994) make a mention of the prevalence of the river blindness disease or the onchocerciasis endemic along the river especially in areas located above the Volta River basin, this became a major consideration since it had a significant impact upon the agricultural activities and development. Some other environmental considerations kept in view by the Preparatory Commission of the Volta River Authority (VRA) can be identified to include: the geological and topographical layout of the Volta River basin; the peculiar properties and composition of the soil and the stream flow, particularly in the lower reaches of the Volta River Basin. Teclaff (1990) opines that the stream flow was an important consideration not only because of its impact upon the environment, but also because of its ability to compromise the technological capacity of the dam, in case of alteration or diversion.

Molle (2006) highlights that the task of the Preparatory Commission of the Volta River Authority (VRA) was of extremely high significance as the Volta River is responsible for draining a large area of approximately 154,000 square miles in areas belonging to six different countries namely Ghana, Togo, Mali, Ivory Coast, Burkina Faso and Benin, with a major part that is around 85% being shared by Burkina Faso and Ghana. Similarly, Johnston & McCartney (2010) are of the view that the task of the Preparatory Commission of the Volta River Authority (VRA) was very important because of the patterns of rainfall and the resultant shortages in the storable water in the Volta River Basin (VBS) thereby creating severe implications for the efficient management of water resources in the Basin. This aspect assumes an added significance because of the immense size of the Volta River Basin and the stark contrast in the seasonal patterns of rainfall originating out of the opposite movement of the air masses across the equator.

In the above context, Owusu, Waylen & Qiu (2008) indicate that different air masses are responsible for rainfalls in the North and South of the Volta Basin, where the overall result is a decrease in annual precipitation; which has adverse possible consequences in terms of drought. As this drought is also a cause of several socio-economic difficulties all across the Basin, the Preparatory Commission of the Volta River Authority (VRA) had to keep in view the possible or potential adverse impact of the planned hydropower operations, manifesting primarily in terms of depletion of the stored water supply below tolerance levels. Besides having a direct impact on the surrounding communities, this depletion of the stored water supply below tolerance levels could also have serious consequences for the water share going towards the agricultural activities in the Volta River Basin area (Biney, 2010).

2.3. Important Environmental Concerns with the VRA Project

Wen & Chu (1984) highlight that the principal benefits associated with the construction of the Akosombo Dam on the Volta River included: acceleration and enhancement of the national economic growth; massive generation of electric power; enhancement in the water transportation and fishing activities in the upstream localities; and the im-

provement of irrigated farming opportunities in the lower regions. The Kpong Dam (Fig. 5 bellow) was added at a later stage in order to accommodate the demands of electricity originating out of the rapid industrialization in Akosombo, Sekondi-Takoradi, Kumasi and Accra-Tema (Andreini et al., 2000). According to Gyau-Boakye (2001), though this strategy addressed the energy requirements effectively, the biophysical and ecological features and processes across the Volta River Basin were seriously impacted because of the construction of these two dams and the resultant impoundment of the Volta River. Two major impacts included the deceleration of river flows in both up and down stream areas; and intense flooding of agricultural sites in the upstream localities.

Table 3. Impacts of Floods in the Volta Basin 1985-1999

Impact / Year	Number of victims of the flood	Number of deaths	Number of people injured	Number of houses damaged	Area of farmland flooded (ha)	Number of livestock perished (head / cattle, goats, poultry, etc.)	Number of dams destroyed	Distance of road destroyed (km)	Number of bridges destroyed	Number of schools damaged
1985	270,000 (Be)	61 (Be)	-	11,637 (Be)	17,412 (Be)	5,421 (Be)	-	2,704 (Be)	201 (Be)	651 (Be)
1988	270,000 (Be) 23,324 (BF)	16 (BF)	-	-	30,000 (Be)	-	-	-	-	-
1991	700,000 (Be)	-	-	-	556 (Be)	-	-	-	-	-
1992	5,485 (BF)	6 (BF)	-	3,133 (BF)	-	-	14 (BF)	-	-	-
1994	74,080 (BF)	22 (BF)	4 (BF)	4,600 (Be) 21,000 (BF)	7,690 (Be) 106,164 (BF)	-	18 (BF)	-	-	-
1996	147,901 (Be)	-	-	-	1,544 (Be)	-	-	-	-	-
1999	51,342 (BF)	6 (BF)	18 (BF)	2,188 (BF)	-	-	-	-	-	-

(GWP, 2017)

Table 4. Impacts of Floods in the Volta Basin 2006-2015

Impact / Year	Number of victims of the flood	Number of deaths	Number of people injured	Number of houses damaged	Area of farmland flooded (ha)	Number of livestock perished (head / cattle, goats, poultry, etc.)	Number of dams destroyed	Distance of road destroyed (km)	Number of bridges destroyed	Number of schools damaged
2006	3,476 (Be)	-	-	1,382 (Be)	5,459 (Be)	-	-	-	-	-
2007	146,202 (BF) 300,000 (Gh.)	83 (BF)	74 (BF)	26,833 (BF)	-	20,000 (BF)	-	-	-	-
2008	24,676 (BF)	5 (Be) 5 (BF)	54 (BF)	-	15,498 (Be)	3,190 (Be)	-	-	-	-
2009	180,386 (BF)	41 (BF)	62 (BF)	33,172 (BF)	-	-	-	-	-	-
2010	680,000 (Be) 25,112 (Gh)	46 (Be) 17 (Gh)	-	55,000 (Be) 3,234 (Gh) 3,832 (Tg)	-	1,109 (Gh)	-	-	-	455 (Be)
2011 - 2015	46,871 (Be) 255,849 (BF) 1996 (Cl)	25 (Be) 211 (Cl)	215 (Be) 3 (Cl)	11,652 (Be)	140,287 (Be)	37,339 (Be)	-	-	-	119 (Be)

(GWP, 2017)

Barry et al. (2005) opine that when the flows were reduced in the Volta River because of the construction of the two new dams, there was an impact upon the existing natural processes in the area, which manifested primarily in terms of: blockages in the estuary; intense silting; an abnormal increase in the populations of the aquatic snails; and also an abnormal increase in the population of aquatic weeds. In a similar context, Gordon & Amatekpor (1999) indicate that when aquatic population invaded the main course of the Volta River, it impacted two main dimensions, namely, a visible decrease in the harvest leading to abnormally low annual production of the agricultural products, which failed to meet the national demand; and the lessening up of the navigable space in channels in both the up and downstream regions. Bellow is the Kpong dam which has a capacity of 152 MW, owned and operated by the Volta River Authority (VRA).

Figure 5: Kpong dam (Multiconsult, 2019)

Zakhary (1997) highlights that the abnormal increase in the population of snails was the product of the wide scale colonization by the aquatic weeds; and or the reduction in the rate of flow of water in the main channel. Two important species of snails that are the Biomphalaria pfeifferi and Bulinus truncatus rohfsi were the intermediate hosts for S. mansoni and Schistosoma haematobium, respectively and were responsible for the increase in prevalence rates of intestinal schistosomiasis by almost 53% in a few riparian communities. Along with these, a few lakeside communities also experienced an abnormal rise in the prevalence rates of intestinal and unrinary bilharzias, where this rise was approximately 70-75% for the adults and 100% for the children (Wen & Chu, 1984).

Williams et al. (2016) observe that in numerous riparian communities located in the downstream localities and along the Lower Volta Basin (LVB), shrimp constituted an important source of protein-based diet and was also an important pillar of local econo-

my and rural fishing industry; however, the shrimp population was greatly reduced because of the increase in populations of aquatic weed.

Andreini et al. (2000) highlight that though agricultural growth and development were important objectives behind the construction of the two main dams, the result was exactly the opposite. This was mainly because of the elimination of the natural flooding phenomenon, which was responsible in the upstream areas, for the improvement of fertility of soil through the mineral rich alluvial deposits. The result was a significant reduction in creek agriculture and crop yields and the decline in the food production. In a similar context, Rahaman, Lawrence & Roper (2004) identify three economic activities, which were adversely impacted, especially in the downstream communities. These included: clam-picking, creek fishing and river fishing. The direct results of this adverse impact could be observed in terms of intense poverty and deprivation in the riparian communities from the downstream area, a phenomenal increase in crime rates and prostitution because of poverty breaking down the socio-cultural values amongst the affected populations; an abnormal rise in the incidence of sexually transmitted diseases; and migration of the populations on a massive scale that is approximately twenty thousand people being displaced each year from the riparian communities to the urban centres like Accra, Adidome, Volivo, Amedeka and Akuse (Gordon & Amatekpor, 1999).

2.4. Important Environmental Concerns of the VRA Project

Konadu-Agyemang, Saku & Haasch (2006) are of the view that the plan to construct a dam on the Volta river that is the Akosombo Dam, should have been accompanied by the realization that the reservoir area of the newly created Volta Lake would cover a vast expanse comprising of about 3.6% of the total land area in Ghana that is around

8500 square kilometres, with a lake perimeter of about 4800 kilometres length. The planners should therefore have foreseen the radical transformation and modification of the biological, ecological, and physical and the socio-economic environment in the area, both above and below the new dam. Also, Molle (2009) is of the view that the implementation body for the Volta River Project failed to ensure the implementation upon the recommendations of the preparatory commission in the desired manner primarily in terms of failing to adopt a multi-disciplinary approach towards finding out a solution to the emerging problems. This is viewed by Andreini et al. (2000) as a failure to devote equivalent attention towards the engineering or technological and non-engineering or social.

In the same context, Gyau-Boakye (2001) draws attention to the fact that at the time of undertaking the Volta River project, there was already a high incidence of water-borne diseases along the Volta River especially the bilharziasis or urinary schistosomiasis. Therefore, the explosive outbreak of this disease following the ecological and physical changes should have been expected and incorporated in the overall project planning and implementation phases. According to both Steinmann et al. (2006) and Gordon & Amatekpor (1999), the main public health-related problems arising out of the implementation of the Volta River Project were because the two main disease episodes switching places, where one was the characteristic of the benthic riverine system (onchocerciasis or river blindness transmitted by the black-fly Simuluim damnosum); and the other was the feature of the lotic riverine systems (urinary schistosomiasis - a chronic snail-borne infection). Though the endemicity of the latter was already a characteristic of areas along the Volta River, it was low and nobody could expect the switch between the locales because of the formation of the new lake. This particular argument needs further

exploration of the relationship between the switch in disease locales and the human resettlement.

According to Gutman (1994) and De Wet (2006), the most serious impact of the Volta River Authority (VRA) project has been by virtue of the abnormally large-scale human resettlement problem it caused. Because of the vast socio-economic and environmental adversities this resettlement has caused in the Volta River Basin area, the aspect of abnormally large-scale human resettlement should have been accorded due priority and significance by the planning authority. While Gutman (1994) identifies the significant environmental impacts of the human resettlement to include: shifting of commercial activities like agriculture and fishing and disturbance of the local ecosystems; De Wet (2006) argues that though this aspect was included in the planning phase, it was generally ignored in the implementation phase primarily because of the lack of foresight on part of the executors.

In the above context, Tamakloe (1994) is of the opinion that once the reasons behind this neglect are examined, the principal cause can be identified in the form of less than sufficient time made available for the implementation phase and the hurried nature of the activities during the implementation phase. This hurrying and urgency by the Government of Ghana compelled the Volta River Authority (VRA) to reprioritize the recommendations of the planning commission and in the process; the aspect of human resettlement was generally neglected. On the other hand, Obosu (1996) is of the opinion that it was in fact the lack of sufficient administrative capacity with the Volta River Authority (VRA) during the implementation phase, which led to the executors of the project neglecting the aspect of the resultant human resettlement. There were simply not that many supervisors and planners available with the authority to oversee the resettle-

ment process in the requisitely deliberate and comprehensive manner. Also, Tamakloe (1994) highlights that the problem of human resettlement was mismanaged primarily because of lack of requisite political will, as the political leadership was not interested in seeing beyond the economic fruitages of the project due to opposition pressure; while Obosu (1996) indicates at the shortage of requisite financial resources needed for the resettlement. As most of the funds had already been diverted towards the completion of the project itself, very little was available for the resettlement process. According to McMillan (1995), the mismanagement of the human resettlement aspect was the result of not involving the local communities during the planning process and obtaining the commitment and understanding on the part of these communities before the start of the implementation phase. Rather, the communities were treated as unconcerned entities, while the project gained priority over all other human and environmental considerations. Zakhary (1997) discusses the combination of the two factors that are the health-related impacts and the human resettlement caused by the implementation of the Volta River project; and highlights that the biological explosion of aquatic weeds as a result of the creation of Volta Lake, was further aggravated by the mass migration situation. This assertion can be assessed as correct once the nature and direction of the mass migration is examined, which was from the regions of high endemicity of the disease towards the fishing communities ahead of the head pond area, thereby ensuring that most localities situated around the new Lake witnessed a significant increase in the prevalence of the disease. The latter situation that is the situation after the formation of the Lake becomes clear once the studies of both Jobin (1999) and Steinmann et al. (2006) are examined, according to which, the disease affected mostly the fishermen communities primarily because of their heightened exposure to the water of the lake in terms of setting up of

fish traps, swimming, bathing and drawing up of water from the lake. Moreover, according to Zakhary (1997), the fishermen also became the key vector of the disease because of their peculiar migratory habits and their travelling from one area to another in accordance with the variations in the population of fish with the changing seasons.

2.5. Socio-economic Cost of the Environmental Concerns

Numerous experts believe that various socio-economic changes have resulted from the Volta River Project primarily because of the variations in the seasonal flow patterns of the river's tributaries and the water quantity and because of the effects of the climate change in the Basin area upon the rivers' hydrological regimes (Oguntunde et al., 2006; and Gyau-Boakye, 2001). According to Oguntunde et al. (2006), these changes have been observed in terms of a marked decrease in the average volume of water and stark and random variations in the seasonal and temporal distribution patterns, ever since the development of the project. Over a period of time these changes have resulted into water shortages of very serious nature to an extent where a few of the rivers flowing in the Volta Basin remain dry for considerable durations of time. This observation is supported by Gyau-Boakye (2001), who emphasizes on the frequent related floods and highlights that the climatic variations in the Volta Basin have serious socio-economic implications because of decrease in the values of precipitation, reduction in the water-dependent agriculture, rapid drying up of perennial streams and a serious reduction in the overall availability of water.

Once the above situation is observed against the backdrop of the fifty years climatic projections for the area, the gravity becomes more evident. These projections indicate that till 2050, the Volta Basin is expected to witness a gradual warming up because of

increasing fluctuations in temperatures, especially a significant increase in temperature in the northern parts by almost 2.2-2.3°C. This is expected to be further aggravated with severe variations in the flows of streams and also alternative periods of high rainfalls accompanied by floods and severe droughts after every ten to twelve years; while overall the wet periods are going to get smaller and the dry spells are going to lengthen, thereby creating serious implications for the riparian communities (Palmer et al., 2008).

While discussing the socio-economic dimension of climate change in the Volta Basin, Tsikata (2006) is of the view that an increase in population has already started exacting a toll on the availability of water in terms of an added demand for livestock, agriculture, urban communities and domestic use; while the development of huge infrastructures like the two main dams on the Volta River, the industrial and agricultural development and the mining activities are adversely affecting the seasonal flows and the quantity of available water. This is substantiated by Johnston & McCartney (2010) who were of the view that the water pollution as industrial and mining activities, cause pollution of the river water and the water quality degrades as a result. While examining the reasons of the water pollution, Tsikata (2006) considers agriculture more responsible than mining or industrial sectors as it involves the unregulated use of various chemicals and harmful pesticides. Similarly, Straškraba, Tundisi & Duncan (1993) believe that the water pollution and also the reduction in the availability of biochemical oxygen have been the result of mainly the domestic waste and contaminants discharge from the urban communities, which mushroomed after the development of the Volta River Authority (VRA) project.

Poor land use and deforestation can be identified as yet two other important results of the Volta River Authority (VRA) project, which have serious socio-economic implica-

tions. In this context, the poor land-use practices, especially in the Volta River's upper watershed, can be identified to include: over-cultivation, unregulated agricultural activities, felling of trees, and deliberately setting of bush fires to clear the land for cultivation. All these are leading to an increase in the silt levels and also increased runoffs, which in turn cause both coastal erosion and also flooding, particularly in various parts of the White Volta sub-basin (Codjoe, 2004). In the context of land-use, Codjoe (2004) also identifies certain others such as emergence of deserts, gravel and sand extraction, a substantial increase in sediment loads, burning up of farmlands, mining activities on both the river beds and river banks and the harvesting of wood for fuel. Furthermore, Andreini et al. (2000) opine that the deforestation and the bad land-use practices in the Volta River Basin can result into an irreparable damage to the existing wetlands and ecosystems, thereby adversely impacting the fish populations in the Volta River and exercising a negative impact upon the commercial fishing activities.

Coastal erosion is yet another environmental impact of the Volta River project having serious economic implications as according to both McCartney (2009) and Bollen et al. (2011), this erosion, especially in the downstream areas, is being caused by climate changes leading to rise in the sea level, an enhancement in storm intensity and variations in the river flow patterns along with mangrove eradication, mining activities, and the construction of the dams causing the wide scale displacement of gravel, sediment and sand. The evidence of this impact can be found in terms of the modification of the Volta Estuary and loss of beachfront to erosion in many areas in Ghana such as Ada and Keta (Bollen et al., 2011).

2.6. Remedial Strategies and their Effectiveness

Since the development and implementation of the Volta River project, a number of different strategies have been undertaken by the Government of Ghana in consultation and coordination with certain international agencies. Towards the mitigation of the environmental impact of the project, in 1963, the Government of Ghana in coordination with the University of Ghana established the Volta Basin Research Project (VBRP). Till date, this organization has produced much valuable output in terms of both the research on the environmental impact and the suggested mitigation strategies (McCartney, 2009).

According to both Jobin (1999) and Biney (2010), most of the remedial strategies aimed at reducing the environmental impact of the Volta River Authority (VRA) project have been aimed principally at disease eradication and health-related issues without exerting any significant impact upon the surrounding environment, in terms of: the ecological strategies employed towards the destruction of the primary hosts' habitats, biological control strategies aimed at the disruption of the life-cycles of the disease causing organism's life cycle, and the use of chemotherapy with the help of a drug called Praziquantel. Furthermore, Biney (2010) highlights that the risks of disease and infections in the most vulnerable communities were also addressed through raising awareness through public education and making available public sanitary facilities.

With special reference to chemotherapy, Gordon & Amatekpor (1999) indicate that this was carried out primarily in terms of drug administration to the affected communities, where the drug used was Biltricide or praziquantel tablets – an effective treatment aimed at the reduction of eggs and worms being borne by the people infected with the disease. Through the administration of this drug, not only the damage being caused by the schistosome parasite in human hosts was substantially reduced but also the further

contamination of virtually preserved water resources was also made possible. In this context, Biney (2010) highlights that the drug or chemotherapy was primarily administered to the school children and fisher communities.

Men, as these were identified the most vulnerable categories. With reference to the ecological and biological control strategies methods aimed at the eradication of snail population, Palmer et al. (2008) mention that both mechanical and manual cleaning of the weeds were carried out as these weeds provided both support and nourishment to the snail communities. In this context, Tamakloe (1994) highlights the formation of the cooperative groups comprising of the local fishermen who belonged mainly to the communities located in the Lower Volta Basin and also the head-pond areas. These groups were initially motivated to participate in the clearance of weeds on the promise of a revival in the fish populations; and were tasked for the organization of local population towards the weeds eradication. According to Tamakloe (1994), though this strategy was somewhat successful as it led to a slight improvement in the rates of river flows; the reluctance of the communities to actively participate in the absence of any monetary incentives adversely affected the strategy's full and potential effectiveness. As a result of this non-cooperative attitude, the cooperative groups collapsed soon after their establishment.

Anthony, Oyédé & Lang (2002) mention the removal of spits and sandbars obstructing the river's accessibility to the sea in order to allow the inflow of salt water as a natural antidote against the snail populations as snails cannot survive in a saline environment. This strategy proved highly effective as once the river outlet at estuary was cleared, the salt seawater intruded inland for many a kilometres and in the process destroyed snail colonies at a large scale. In this context, Tsikata (2004) highlights that the upstream dif-

fusion of salt water was observed till a distance of approximately thirty kilometres and the resultant devastation of the snail population caused a 70% reduction in the prevalence rates of bilharzias or schistosomiasis.

According to Gordon & Amatekpor (1999), public awareness regarding the health-related problems was enhanced through education of specially the riparian communities on subjects of the disease pathology and transmission along with the usefulness of the control strategies. Moreover, the communities were also educated with regards to the requisite changes which were required to be made in the socio-cultural habits towards arresting the spread and transmission of the disease. This education was imparted in the form of radio programmes which combined education with entertainment and lectures to the local communities. The inclusion of the disease related subjects in the school curriculums. Tsikata (2004) contends that this strategy proved highly effective as it led to a substantial decrease in the incidence of bilharzia amongst school-going children. Also that there was almost a 70-90 percent reduction in the disease prevalence; while the risk was considerably reduced even where the disease resurfaced.

On the other hand, both Scudder (1994) and Gocking (2005) are of a view that the remedial strategies aimed at addressing the environmental impacts of the Volta River project, though somewhat successful in some local communities, remained ineffective overall. The reasons for this ineffectiveness have been identified in the form of non-cooperative attitudes of the local populations and their refusal to make the requisite changes in their behaviours and attitudes. Illiteracy and lack of general awareness. According to Gocking (2005), both these reasons were responsible for the high rates of re-infection of bilharzias or schistosomiasis in school-going children from a few communities, while the overall disease reinfection rate remained at 6% even after a decade and

half of sustained efforts. Moreover, Gocking (2005) also highlights that though the weed removal efforts and strategies were initially successful, they gradually became ineffective as the seeding material was still present in the creeks and ponds and it thrived as ample sunlight was available because of the shallow depth of the water bodies. Similarly, Titiati (1997) is of the opinion that though the saltwater killed many snail communities, the continued presence of various nutrients in the water because of the agricultural activities in Akosombo area and also the availability of numerous physical barriers and sheltered coves, ensured that the weeds persisted upland and promoted the growth of snails.

2.7. Environmental Theories

In order to determine the environmental impact of the Volta River Authority (VRA) project and identifying their adverse impact upon the socio-economic development in Ghana, two important environmental theories have been chosen, they are the Theory of Unequal Ecological Exchange and Environmental Degradation as put forward by Jorgenson (2006); and the Theory of Environmental Degradation as presented and discussed by Caviglia-Harris, Chambers & Kahn (2009).

The Theory of Unequal Ecological Exchange and Environmental Degradation primarily focuses upon the phenomenon of international trade in terms of the vertical flow of exports, which allows an externalization of environmental impacts by the developed countries to less developed countries, thereby leading to a substantial increase in the environmental harm in the less-developed countries in the form of increased greenhouse gas emissions, industrial water pollution, adverse impacts upon the biodiversity and defor-

estation. Furthermore, such externalization is also coupled with an overall suppression of the resource consumption levels in the less-developed countries as compared to the globally sustainable thresholds, thereby causing the manifestation of important public health implications. The resultant situation is an ecological inequality of the relationships between the well-developed and the less-developed countries (Jorgenson, 2006).

The Theory of Unequal Ecological Exchange and Environmental Degradation also draws attention towards the observation that once foreign investment increases in the less-developed countries, an ideal outcome is the prevalence of the use of cleaner production and manufacturing processes and cleaner technologies in both the primary and secondary sectors of the economy. On the contrary, this investment mostly results into the adoption of dirty and sub-quality extraction and production methodologies, which causes environmental deterioration and degradation and exercises an adverse impact upon the human well-being (Jorgenson, 2006).

Before discussing the applicability of this theory, it is considered pertinent to examine the foreign investment and exports scenario in Ghana. According to a 2013 estimate, the country's total exports amounted to roughly US $18.8 billion, with the most important exports including: gold exports at US $5.56 billion; cocoa beans exports at US $5.02 billion and cocoa paste export at US $399 million; crude petroleum exports at US $3.48 billion; and export of special purpose ships at US $608 million (OEC, 2015).

The beneficiaries of these exports include some of the leading and well-developed economies of the world along with some developing countries, for example, exports of US $3.18 billion to Iran; exports of US $3.14 billion to South Africa; exports of US

$1.66 billion to the United Arab Emirates (UAE); exports of US $1.24 billion to Switzerland; and exports of US $1.14 billion to France (OEC, 2015).

Considering the applicability of the Theory of Unequal Ecological Exchange and Environmental Degradation, it can be examined in two important directions. In the first direction lies the industrial and mining sector, where the industrial sector and infrastructure refer to the exports of cocoa paste and manufacturing of special purpose ships; while the mining sector refers to the exports of crude petroleum and gold. Once Volta River Authority (VRA) is seen as the principal source of sustained energy and power for the mining and industrial sectors, an argument can be developed that in order to boost the industrial development, the Volta River Authority (VRA) project was hastily developed, thereby leaving a huge room for significant shortcomings and weaknesses, which manifested in terms of adverse environmental impacts with the passage of time. In the second direction, an externalization of environmental impacts and costs by the developed countries like the UAE, France and South Africa to Ghana can be observed, which magnified the environmental degradation related to the Volta River Authority (VRA) project while it can also be argued that the foreign direct investment in Ghana may have resulted into the adoption of dirty and sub-quality extraction and production methodologies in the mining and industrial sectors, which caused environmental deterioration and degradation and exercised an adverse impact upon the human well-being.

The Theory of Environmental Degradation, on the other hand, considers environmental degradation and deterioration as the result of a continuous series of overlapping vicious circles culminating into a downward spiral, thereby leading to adverse environmental

and socio- economic consequences. This theory also views the environmental degradation and deterioration occurring in the form of a gradual and accelerating transformation (Caviglia-Harris, Chambers & Kahn, 2009).

The continuous series of overlapping vicious circles as proposed by the Theory of Environmental Degradation can also be observed in case of the Volta River Authority (VRA) project in Ghana. It can be argued that the circles initiated with the wrong prioritization of the production of cheap and cost-effective electricity over all other socio-economic and environmental considerations. This was then coupled with the huge potential of earning profits from the mining industry along with the profits to be earned from the Republics of Benin, Togo and the Burkina Faso in return for power exports. Two other supporting factors were the provision of requisite energy to the industrial sector in Ghana, the expected development, the improvement in the irrigation and agricultural systems. Wrong prioritization can thus be argued as the principal reason that all the overlapping interests or circles transformed into a downward spiral leading towards a deterioration of the socio-economic atmosphere along with causing environmental devastation. This transformation remained unchecked and uncontrolled primarily because of the short term economic advantages and their immense benefits for a less-developed country like Ghana.

3. RESEARCH METHOD

In this chapter the research methodology is introduced under the five main headings of research design, data collection methodology, sample and population, analysis methodology and limitations of the research.

3.1. Research Design

This thesis follows a qualitative research design, whereby the research is based solely on the data available from secondary data sources. However, some quantitative data was collected with regards to the socio-economic cost of the Volta River Authority (VRA) project and its environmental impact. Therefore, while the review of literature constitutes the basis for both the discussion of the main argument and the qualitative approach, the quantitative aspect caters for the provision of an empirical evidence base, and the combinations of the quantitative and qualitative approaches which make this research a mixed-methods study. This approach is adopted because of several advantages, the primary one amongst which is the compensation of weaknesses of one approach with the strengths of the other. Furthermore, while the combination of the two approaches make the concept of triangulation applicable and useful; the mixed-methods approach is also considered useful towards enriching the scope of discussion and an in-depth understanding of the research subject (Maxwell, 2012).

3.2. Data collection method

It is important to mention that during the course of this research no primary data collection was carried out or employed either with reference to the qualitative or quantitative data. However, the quantitative data regarding the details of the Volta River Authority (VRA), the power generation facilities and the socio-economic impact on the environment, where applicable, has been collected from a few primary sources including the Office of the National Archives in Ghana and the Energy Commission of Ghana.

The secondary data collection methodology is adopted primarily because of its advantages due to the ease in data collection, simplicity of analysis, reliability of findings, and the possibility of confirmation of findings of one research from the findings of another (Maxwell, 2012).

3.3. Dataset

The dataset for this research comprises of findings from five important studies with regards to five important areas that are the significant environmental considerations catered for by the preparatory commission of the Volta River Authority (VRA) which forms the basis for the first research question, important environmental concerns associated with the individual phases of the Volta River Authority (VRA) project is where the second research question was derived from, steps lacking in the implementation methodology of the Volta River Authority (VRA) project with reference to the observed environmental concerns became the pillar upon which the third research question stood, socio-economic cost of the environmental concerns associated with the Volta River Authority (VRA) project, this forms the basis for the

fourth research question and effectiveness of the remedial strategies was used to formulate the fifth research question. The studies include an article on social and environmental reporting and institutional legitimacy by Rahaman, Lawrence & Roper (2004); a study on the water resources decision-making and scientific capacity building by Rodgers et al. (2007); a study on the commodification of Ghana's Volta River by Agbemabiese & Byrne (2005); a case study of the effects of the Akosombo and Kpong power schemes by Agbenyo (2009); and a comparative study of the Akosombo and Bui dam projects by Miescher & Tsikata (2009).

The study also include five books published by the Energy Commssion of Ghana tittled Strategic National Energy Plan 2006-2020-Main Report, Energy Demand Sectors of the Economy, Energy Supply to the Economy - Petroleum, Energy Supply to the Economy-Woodfuels and Renewables, Energy Supply to the Economy-Electricity.

3.4. Sample and population

The population for this research included all the researches and studies published about the Volta River Authority (VRA) and its environmental impacts since the initial development of the project. However, towards the simplification of analysis and a careful selection, a total of five studies were selected using a purposeful sampling strategy, whereby the past researches were selected based upon pre-selected inclusion and exclusion criteria. This criterion primarily referred to the authenticity of the source and the reliability of the findings of the studies or researches. Within the purposeful sampling strategy, homogeneous sampling technique was employed towards obtaining a homogeneous sample where all the consulted studies and researches were overall uniform in nature (Maxwell, 2012).

3.5. Limitation of the study

This research was primarily limited by the researcher's lack of prior exposure to the techniques of thematic analysis and the systematic literature review and the technicalities involved therein. Moreover, the material available on the environmental impact of the Volta River Authority (VRA) project was immense, though scattered in nature and required more time for sifting, collation and analysis.

4. FINDINGS, DISCUSSION AND ANALYSIS

The discussion in this chapter is divided into three main areas that are presentation of the findings from the systematic literature review, analysis and discussion of the results of the analysis towards clarification of research objectives and analysis of findings in the light of the two main environmental theories.

4.1. Presentation of the results of the systematic literature review

The findings from the systematic literature review have been tabulated in detail in Appendix 1. These findings have been presented below in terms of the selected sources of literature, the important findings, quality parameters of the selected sources of literature, reliability evaluation of findings from the systematic literature review, and inconsistencies across the selected sources of literature.

4.1.1. Selected sources of literature

The summary of past studies and researches, which were selected for the systematic review of academic literature, is tabulated below in Table 5.

Table 5. Selected Sources of Literature

Research Area	Selected Sources of Literature
1. Significant Environmental Considerations Catered for by the Preparatory Commission of the Volta River Authority (VRA).	Article on social and environmental reporting at the Volta River Authority (VRA) with reference to institutional legitimacy by Rahaman, Lawrence & Roper (2004) and published in Critical Perspectives on Accounting. Study on the Global Change and the Water Cycle (GLOWA) Volta Project as a framework for water resources decision-making and scientific capacity building in the West African basin by Rodgers et al. (2007) and published in the Integrated Assessment of Water Resources and Global Change. Study on the commodification of Ghana's Volta River as
2. Important Environmental Concerns Associated with the Individual Phases of the Volta River Authority (VRA) Project	
3. Steps Lacking in the Implementation Methodology of the Volta River Authority (VRA) Project with Reference to the Observed Environmental Concerns	

4. Socio-economic Cost of the Environmental Concerns Associated with the Volta River Authority (VRA) Project	an example of Ellul's autonomy of technique by Agbemabiese & Byrne (2005) and published in the Bulletin of Science, Technology & Society.
5. Effectiveness of the Remedial Strategies	Case study of the effects of the Akosombo and Kpong power schemes on six selected Mafi-communities in the Volta region by Agbenyo (2009) and published by the University of Cape Coast. Comparative study of the Akosombo and Bui dam projects in terms of the hydro-power and the promise of modernity and development in Ghana by Miescher & Tsikata (2009) and published in the Ghana Studies.

4.1.2. Summary of findings from the systematic literature review

The summary of findings from the past studies and researches are presented in the succeeding paragraphs in accordance with the five research questions related to: 1. the significant environmental considerations catered for by the Preparatory Commission of the Volta River Authority (VRA), 2. The important environmental concerns associated with the individual phases of the Volta River Authority (VRA) project, 3. Steps lacking in the implementation method of the Volta River Authority (VRA) project with reference to the observed environmental concerns, 4. The socio-economic cost of the environmental concerns associated with the Volta River Authority (VRA) project, and 5. the effectiveness of the remedial strategies. The detailed findings have been made available in Appendix I.

Significant Environmental Considerations Catered for by the Preparatory Commission of the Volta River Authority (VRA)

As far as the significant environmental considerations catered for by the Preparatory Commission of the Volta River Authority (VRA) are concerned, the summary of findings is presented in Table 6, below.

Table 6. Significant Environmental Considerations (1)

Source	Findings
1. Rahaman, Lawrence & Roper (2004).	Possible impact upon the natural environment of the areas Possibility of flooding Threat to local wildlife
2. Rodger et al. (2004).	Possible water shortage due to multiple resource use
3. Agbemabiese & Byrne (2005).	Impact upon water resource Impact upon environment Impact upon ecology
4. Agbenyo (2009)	Possible general environmental impact
5. Miescher & Tsikata (2009)	Possible impact upon the river flows

Important Environmental Concerns of VRA

With regards to the important environmental concerns associated with the individual phases of the Volta River Authority (VRA) Project, the findings have been presented in Table 7, below.

Table 7. Important Environmental Concerns (2)

Source	Findings
1. Rahaman, Lawrence & Roper (2004)	Significant permanent alteration of natural environment Spread of water-borne diseases Intense flooding in periods of heavy rainfall Impact of high tension power lines on wildlife High levels of environmental pollution because of thermal generation plants Adverse impact of land degradation along the Volta Lake
2. Rodgers et al. (2007)	Water scarcity because of competition for water Prevalence of water-borne diseases
3. Agbemabiese & Byrne (2005)	Adverse impact upon wildlife

4. Agbenyo (2009)	Adverse impact upon the population of aquatic species Adverse impact upon the flow of the Volta River Magnified propagation in the species of waterweeds Magnified increase in the water borne diseases Deforestation and erosion along the banks of the Volta River Eutrophication through discharge of wastes and the use of agro-chemicals Deforestation causing erratic rainfall patterns in the area
5. Miescher & Tsikata (2009)	Adverse impacts upon local biodiversity and preservation of land-scape and ecosystems Prevalence of diseases Emission of greenhouse gases due to its rotten vegetation Frequent flooding causing destruction of natural environment

Table 8. Steps Lacking in Implementation (3)

Source	Findings
1. Rahaman, Lawrence & Roper (2004)	Spread of water-borne diseases in the surrounding villages Impact of high tension power lines on wildlife Environmental pollution because of thermal generation plants Land degradation along the shores of Volta Lake Water scarcity
2. Rodgers et al. (2007)	Effective water resource management strategy Spread of water-borne diseases in the surrounding villages
3. Agbemabiese & Byrne (2005)	Spread of water-borne diseases in the surrounding villages Preservation of ecological, agricultural and sociological values
4. Agbenyo (2009)	Preservation of the species in the area Preservation of the flow of the Volta River Spread of water-borne diseases in the surrounding villages Impact of deforestation and erosion along the banks of the Volta River Discharge of wastes and the use of agro-chemicals
5. Miescher & Tsikata (2009)	Preservation of the local biodiversity, landscape and ecosystems Spread of water-borne diseases in the surrounding villages Emission of greenhouse gases Frequent flooding

4. Socio-economic Cost of Environmental Concerns of VRA

As far as the socio-economic costs of the environmental concerns associated with the Volta River Authority (VRA) project are concerned, the summary of findings is presented in Table 9, below.

Table 9. Socio-economic Cost of Environmental Concerns (4)

Source	Findings
1. Rahaman, Lawrence & Roper (2004)	Collapse of economic activity
2. Rodgers et al. (2007)	Decrease in economic activity
3. Agbemabiese & Byrne (2005)	Decrease in economic activity
4. Agbenyo (2009)	Collapse of economic activity Reduced water transportation Migration of population because of prevalence of diseases Farming and wood harvesting causing deforestation and erosion
5. Miescher & Tsikata (2009)	Ineffective and failed resettlement Failed plans for a cash crop economy Adverse impact upon local economy Economic loss of downstream communities Failed industrialization and irrigation Migration of large population segments

5. Effectiveness of the Remedial Strategies

As far as the effectiveness of the remedial strategies is concerned, the summary of findings has been presented in Table 10, below.

Table 10. Effectiveness of the Remedial Strategies (5)

Source	Findings
1. Rahaman, Lawrence & Roper (2004)	Impact assessment. Establishment of a new functional department called the Real Estate and Environment

	Department. Public acknowledgement and reporting. Reforestation of large tracts of degraded land. Raising awareness of local population. Engagement of all stakeholders. Establishment of medical facilities. Medical funding. Influence and pressure of the World Bank.
2. Rodgers et al. (2007)	The Water Resource Commission Act. Effective functioning and accomplishments of the Water Resource Commission Act (WRC).
3. Agbemabiese & Byrne (2005)	Ineffective disease treatment.
4. Agbenyo (2009)	Failed resettlement and compensation schemes.
5. Miescher & Tsikata (2009)	Failed resettlement and compensation schemes.

4.1.3. Quality parameters and reliability of the selected sources

Two important quality parameters were established for the selected sources for the systematic review that is separately for a journal article, published study or book. These included a peer-reviewed journal for an article or essay and a reputed educational institution or publishing house for a study or book respectively. The details of sources are provided in Appendix I and summarized in Table 11, below and these details make it obvious that all sources selected for the review are of a high quality and therefore their findings can be termed as reliable.

Table 11. Quality Parameters of the Selected Sources

Source	**Published in/by**	**Reliability**
1. Rahaman, Lawrence & Roper	Critical Perspectives on	High

(2004	Accounting	
2. Rodgers et al. (2007)	Integrated Assessment of Water Resources and Global Change	High
3. Agbemabiese & Byrne (2005)	Bulletin of Science, Technology & Society	High
4. Agbenyo (2009)	University of Cape Coast	High
5. Miescher & Tsikata (2009)	Ghana Studies	High

4.1.4. Inconsistencies across the selected sources of literature

Throughout the process of the systematic literature review, inconsistencies across the selected sources were expected in two main dimensions. These were the methodological and the conceptual inconsistencies. While a lot of methodological inconsistencies were observed, no conceptual inconsistencies have been observed as all the sources consulted agree upon the impacts of the Volta River Authority (VRA) Project. The details of methodological inconsistencies are provided in Table 12, below.

Table 12. Methodological Inconsistencies

Source	Methodology
1. Rahaman, Lawrence & Roper (2004)	Secondary research
2. Rodgers et al. (2007)	Mixed methods research including both primary and secondary research.
3. Agbemabiese & Byrne (2005)	Primary case study approach using both qualitative and quantitative methods.
4. Agbenyo (2009)	Primary case study.

4.2. Discussion of the findings from the literature review

The findings from the systematic literature review are discussed in the succeeding sub-sections in the five main areas. These are, the significant environmental considerations catered for by the Preparatory Commission, the important environmental concerns associated with the individual phases of the project, steps lacking in the implementation method of the project with reference to the observed environmental concerns, the socio-economic cost of the environmental concerns associated with the project and the effectiveness of the remedial strategies.

4.2.1. Significant environmental considerations of VRA

The findings from the systematic review of literature have indicated that the Preparatory Commission of the Volta River Authority (VRA) did cater for environmental considerations occurring in the long run however, these concerns were either too general in nature because of lack of vision or were overruled in favour of economic ambitions of the political leadership of the country. A few significant environmental considerations catered for by the Commission included the possible impact upon the natural environment of the areas surrounding the project both in the upstream and downstream areas; the possibility of flooding in the surrounding areas; the possible threats to the local wildlife; the adverse impact upon water resource in terms of the possible water shortage due to the immense requirement of the agricultural and irrigation sector; a general adverse impact upon the environment and ecology in the surrounding areas; and the possible impact upon the river flows (Rahaman, Lawrence & Roper, 2004, Rodgers et al., 2007; Agbemabiese & Byrne, 2005, Agbenyo, 2009 and Miescher & Tsikata, 2009).

The above findings from the systematic review of literature have also been found in line with the major conclusions from the literature review which indicated that the work of the Preparatory Commission of the Volta River Authority (VRA) project, though correctly scoped, suffered from a wrong prioritization of the energy needs of Ghana over the environmental, public health and socio-cultural concerns (Alhassan, 2009 and Odame-Ababio, 2003). However, it is pertinent to note that this was not entirely the fault of the Preparatory Commission but was mainly the result of the influence of the political leadership of Ghana.

4.2.2. Important environmental concerns of the VRA project

The findings from the systematic review of literature have indicated that there have been numerous important environmental concerns associated with the individual phases of the Volta River Authority (VRA) project. For example, there has been a significant and permanent alteration of the natural environments of the areas surrounding the various project components especially in areas of Torgome, Natriku, West Kpong, South Senchi, Fadzoku and Old Akrade. This alteration has not only caused frequent and intense flooding in periods of heavy rainfall especially once excess water is spilled out from the dam, but has also exercised an adverse impact upon the flow of the Volta River and has destroyed the natural environment. Moreover, the transformation of the natural environment in the area in terms of land degradation along the Volta Lake for example deforestation and erosion have caused erratic rainfall patterns in the area while eutrophication has occurred because of the unmonitored and non-regulated discharge of wastes

and the use of agro-chemicals (Rahaman, Lawrence & Roper, 2004; Rodgers et al., 2007; Agbemabiese & Byrne, 2005; Agbenyo, 2009; and Miescher & Tsikata, 2009). Another important environmental concern was observed in the form of the prevalence of various water-borne diseases. For instance, widespread instances of bilharzia or urinary schistosomiasis amongst school-going children from communities along the 4000-mile shoreline of the Volta lake and river-blindness or onchocerciasis amongst children and adults along with Malaria due to large mosquito population, have been found rampant and major causes of mortality (Rahaman, Lawrence & Roper, 2004; Rodgers et al., 2007; Agbemabiese & Byrne, 2005; Agbenyo, 2009; and Miescher & Tsikata, 2009).

Similarly, adverse impacts upon local biodiversity and preservation of landscape and ecosystems was observed for instance the population of fish along with other aquatic species including those of oyster, shrimps and tilapia have declined drastically due to the manifold increase in fishing activity emerging as a main livelihood, there was a magnified propagation in the species of waterweeds such as Utricularia Spp, Eichhornia Crassipes, Moss, Panicum Maxima and Scirpus Cubensis, which has adversely impacted river flows (Rahaman, Lawrence & Roper, 2004; Rodgers et al., 2007; Agbemabiese & Byrne, 2005; Agbenyo, 2009; and Miescher & Tsikata, 2009).

Some other important environmental concerns have been identified in the form of the adverse impact of high tension power lines on wildlife, high levels of environmental pollution because of thermal generation plants and the resultant emission of greenhouse gases, water scarcity because of competition for water between the irrigation sector in the northern and central Volta basin and hydro-power generation in the south; and the

emission of greenhouse gases due to the rotten vegetation (Rahaman, Lawrence & Roper, 2004; Rodgers et al., 2007; Agbemabiese & Byrne, 2005; Agbenyo, 2009; and Miescher & Tsikata, 2009).

The above findings from the systematic review of literature have also been found in line with the major environmental and ecological concerns identified from the literature review as highlighted by Gyau-Boakye (2001), Barry et al. (2005), Gordon & Amatekpor (1999), Zakhary (1997), Wen & Chu (1984), Williams et al. (2016), Rahaman, Lawrence & Roper (2004) and Andreini et al. (2000).

4.2.3. Steps lacking in the method of implementation

In line with the environmental concerns, several important steps have also been found lacking in the implementation methodology of the Volta River Authority (VRA) project. For example, the implementation strategy failed to account for the alteration of the natural environment leading to flooding and failed to build reservoirs to contain and store the flood water which could not only have mitigated the impact of flooding in periods of heavy rainfall but could also fulfil the requirements of the irrigation sector. Similarly, no attention was paid towards the possibility of reduced flow of the Volta River and the resultant impact upon the natural environment. Also the implementation methodology failed to provide for any mechanisms to regulate the farming activity along the banks of rivers and the Volta Lake to guard against deforestation and erosion as well as to prevent the discharge of waste products and the use of agro-chemicals (Rahaman, Lawrence & Roper, 2004; Rodgers et al., 2007; Agbemabiese & Byrne, 2005; Agbenyo, 2009; and Miescher & Tsikata, 2009).

On the face of it, the implementation methodology also failed to incorporate mechanisms to guard against the outbreak of infectious diseases like bilharzia or urinary schistosomiasis and river-blindness or onchocerciasis. However, when examined in detail, it can be seen that the increased instance of these diseases because of the increase in population of snails et cetera could hardly been foreseen. However, the same cannot be said about the outbreak of malaria as the increase in the mosquito population should have been foreseen as a natural and automatic consequence of developing large bodies of water (Rahaman, Lawrence & Roper, 2004; Rodgers et al., 2007; Agbemabiese & Byrne, 2005; Agbenyo, 2009; and Miescher & Tsikata, 2009).

Though being discussed in one of the subsequent sections under the socio-economic impacts, it has been found that the implementation methodology of the Volta River Authority (VRA) failed to check the impact of increased fishing activities upon the local biodiversity and ecosystems, as a result of which, the populations of fish, oyster, shrimps and tilapia have declined manifold. Similarly, the increase in the population of waterweeds should have been determined as a natural consequence of developing one of the largest manmade lakes in the world; however this aspect was neglected which not only gave rise to the increased instance of diseases but also adversely impacted the river flows (Rahaman, Lawrence & Roper, 2004; Rodgers et al., 2007; Agbemabiese & Byrne, 2005; Agbenyo, 2009; and Miescher & Tsikata, 2009).

The fact that there have been high levels of environmental pollution because of thermal generation plants and the emission of greenhouse gases cannot be considered as a failure of the original implementation methodology as in the beginning only hydropower plants were planned. However, this emission should have been catered for by subse-

quent planning and while deciding upon the scale of the intended thermal plants. Similarly, the implementation method for the Volta River Authority (VRA) project also failed to cater for the emission of greenhouse gases due to the rotten vegetation and the possible impact of high tension power lines on wildlife. Moreover, this implementation methodology also lacked a comprehensive and effective water resource management strategy to balance out the water shares going to the irrigation sector in the upstream areas and hydro-power generation in the downstream areas. Overall, it has been found that the ecological, agricultural and sociological values of the Volta River region were compromised in favour of ambitions for rapid industrial and economic development in Ghana by the political leadership (Rahaman, Lawrence & Roper, 2004; Rodgers et al., 2007; Agbemabiese & Byrne, 2005; Agbenyo, 2009; and Miescher & Tsikata, 2009).

The above findings from the systematic review of literature have also been found in line with the steps lacking in the implementation methodology of the Volta River Authority (VRA) project identified from the literature review as highlighted by Konadu-Agyemang, Saku & Haasch (2006), Molle (2009), Andreini et al. (2000), Gyau-Boakye (2001), Steinmann et al. (2006), Gordon & Amatekpor (1999), Gutman (1994), De Wet (2006), Tamakloe (1994), Obosu (1996), McMillan (1995), Zakhary (1997) and Jobin (1999).

4.2.4. Socio-economic cost of the environmental issues of the VRA project

The findings from the systematic review of literature have indicated that there has been a very high socio-economic cost of the Volta River Authority (VRA) project primarily because the project was aimed at economic growth, but it only brought along misery to

some people and deprivation, especially for the local population. This was because there was a total collapse of economic activity all along the banks of the Volta River because of the drastic reduction in the populations of oyster, shrimps and tilapia, which occurred because of increased fishing activities; while the water transportation in the downstream areas was drastically impacted because of increase in the populations of the waterweeds, the shallow water levels and floating vegetation below the dam. This reduced transportation caused a breakdown of local small trade activities and prevented the local movement of the workforce (Rahaman, Lawrence & Roper, 2004; Rodgers et al., 2007; Agbemabiese & Byrne, 2005; Agbenyo, 2009; and Miescher & Tsikata, 2009).

Another important socio-economic impact of the Volta River Authority (VRA) project was in the form of large scale displacement of the local population primarily because of the prevalence of waterborne diseases and the resultant increase in child mortality and also because of the frequent flooding and its adverse impact upon local economic activities. The displacement of the population has also been found the result of an unsuccessful and ineffective resettlement strategy as new communities failed to develop in the absence of requisite infrastructure and economic opportunities. Also while the new settlements lacked basic infrastructure and services, the plans for a cash crop economy failed in the new settlements and the modernization promises for instance industrialization and irrigation, failed to materialize for the Ghanaian people. Moreover, as the project exercised an adverse impact upon economies in downstream areas which were dependent upon farming, fishing, clam picking, and some small-scale trade and the perceived benefits of the Volta River project failed to make up for the economic loss of downstream communities; the local population extensively engaged in farming and

wood harvesting activities for sustenance, which in turn caused deforestation and erosion (Rahaman, Lawrence & Roper, 2004; Rodgers et al., 2007; Agbemabiese & Byrne, 2005; Agbenyo, 2009; and Miescher & Tsikata, 2009).

The above findings from the systematic review of literature is in line with the socioeconomic costs of the Volta River Authority (VRA) project, identified from the literature review as highlighted by Oguntunde et al. (2006), Gyau-Boakye (2001), Tsikata (2006), Johnston & McCartney (2010), Straškraba, Tundisi & Duncan (1993), Codjoe (2004), Andreini et al. (2000), McCartney (2009) and Bollen et al. (2011).

4.2.5. Effectiveness of the remedial strategies

With regards to the effectiveness of different remedial strategies implemented to address the negative environmental and socio-economic impact of the Volta River Authority (VRA) project, the findings from the systematic review of literature have indicated that during the initial years, some of the following effectiveness were lacking. The resettlement and compensation strategies were lacking in many different aspects and fell short of the intended aims, the application of dichloro-diphenyl trichloro-ethane (DDT) and other pesticides towards arresting the spread of diseases in the communities located along the shoreline of Lake Volta was also ineffective and also negatively affected the water supplies of inhabitants (Rahaman, Lawrence & Roper, 2004; Rodgers et al., 2007; Agbemabiese & Byrne, 2005; Agbenyo, 2009; and Miescher & Tsikata, 2009).

The situation changed because of the increased influence of international organizations like the World Bank, which led to improved situation following a detailed assessment of impact upon environment and identification of relevant remedial strategies with the as-

sistance of hired international consulting firms. The government of Ghana also established a new functional department called the Real Estate and Environment Department (REED), which was made responsible for the constant monitoring and reporting (publicly acknowledged and declared) on the social and environmental impacts of Volta River Authority (VRA)'s operations along with identifying ways of quantification and integration of environmental and social costs within the Volta River Authority (VRA)'s reporting system. An evidence of this is found in terms of arresting the adverse impact of land degradation along the Volta Lake through reforestation of large tracts of degraded land, through raising the awareness of local population through education and engagement with involvement about environmental degradation and engagement of all relevant stakeholders. Moreover, the Real Estate and Environment Department also managed to establish a modern and well-equipped hospital called the Akosombo Township Hospital, which employed the services of specialist doctors for the treatment of villagers in the surrounding areas of the lake, while creating a trust fund of US$ 500,000 for the treatment of sick villagers suffering from water-borne diseases (Rahaman, Lawrence & Roper, 2004).

As part of the remedial strategy, in 2000, with the technical and financial help of the German Government, the Global Change and the Water Cycle (GLOWA) Volta Project was initiated, which was tasked to analyse the physical and socio-economic determinants of the hydrologic cycle within the Volta Basin in an integrated and comprehensive manner, and was also aimed at the designing and implementation of a scientifically sound Decision Support System (DSS) for the sustainable development of water resources in the Volta Basin under the changing environmental conditions. The project

comprises of physical scientists, geographers, hydrologists and climatologists along with anthropologists, sociologists and agricultural economists (Rodgers et al., 2007).

The establishment of the Water Resources Commission (WRC) in 19996 was yet another important remedial measure, which was primarily the result of the Water Resource Commission Act passed by the Ghanaian Parliament. This Act accorded the powers of management of national water resources to the Water Resource Commission (WRC) and prohibits all persons or organizations to divert, dam, store, abstract or use water, or to develop or maintain physical structures for the use of water resources without the consent of Water Resources Commission (WRC). The important tasks of Water Resources Commission (WRC) include: proposing, coordinating and monitoring plans and activities related to the development, improvement, utilisation and conservation of water resources, regulation of water storage and collection rights, dissemination of relevant information and research and development of water resources, monitoring programmes related to the operation and maintenance of water resources and render advice on water resources to both the government and the pollution control agencies. The fact that these tasks have been performed effectively is obvious from the accomplishments of the Water Resource Commission (WRC). Some of these accomplishments include: drafting of a Water Policy, introduction of water use regulations and tariffs for the abstraction of raw water, initiation of two Basin Pilot Projects in the Densu and White Volta Basins for the testing of Integrated Water Resource Management (IWRM) strategies, enhancement of public awareness, promoting stakeholders' participation, introduction of the Basin Commission concept, establishment of a Water Resource Information System (WRIS) for the collection, collation and dissemination of relevant information and es-

tablishment of international water sharing and management mechanisms within the Volta-Basin (Rodgers et al., 2007).

The above findings from the systematic review of literature have also been found in line with the effectiveness of the remedial strategies as argued by Jobin (1999), Biney (2010), Gordon & Amatekpor (1999), Palmer et al. (2008), Tamakloe (1994), Anthony, Oyédé & Lang (2002), Tsikata (2004), Scudder (1994), Gocking (2005) and Titiati (1997).

4.3. Analysis methodolgy

The primary analysis methodology for this research was the systematic literature review that is the identification, critical evaluation and integration of all the findings of all individual studies, which are high quality and relevant in nature, in an organized and planned manner (Maxwell, 2012). This systematic literature review was characterised by establishment of the level of clarification on the research subject as determined with respect to the selected researches; identification of inconsistencies, gaps, conflicts and relationships amongst different sources and determining the applicable reasons; conceptualization of the highlighted ideas, evaluation and determining directions for future research. The advantages of this systematic literature review were identified as objectivity, systematic evaluation, transparency and replicability. Furthermore, the element of bias in the interpretation and analysis of the findings was addressed through adhering to a systematic process of research and a consistent application of the inclusion and exclusion criteria (Denzin & Lincoln, 1994).

The systematic review of literature was out in five main stages which are as follows; scoping, planning, identification or searching, screening and eligibility. During the

scoping stage, the research aim and objectives were formulated and all efforts were made to locate a previously published review of literature on the subject of environmental impacts of the Volta River Authority (VRA) project. During the planning stage, the research objectives were broken down into individual subject areas and concepts towards development of the appropriate search terms, the preliminary inclusion and exclusion criteria were formulated and a meticulous record keeping system was developed. As part of the identification or searching stage, the search terms were used to locate and identify a few relevant electronic databases, the search results were inspected in a careful and deliberate manner and additional searches were conducted towards ensuring that all relevant published and unpublished work has been located and screened through. During the screening stage, the references were exported to a citation manager for the collation of the search results and the titles and abstracts of the selected literature sources were scrutinized in detail. During the final stage of eligibility, the full texts of the selected sources were screened in detail in accordance with the inclusion and exclusion criteria (Denzin & Lincoln, 1994).

The qualitative analysis was carried out while employing the technique of thematic analysis, which was employed in the form of a thorough scrutiny of the secondary sources of data in order to identify, evaluate and record the emerging themes or patterns on the environmental impact in the Volta River area because of the Volta River Authority (VRA) project (Denzin & Lincoln, 1994).

4.4. Analysis of findings in terms of the modern theories of motivation

In this section, the analysis of the findings from the systematic literature review is carried out in terms of two main theories. The Theory of Unequal Ecological Exchange and Environmental Degradation and the Theory of Environmental Degradation.

4.4.1. Theory of unequal ecological exchange

The applicability of the Theory of Unequal Ecological Exchange and Environmental Degradation was sought in two important dimensions that were the hasty development of the Volta River Authority (VRA) project towards rapid industrial development and economic growth and foreign investment in Ghana leading to the adoption of dirty and sub-quality extraction and production methodologies in the mining and industrial sectors (Jorgenson, 2006). The findings from the systematic review of literature confirm the applicability of both these dimensions. It has been found that the political leadership of Ghana had a mistaken belief that the Volta River Authority (VRA) was key to rapid industrialization and economic growth. Therefore, all environmental and socio-economic concerns were put aside and compromised in favour of this perception. This misperception and the hasty development strategy left a wide room for weaknesses and shortcomings, which with the passage of time, manifested into adverse environmental impacts. Moreover, the externalization of environmental impacts and costs associated with the industrialization and mining activities has also been found evident primarily in terms of the emission of greenhouse gasses and other adverse impacts of the thermal power projects (Rahaman, Lawrence & Roper, 2004; Rodgers et al., 2007; Agbemabiese & Byrne, 2005; Agbenyo, 2009; Jorgenson, 2006; and Miescher & Tsikata, 2009).

4.4.2. Theory of environmental degradation

The applicability of the Theory of Environmental Degradation was examined in terms of the environmental degradation and deterioration occurring as the result of a continuous series of overlapping vicious circles culminating into a downward spiral, thereby

leading to adverse environmental and socio-economic consequences and the environmental degradation and deterioration occurring in the form of a gradual and accelerating transformation (Caviglia-Harris, Chambers & Kahn, 2009). Once the findings from the systematic review of literature are examined, it can be seen that the applicability of this theory stands confirmed as the Volta River Authority (VRA) project was initially planned and implemented on a false premise and misjudgement, in favour of which the production of cheap and cost-effective electricity was prioritized and favoured over all other socio-economic and environmental considerations. Also, the failure of the resettlement and compensation strategies drove the displacement of large segments of population and the devastation of local economic activities. While greatly disturbing and adversely impacting the local economy and environment, these failures also led the local population engaging in unwanted agricultural and commercial activities like intensive fishing, farming and wood harvesting, which became the secondary causes of environmental destruction (Rahaman, Lawrence & Roper, 2004; Rodgers et al., 2007; Agbemabiese & Byrne, 2005; Agbenyo, 2009; Caviglia-Harris, Chambers & Kahn, 2009; and Miescher & Tsikata, 2009)

5. CONCLUSION AND RECOMMENDATIONS

In conclusion, one can confidently say that the Volta River Authority (VRA) project was achieved by the Government and people of the Republic of Ghana.

5.1. Main conclusions and the achievement of research aim and questions

There were five research questions that were: the significant environmental considerations catered for by the Preparatory Commission of the Volta River Authority (VRA), the important environmental concerns associated with the individual phases of the Volta River Authority (VRA) project, steps lacking in the implementation method of the Volta River Authority (VRA) project with reference to the observed environmental concerns, the socio-economic cost of the environmental concerns associated with the Volta River Authority (VRA) project and the effectiveness of the remedial strategies.

With regards to the significant environmental considerations catered for by the Preparatory Commission of the Volta River Authority (VRA), it can be concluded that though the Preparatory Commission did cater for a few important environmental considerations, an exact focus was lacking. Moreover, the considerations which were incorporated in the planning were based upon a faulty premise that is the political leadership's decision to prioritize power and electricity production over all environmental and socio-economic concerns. It has also been found out that the environmental considerations catered for by the Commission were only general in nature and did not accompany any feasible strategy or vision.

As far as the important environmental concerns associated with the individual phases of the Volta River Authority (VRA) project are concerned, from the discussion it can be concluded that all the components and phases of the Volta River Authority (VRA) project gave rise to significant environmental concerns both during the initial stages of the project and also along with the development of new components like the thermal power

projects. The important environmental concerns have been identified to include: permanent and large scale transformation of the natural environment of the areas surrounding the Volta Lake and power generation facilities, frequent and intense flooding because of spillage from the dams, destruction of the natural environment, land degradation in terms of deforestation and erosion, erratic rainfall patterns, eutrophication, prevalence of various water-borne diseases including urinary schistosomiasis, onchocerciasis and malaria, adverse impact upon the local biodiversity, devastation of the local landscape and ecosystems, disturbance and reduction of the river flows, environmental pollution because of emission of greenhouse gases and water scarcity.

With regards to the steps lacking in the implementation method of the Volta River Authority (VRA) project it can be concluded that several important steps were lacking, which marred the effectiveness of the implementation method. These steps have been identified to include: absence of vision and lack of strategy to guard against the spread of water-borne diseases in the surrounding villages, lack of incorporation of the impact of high tension power lines on wildlife, lack of strategy to guard against environmental pollution because of thermal generation plants, lack of incorporation of any strategy against land degradation along the shores of Volta Lake, lack of vision on possible water scarcity because of the sharing of water resource by the irrigation and hydropower generation sectors, lack of strategy aimed at the preservation of the species, landscape and ecosystems in the area and the flow of the Volta River and its subsidiaries, lack of strategy to counter the impact of deforestation and erosion along the banks of the Volta River and prevention of the discharge of wastes and the use of agro-chemicals, lack of

strategy to prevent or reduce the emission of greenhouse gases; and the lack of planning to guard against frequent flooding.

With regards to the socio-economic cost of the environmental concerns associated with the Volta River Authority (VRA) project, it can be concluded that the overall Volta River Authority (VRA) project resulted into a high socioeconomic cost as it deprived the local population of not only their lands without the promised compensation but also denied them suitable and alternative earning opportunities. The important socioeconomic impacts of the Volta River Authority (VRA) project is identified in terms of devastation of all economic activities, disturbance of the water transportation in the downstream areas, and large scale displacement of the local population.

With reference to the effectiveness of the remedial strategies aimed at the adverse environmental and socio-economic impact of the Volta River Authority (VRA) project, it can be concluded that this effectiveness was absent in the initial years when the remedial strategy was mainly reactive and short term in nature, for instance the use of Dichloro-Diphenyl Trichoro-ethane (DDT) and pesticides aimed at disease control. However, with the passage of time this effectiveness was enhanced. The principal reasons behind this enhanced effectiveness is identified to include: the increased influence of the World Bank, deliberate assessment and planning with foreign assistance, constant monitoring and transparent and accountable reporting, quantification and integration of environmental and social costs, raising public awareness, engagement and involvement of all relevant stakeholders, establishment of properly funded, equipped and staffed medical facilities, use of the Decision Support System (DSS), development of appropriate legis-

lation and institutions for water management and distribution, appropriate policy formulation and effective policy implementation.

In addition to the above, it can also be concluded that both the Theories of Unequal Ecological Exchange and Environmental Degradation can be applied to the case of the Volta River Authority (VRA). The Theory of Unequal Ecological Exchange and Environmental Degradation have been found applicable both in terms of the mistaken beliefs of the Ghanaian political leadership and the resultant compromise over the environmental and socio-economic concerns and the externalization of environmental impacts and costs. Similarly, the Theory of Environmental Degradation has been found applicable in terms of environmental degradation and deterioration starting with faulty prioritizing and intensifying with each subsequent phase of the Volta River Authority (VRA) project.

Overall, from the discussion in this dissertation, it can be concluded that the Volta River Authority (VRA) project was perceived by the political leadership of Ghana to have a critical economic significance primarily because of the scale and scope of the power generation operations and infrastructure and the resultant fulfilment of the power needs of the industrial and mining sectors. It was believed that with the establishment and implementation of this project, Ghana would be put on the path to sustainable development and progress. However, the political leadership of the country chose to ignore the advice of experts who highlighted the possible adverse of environmental and socioeconomic impacts of the project and they decided to go forward with the subsequent phases of the project even when the first phase proved to fall far short of the intended objectives.

Once all the factors are examined, it becomes evident that it was in fact the failure and ineffectiveness of the resettlement strategy and the compensation mechanisms which became the root of all other problems. This failure and ineffectiveness can be primarily attributed to not only the deficiency of requisite resources with the Government of Ghana but also the faulty vision of the political leadership which failed to incorporate all the relevant environmental and socioeconomic concerns into the project planning. Once the resettlement strategy failed to materialize and the displaced population failed to get fairly compensated, the result was a large scale migration for almost half the affected population towards the urban centres and upstream areas while the remaining half in the absence of suitable commercial opportunities, chose to engage in farming and wood harvesting and also fishing activities. The result of all these commercial activities was an adverse impact upon the local biodiversity and ecology.

5.2. Recommendations for further research

During the course of discussion and the systematic review of literature two points were observed. Firstly, the peculiar dynamics of Continental Politics and with African continent and their unique way of politicking, social structures and geographies render most of the economic solutions ineffective. Even once these solutions have proved to be effective in other continents of the world, these lose their utility sometimes when they are applied in the African context. The case of the Volta River Authority (VRA) is an important case in which Ghana failed to reap the benefits of a large hydropower generation project like that primarily because of faulty planning, incorrect prioritization and lack of foresight on part of the political leadership at the time due to opposition pressure. This makes it important to identify and examine the factors which decide the suitability of

economic development policies and policy direction in the African context. Secondly, though various remedial strategies have been found in various studies and researches, a comprehensive strategy to address all or most of the environmental concerns associated with the Volta River Authority (VRA) project is missing, especially a strategy to undo or address to the maximum possible extent, the damage that has already been caused by the project. This makes it important to investigate the possibility of devising such a strategy with or without international assistance.

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APPENDIX 1. Findings from the systematic review of literature

Source	Published In/by	Subject	Methodology	Findings	Reliability
Significant Environmental Considerations Catered for by the Preparatory Commission of the VRA					
1. Rahaman, Lawrence & Roper (2004)	Critical Perspectives on Accounting	Social and environmental reporting at the VRA: institutionalised legitimacy or legitimating crisis?	Secondary research	Possible impact upon natural environment of the areas Possibility of flooding Threat to local wildlife	High
2. Rodgers et al. (2007)	Integrated Assessment of Water Resources and Global Change	The GLOWA Volta Project: A framework for water resources decision-making and scientific capacity building in a transnational West African basin	Mixed methods research including both primary and secondary research	Possible water shortage due to the immense requirement of the agricultural and irrigation sector.	High
3.Agbemabiese & Byrne (2005)	Bulletin of Science, Technology & Society	Commodification of Ghana's Volta River: an example of Ellul's autonomy of technique	Primary case study approach using both qualitative and quantitative methodologies	Impact upon water resource Impact upon the environment Impact upon the ecology	High
4. Agbenyo (2009)	University of Cape Coast	Effects of the Akosombo and Kpong power schemes on six selected Mafi-communities in the Volta region	Primary case study	Possible general environmental impact.	Medium
5. Miescher & Tsikata (2009)	Ghanaian Studies		Secondary research	Possible impact upon the river flows.	High
Important Environmental Concerns Associated with the Individual Phases of the VRA Project					
1. Rahaman, Lawrence & Roper (2004	Critical Perspectives on Accounting	Social and environmental reporting at the VRA: institutionalised legitimacy or legitimating crisis?	Secondary research	Significant permanent alteration of natural environment of the areas in Torgome, Natriku, West Kpong, South Senchi, Fadzoku and Old Akrade Spread of water-borne diseases including bilharzias and river blindness and heavy prevalence in the surrounding villages Intense flooding in periods of heavy rainfall especially once excess water is spilled out from	High

				the dam Impact of high tension power lines on wildlife High levels of environmental pollution because of thermal generation plants Adverse impact of land degradation along the Volta Lake	
2. Rodgers et al. (2007)	Integrated Assessment of Water Resources and Global Change	The Global Change and the Water Cycle project (GLOWA) Volta Project: A framework for water resources decision-making and scientific capacity building in a transnational West African basin	Mixed methods research including both primary and secondary research	Water scarcity because of competition for water between the irrigation sector in the northern and central Volta basin and hydro-power generation in the south Prevalence of Onchocerciasis or river blindness in the Northern regions of the basin	High
3.Agbemabiese & Byrne (2005)	Bulletin of Science, Technology & Society	Commodification of Ghana's Volta River: an example of Ellul's autonomy of technique	Primary case study approach	Wide spread in stance of bilharzia or urinary schistosomiasis amongst school-going children from communities along the 4000-mile shoreline of the Volta lake. Widespread instance of river-blindness or onchocerciasis amongst children and adults Impact upon wildlife especially the population of fish due to the manifold increase in fishing activity as a main livelihood	High
4. Agbenyo (2009)	University of Cape Coast	Effects of the Akosombo and Kpong power schemes on six selected Mafi-communities in the Volta region	Primary case study approach using both qualitative and quantitative methodologies	Adverse impact upon the population of aquatic species including those of oyster, shrimps and tilapia Adverse impact upon the flow of the Volta River Magnified propagation in the species of waterweeds such as Utricularia Spp, Eichhornia Crassipes, Moss, Panicum Maxima and Scirpus Cubensis Magnified increase in the water borne diseases like bilharzias and malaria due to large mosquito population Deforestation and erosion along	Medium

				the banks of the Volta River Eutrophication through discharge of wastes and the use of agro-chemicals Deforestation causing erratic rainfall patterns in the area	
5. Miescher & Tsikata (2009)	Ghanaian Studies	Hydro-power and the promise of modernity and development in Ghana: comparing the Akosombo and Bui dam projects	Secondary research	Adverse impacts upon local biodiversity and preservation of landscape and ecosystems Prevalence of diseases such as serious health hazards such as bilharzia or schistosomiasis Emission of greenhouse gases due to its rotten vegetation Frequent flooding causing destruction of natural environment	High
Steps Lacking in the Implementation Method of the VRA project with reference to the observed Environmental Concerns					
1. Rahaman, Lawrence & Roper (2004)	Critical Perspectives on Accounting	Social and environmental reporting at the Volta River Authority (VRA): institutionalised legitimacy or legitimating crisis?	Secondary research	Absence of vision and lack of strategy to guard against the spread of water-borne diseases in the surrounding villages Lack of incorporation of the impact of high tension power lines on wildlife Lack of strategy against environmental pollution because of thermal generation plants Lack of incorporation of any strategy against land degradation along the shores of Volta Lake Lack of vision on possible water scarcity because of the sharing of water resource by the irrigation and hydropower generation sectors	High
2. Rodgers et al. (2007)	Integrated Assessment of Water Resources and Global Change	The Global Change and the Water Cycle project (GLOWA) Volta Project: A framework for water	Mixed methods research including both primary and secondary research	Absence of comprehensive and effective water resource management strategy to balance out the water shares going to the irrigation sector in the upstream areas and hydropower generation in the	High

		resources decision-making and scientific capacity building in a transnational West African basin		downstream areas Absence of vision and lack of strategy to guard against the spread of water-borne diseases in the surrounding villages	
3.Agbemabiese & Byrne (2005)	Bulletin of Science, Technology & Society	Commodification of Ghana's Volta River: an example of Ellul's autonomy of technique	Primary case study approach	Absence of vision and lack of strategy to guard against the spread of water-borne diseases in the surrounding villages Ecological, agricultural and sociological value of the Volta River region compromised in favour of industrial development	High
4. Agbenyo (2009)	University of Cape Coast	Effects of the Akosombo and Kpong power schemes on six selected Mafi-communities in the Volta region	Primary case study approach using both qualitative and quantitative methodologies	No strategy to preserve the species in the area No strategy to preserve the flow of the Volta River Absence of vision and lack of strategy to guard against the spread of water-borne diseases in the surrounding villages No strategy to counter the impact of deforestation and erosion along the banks of the Volta River No strategy to prevent the discharge of wastes and the use of agro-chemicals	Medium
5. Miescher & Tsikata (2009)	University of Cape Coast	Effects of the Akosombo and Kpong power schemes on six selected Mafi-communities in the Volta region	Primary case study approach using both qualitative and quantitative methodologies	No strategy to preserve the local biodiversity and ensure preservation of landscape and ecosystems Absence of vision and lack of strategy to guard against the spread of water-borne diseases in the surrounding villages No strategy to prevent or reduce the emission of greenhouse gases No strategy to prevent frequent flooding	Medium

Socio-economic Cost of the Environmental Concerns Associated with the VRA project					
1. Rahaman, Lawrence & Roper (2004)	Critical Perspectives on Accounting	Social and environmental reporting at the Volta River Authority (VRA): institutionalised legitimacy or legitimating crisis?	Secondary research	Collapse of economic activities	High
2. Rodgers et al. (2007)	Integrated Assessment of Water Resources and Global Change	The Global Change and the Water Cycle (GLOWA) Volta Project: A framework for water resources decision-making and scientific capacity building in a transnational West African basin	Mixed methods research including both primary and secondary research	Decrease in economic activities	High
3.Agbemabiese & Byrne (2005)	Bulletin of Science, Technology & Society	Commodification of Ghana's Volta River: an example of Ellul's autonomy of technique	Primary case study approach using both qualitative and quantitative methodologies	Decrease in economic activities	High
4. Agbenyo (2009)	University of Cape Coast	Effects of the Akosombo and Kpong power schemes on six selected Mafi-communities in the Volta region	Primary case study approach using both qualitative and quantitative methodologies	Collapse of economic activity along the banks of the Volta River because of the drastic reduction in the populations of oyster, shrimps and tilapia Reduced water transportation in the downstream areas because of waterweeds and shallow water level; floating vegetation below the dam Migration of population because of prevalence of diseases Farming and wood harvesting causing deforestation and erosion	Medium
5. Miescher & Tsikata (2009)	Ghanaian Studies	Hydro-power and the promise of modernity and development in Ghana: comparing the Akosombo and Bui dam projects	Secondary research	Resettlement was not successful and effective as new communities failed to develop in the absence of requisite infrastructure and economic opportunities. Also the new settlements lacked basic infrastructure	High

				and services Plans for a cash crop economy failed in the new settlements Adverse impact upon economies in downstream areas which were dependent upon farming, fishing, clam picking, and some small-scale trade Benefits of the Volta River Project failed to make up for the economic loss of downstream communities Modernization promises like for instance industrialization and irrigation, failed to materialize Frequent flooding causing migration of large population segments	
Effectiveness of the Remedial Strategies					
1. Rahaman, Lawrence & Roper (2004)	Critical Perspectives on Accounting	Social and environmental reporting at the VRA: institutionalised legitimacy or legitimating crisis?	Secondary research	Assessment of impact upon environment and identification of relevant remedial strategies with the assistance of hired international consulting firms Establishment of a new functional department called as the Real Estate and Environment Department, responsible for monitoring and reporting on the social and environmental impacts of VRA's operations; which identifies ways of quantification and integration of environmental and social costs within the VRA's reporting system Public acknowledgement and reporting of the environmental effects of its operations Arresting the adverse impact of land degradation along the Volta Lake through reforestation of large tracts of degraded land Raising awareness of local population through education and engagement and	High

				involvement about environmental degradation Engagement of all stakeholders Establishment of a modern and well-equipped hospital, Akosombo Township Hospital being serviced by specialist doctors for the treatment of villagers in the surrounding areas of the lake Creation of a Trust Fund of US$ 500,000 for the treatment of sick villagers High effectiveness of remedial strategies because of the influence and pressure of the World Bank	
2. Rodgers et al. (2007)	Integrated Assessment of Water Resources and Global Change	The Global Change and the Water Cycle Project for the Volta Basin (GLOWA) Volta Project: A framework for water resources decision-making and scientific capacity building in a transnational West African basin	Mixed methods research including both primary and secondary research	Volta Project, the Global Change and the Water Cycle Project for the Volta Basin (GLOWA) was aimed at the designing and implementation of a scientifically sound Decision Support System (DSS) for the sustainable development of water resources in the Volta Basin under the changing environmental conditions. The Global Change and the Water Cycle Project for the Volta Basin (GLOWA) was initiated in the year 2000 and funded by the German Government and is tasked to analyse the physical and socio-economic determinants of the hydrologic cycle within the Volta Basin in an integrated and comprehensive manner. The project comprises of physical scientists, geographers, hydrologists and climatol-	High

				ogists along with anthropologists, sociologists and agricultural economists The Water Resource Commission Act was passed by the Ghanaian Parliament in 1996, which accords the powers of management of national water resources to the Water Resource Commission (WRC). This Act prohibits all persons or organizations to divert, dam, store, abstract or use water, or to develop or maintain physical structures for the use of water resources without the consent of WRC. Tasks of WRC include: proposing, coordinating and monitoring plans and activities related to the development, improvement, utilisation and conservation of water resources; regulation of water storage and collection rights; dissemination of relevant information and research and development on water resources; monitoring programmes related to the operation and maintenance of water resources; and render advice on water resources to both the government and the pollution control agencies. Accomplishments of the Water Resource Commission (WRC) include: drafting of a Water Policy; introduction of water use regulations and tariffs for the abstraction of raw water; initiation of two Basin	

				Pilot Projects in the Densu and White Volta Basins for the testing of Integrated Water Resource Management (IWRM) strategies; enhancement of public awareness; promoting stakeholders' participation; introduction of the Basin Commission concept; establishment of a Water Resource Information System (WRIS) for the collection, collation and dissemination of relevant information; and establishment of international water sharing and management mechanisms within the Volta-Basin	
3.Agbemabiese & Byrne (2005)	Bulletin of Science, Technology & Society	Commodification of Ghana's Volta River: an example of Ellul's autonomy of technique	Primary case study approach	Application of dichloro-diphenyl trichloro-ethane (DDT) and other pesticides towards arresting the spread of diseases in the communities located along the shoreline of Lake Volta was ineffective and also negatively affected the water supplies of inhabitants	High
4. Agbenyo (2009)	University of Cape Coast	Effects of the Akosombo and Kpong power schemes on six selected Mafi-communities in the Volta region	Primary case study approach using both qualitative and quantitative methodologies	Resettlement and compensation schemes failed	Medium
5. Miescher & Tsikata (2009)	Ghanaian Studies	Hydro-power and the promise of modernity and development in Ghana: comparing the Akosombo and Bui dam projects	Secondary research	Resettlement and compensation schemes failed	High