

THE SUSTAINABLE INTEGRATED DEVELOPMENT OF THE VOLTA BASIN IN GHANA

Edited by

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Background by the Editors

Various benefits as well as problems were expected from the post-independence damming of the river Volta at Akosombo (1963) and at Kpong (1981), and the subsequent formation of two artificial lakes over vast stretches of land behind the dams in Ghana. The benefits include:

- massive outputs of hydroelectric power;
- enhanced fishing and water transportation upstream; and,
- improved opportunities for irrigated farming, especially in the lower reaches, and their attendant multiplier economic effects.

Among the problems are:

- flooding of settlements and agricultural land;
- destabilisation of the traditional land holding arrangements by state expropriation and the flooding;
- and environmental perturbations resulting in increased water-borne diseases;
- proliferation of aquatic weeds, and the diminished fishing prospects;
- and the attendant economic depression in the lower Volta basin which, predictably, has precipitated a storm of local protest and disaffection.

Research into the maximisation of the benefits and mitigation of the problems, forms the basic mission of the Volta Basin Research Project (VBRP), a multidisciplinary research organisation established by the University of Ghana in 1963.

Since its inception, the VBRP has undertaken a variety of research activities focused on: socio-economic conditions; aquatic plants; water quality; limnology and aquatic ecology; hydrobiology and fisheries; soils and land use; and public health in the basin.

Over 30 years have elapsed since the creation of the main Volta lake and the establishment of the VBRP, whilst about 15 years have elapsed since the formation of the Kpong Head pond. The present stage thus appears to be an appropriate point in time to collaboratively take stock, review the priorities and methodologies, identify information needs, and chart the future research course.

This book is based on the inputs and outputs of a seminar, organised by the Volta Basin Research Project in 1996. The seminar brought together a cross-section of the Ghanaian society - researchers and Volta basin stakeholders including policy makers, administrators and those directly affected by the lakes - for the purpose of debating a long-term research agenda for the sustainable integrated development of the basin. In this way, we expect to open new vistas for research, and to enhance the application of the findings of research to improve the living conditions of the rural communities in the basin as we approach the 21st century.

**C. Gordon
J.K. Amatekpor**

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for sponsoring this publication
and the meeting which led to it

Foreword

The Chairperson, Professor Florence Dolphyne, Pro-Vice Chancellor of the University of Ghana, who is representing the Vice-Chancellor, Professor George Bennneh, Mr. F. N. Andan Chief Director of the Ministry of Lands and Forestry, who is representing the Guest Speaker, Hon. Dr. Kwabena Adjei, Minister of Lands and Forestry, the Chief Executive of the Volta River Authority (VRA), Mr. E.A.K. Kalitsi, Chiefs and other community leaders and Assembly men and women, distinguished participants, it is with considerable pleasure and a deep sense of honour that I deliver this note of welcome on behalf of the Management Board of the Volta Basin Research Project, on the occasion of this seminar on the Sustainable Integrated Development of the Volta Basin.

The seminar is organised by the Volta Basin Research Project (VBRP) of the University of Ghana. Its basic objective is to bring together a cross-section of the Ghanaian society - researchers, administrators, people directly affected by the two artificial Volta lakes, as well as other Volta basin stakeholders and interests, for the purpose of debating a long-term research agenda for the development of the basin, in line with the mandate of the 33-years old VBRP.

The River Volta Basin constitutes a crucially important national asset of inestimable value. It makes up about 70 percent of mainland Ghana; is inhabited by a majority of the country's population; and boasts of other major human and natural resources, including the rich lakes behind the Akosombo and Kpong dams which were constructed to, among other things, generate hydroelectric power to sustain Ghana's growing domestic and industrial requirements. Moreover, as shall be elaborated upon later, although the Akosombo and Kpong dams and their attendant artificial lakes have created significant economic opportunities, they also have created monumental national and international environmental, health and socio-economic problems that warrant greater attention. It is for these reasons that we are happy and encouraged to have succeeded in attracting such a diversity of brains to this seminar to focus on the development of the rich yet poor Volta basin.

We are flattered, beyond belief, to have all of you here today. It is with extreme pleasure that I extend a special welcome to Mr. F.N. Andan, Chief Director and representative of the Guest Speaker, Hon Dr. Kwabena Adjei, the Minister of Lands and Forestry; to Mr. Kalitsi, the Chief Executive of the VRA, the principal supporter of this seminar; and, to our special guests from some of the communities most severely affected by the creation of the artificial lakes in the basin. You are all heartily welcome; but, please, make your voice heard on this historic occasion, so that one day history may say yes, yours was among the voices that, at Legon, on the day of our Lord, Wednesday, 20 March, 1996, registered a positive impact on the developmental charter of the Volta Basin.

Professor E. A. Gyasi,
Department of Geography and Resource Development
Chairman, Volta Basin Research Project

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A comment on the Volta Project. Prof. E. Laing

Emeritus Professor of Botany
University of Ghana, Legon

The pioneers

We must first pay homage to the founding parents and top managers of the Volta Basin Research Project, and the consortium of institutions that have worked on the Volta Basin, and the financial supporters:

President Kwame Nkrumah, for his foresight and responsiveness to the pleas of the advisors for creating a watchdog group that would monitor the changes in the Volta Basin from the pre-impoundment stage;

The Chief Executive of Volta River Authority, Dr. E.L. Quartey and his successors Casely-Hayford and Kalitsi; Vice Chancellor Alex Adum Kwapong, and his successors Bekoe, Sawyer, Benneh;

Directors of sister co-operating institution, Dr. Letitia Obeng, and her successors Dr. Martin A. Odei and Mr. Charles Biney; Directors of VRA Health services;

Successive Chairman of the Board of the VBRP, including: Professor Ewer, Professor Lawson, Professor Clerk; Successive Secretaries of the Board of the VBRP, especially Professor Oliver Davies, Dr. Edmund Thompson and Professor John Dadsen.

The stalwarts of the research teams: Dr. Eric. Kwei, Professor, Dr. Tom Petr, Dr. Biswas, Mrs. Biswas, Reverend Debrunner, Professor Oliver Davies, Mr. Pierce, Mr. John Hall,

Dr. Mosharaf Hossain, Dr. David John, Dr. Ebenezer Obeng-Asamoah, Dr. L.K.A. Derban, and Professor Gil Ashitey.

A host of dedicated field and laboratory assistants, and drivers; and many others whom I must have forgotten to mention individually by name.

I mention these pioneers for their dedication, their unparalleled willingness to work in a team, and their braving of difficult environmental and economic conditions.

The way forward

There is a need for closer integration; organising the work into highly focused research thrusts that are more interdisciplinary; in addition there is the need to emphasise benefits to the communities of the Basin as regards:

- their agriculture e.g. the *adode* (“oyster”) (*Egeria*) and prawn (*Macrobrachium*) fisheries;
- their health, stressing the relationship between water resources development and health: the persisting or increased nuisance of malaria, bilharzia, diarrhoeal diseases and multifarious skin ulcers - the so-called man-made diseases;
- the conservation of biodiversity: e.g. the takrowanua (*Talbotiella gentii*), the Hossana Palm (*Encephalartos barterii*), the West African manatee (*Trichechus senegalensis*), various insectivorous plants

and rheophytes (plants associated with streams and rivers)

Key issues to be considered

New national demands, i.e., the development of the Afram Plains.

Information management - modernize and disseminate aggressively the information collected, in usable form for the various communities - not just the scientific researchers, but also the farming and fishing communities and the policy makers.

New possibilities of relevant income generating activities: attraction of additional funds - via, e.g. consultancies offered to the NGOs operating in the Volta Basin, and similar habitats in and outside Ghana; incorporating the information, lessons, experiences into readable form - texts, publications, videos; discussions in the communication media of radio and television; organising national and international training courses and workshops to disseminate the findings and to share experiences.

Just as the seismologists have established their monitoring stations, with automatic recorders and transmitting systems to a co-ordinating node, and the meteorologists their weather stations, the VBRP, with their partners, should establish similar integrated automatic data collection systems; they should also organise amateur observers, possibly including school children as done by ornithologists and astronomers, to send in data from the wide area.

Convince policy makers and the communities in the Volta Basin and

the environs about the high relevance and practical importance and usefulness of the information you generate. Review the concepts and the models (Jacobson 1994) of definition of sustainability (Sawyer 1995 in TDR); economic accounting of the developmental impacts (Sawyer 1995 in TDR);

Coordinated and collaborative yet decentralised management of the river basin (PEEM River Management Papers - Candiwana et.al. 1994, Diop and Jobin 1994, Mather and others 1994); extend the thinking to various basins of West Africa.

Have we seriously set priorities for the immediate, mid-term and the long-term perspectives, in a co-ordinated fashion, especially in the light of the general call, both national and international, to economise on funds? We suggest we need some extended serious discussion, by way of follow-up, of the various issues that may be outlined in this one-day seminar, towards:

- generating policy, plan and action recommendations;
- institutionalising the internal and external review of both research and management;
- examining the possibilities of building additional field stations (additional to the laboratories in Akosombo and Legon);
- empowering the women and other marginalised groups of the area;
- identifying sources of additional funds.

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Statement by the Minister of Lands and Forestry Hon. Dr. Kwabena Adjei M.P.

Minister of Lands and Forestry,
Accra

Mr. Chairman, Honourable Members of Parliament, Distinguished Seminar Resource Persons, Ladies and Gentlemen, I feel greatly honoured to be the Guest of Honour for this Seminar on the Sustainable Integrated Development of the Volta Basin. This important event seeks to review the state of knowledge of the Volta Basin and to draw up a management oriented research agenda that will ensure the wise and sustainable use of the resources of the Volta Basin so as to support future generations of Ghanaians.

I am particularly glad to note that the organisers of this meeting are adopting both a retrospective and proactive approach, drawing on the experience and wisdom of several senior scientists who have contributed, in no small way, to the wise use of resources in the Volta Basin. Anticipation is the first key to the solution of problems, the second key is the timely engagement of the requisite multi-disciplinary expertise at the earliest possible stage of planning. I commend the organisers for their vision and hope that the outputs of this seminar will be so focused as to assist government to develop and implement policies that will eventually assist the communities of the Volta Basin to use, in a rational manner, the natural resources that surround them.

Mr. Chairman, it has become obvious from the present rate of population

growth that the future of Ghana depends on the wise use of land and its related resources. The Volta Basin within our country, covers a total area of 165,700 square kilometres, about two-thirds of Ghana, and as such can be considered to be our most important physiographical feature which holds the potential as the "bread Basket of the country". Our concern should be how to ensure proper land use and sustainable development of the basin. The Volta Lake itself, with an area of 8,500 square kilometres, is our most important inland water resource supplying electrical energy, food, transportation, recreation and tourism. Thus, the health and sustainability of the resources of the Volta Basin have profound effects on the entire population of Ghana. However, certain activities like bad farming practices along the banks have degraded the vegetation and accelerated erosion with the consequent siltation of the lake. There are also some fishing practices such as the use of explosives and chemicals that could totally destroy the aquatic life of the lake that must be curtailed. These activities if unchecked could lead to reduction in power generating capacity and the shortening of the life of both the Akosombo and the Kpong dams.

Mr. Chairman, solving these problems calls for a holistic and integrated approach with different government agencies providing the expertise and communities providing

the necessary co-operation for the overall management of the basin.

Mr. Chairman, the Government of Ghana has been investing considerably in the strengthening of management and administrative capacity as well as research with the assistance of international donors. Already positive signs of improved planning and better co-ordination exist within sector institutions. These capacity-building activities will be continued in conjunction with the following programmes:

- review of legislative instruments and administrative arrangements to ensure effective resource management and administration;
- development of adequate funding arrangements to ensure continuity of resource management services;
- initiation of inter-ministerial co-operation and maintenance of an inter-agency co-ordinating committee to co-ordinate plans and programmes and review how policy goals can be effectively accomplished, and in particular, to develop a long-term master plan to guide implementation of policies and strategies;
- co-operation with international agencies, research institutions, trade associations, private interest groups and non-governmental organisations concerned with sustainable development of re-

sources, in order to benefit from technological advances, technical assistance and action-oriented initiatives.

Mr. Chairman in 1994, the Ministry of Lands and Forestry adopted a New Forest and Wildlife Policy. Under this new policy, strategies have been developed to ensure environmental quality and perpetual flow of optimum benefits to all segments of the society. This policy draws its principles from both the constitution of Ghana and the Environmental Action Plan. Some of these strategies include:

- Institutional strengthening
- Public education and community participation
- Incentives and technical assistance.

The Ministry is also drafting a land policy that will provide a basis for effective land use.

Mr. Chairman, the information exchange and brainstorming that will take place at this Seminar, should promote a greater understanding of the problems posed by the complexities of the Volta Basin and generate even greater interest in the basin as a life-sustaining resource.

The Role of Volta River Authority in the Development of the Volta Basin E.A.K. Kalitsi

Chief Executive
Volta River Authority
Accra

Abstract

The Volta River Authority was set up as a corporate body by the Volta River Development Act (Act 46) of 1961, which mandated the Authority to plan, execute and manage the Volta River Development. The primary functions of Volta River Authority includes: the generation of electric power for the country's industrialisation, provision of facilities and assistance for the development of the Lake as a source of fish and as a route for the transportation of goods and passengers, and the development of the lake side areas for the health and well-being of the inhabitants living in the lake area. The paper therefore seeks to examine how far the Volta River Authority has tackled these various functions. Not only will the paper address the dams which have already been built on the Volta river, but it will summarise the various studies which have been carried out on the different tributaries of the lake to assess the hydro electric potential of the whole basin and the priority in its development. The paper will then also indicate the various research works which have been done in the areas of fisheries, transportation, health, irrigated agriculture, tourism, and environmental issues. In each case, the paper will show what development projects have already been undertaken by the Authority and what steps the Authority is taking to ensure further development in these areas. Finally, future development plans both on the lake and in the lower Volta area will be highlighted.

Introduction

Planning to develop the hydro-electric potential of the Volta River started as far back as 1916 when Sir Albert Kitson, an Australian geologist, discovered large deposits of bauxite near Kibi, in the Eastern Region of the Ghana. The Volta Basin which has total drainage area of about 400,000 km², with 60% of this area outside Ghana, was considered to have the potential of providing cheap electric power needed to make it worthwhile for Ghana to extract the large bauxite deposits and set up an aluminium industry to process the bauxite.

In 1950's, the Government of that time appointed a Preparatory Commission to assess the feasibility of the proposed Volta River development. The initial report prepared by Sir William Halcrow and Partners of UK in 1956 recommended constructing a dam at the Volta gorge near Adjena. The Halcrow proposals were revised by Kaiser Engineers of the United States of America which shifted the hydro site to Akosombo and proposed use of the electricity generated to smelt imported alumina into aluminium ingots. Development of the bauxite resources for local alumina production was postponed to be un-

dertaken at a later phase. Their report presented in 1959 was accepted by Government and in 1961, an Act of parliament was passed establishing the Volta River Authority (VRA) charged with the responsibility of constructing the dam at Akosombo to generate electric power to serve as a basis for the country's industrialisation and of developing the Volta Basin.

The Volta Lake formed by the Akosombo dam completed by the Authority in 1965 became a source for the development of other non-power potentials like, fisheries, water transportation, water supply, irrigation and tourism. To realise the full benefits of the Volta Basin, VRA has consistently commissioned projects to study both the power and non-power potentials. The results obtained are to demonstrate to both government agencies and private investors the enormous potentials in these sectors for future development.

Specific Functions of the VRA

The Volta River Development Act (Act 46 of 1961) which established VRA specifically enjoins the VRA to plan, execute, and manage the Volta River development. The primary functions include the generation of electric power for industrialisation, provision of facilities and assistance for the development of Lake Fisheries, Lake Transportation, and Lake Side health.

Development of Hydro Power - Akosombo/Kpong Development

The Volta River Authority started the construction of the Akosombo dam on the Volta River in 1961 and

commissioned the initial power plant in 1966. The Akosombo dam is rock-fill type with a thin clay core in the middle. The construction of the Akosombo dam led to the creation of the Volta Lake which is known to be one of the largest man-made lakes in the world (in terms of surface area) with an area of 8,500km². It has a shoreline of about 4,800km and a storage capacity of 152 billion m³ at full supply level. The dam thus created a water head of 64.6 metres (212ft) at Akosombo, which is being used to provide electrical energy.

In 1982, in order to meet the growing demand of the country for electric power, the Authority commissioned a second dam at Kpong about 25km downstream of Akosombo. The Kpong scheme is essentially a run-of-the-river type and thus utilises the discharge from the upstream plant at Akosombo for power generation.

The Akosombo hydroplant (912MW) together with the Kpong hydroplant (160MW) provide a firm energy generation capability estimated at 4,800 GWh/year with a corresponding long-term average of 6,000 GWh/year. The combined existing hydro system currently supplies over 95% of Ghana's electricity needs including that of Valco's 200,000 ton aluminium smelter. The Authority also supplies neighbouring countries of Togo and Benin and until recently supplied Côte d'Ivoire as well.

The demand for power in Ghana has now outstripped the capability of the Akosombo/Kpong hydro system. There are, however, potentials for further development of the hydro resources in the Volta Basin. Studies

conducted by VRA indicate that the estimated potential of unexploited hydropower resources on three major tributaries in the Volta basin is of the order of 905 MW with a corresponding average annual energy generation potential exceeding 3,097GWh. These tributaries are the Black Volta, the White Volta, and the Oti. There are in addition, other sites for hydro development on the Pra and Ankrobra Rivers in the Western Region. Below are summary details of hydro sites on the main tributaries of the Volta.

Black Volta

The Black Volta drains a land area of about 146,820km² and contributes about 18% of the annual flows to the Volta Lake. Studies commissioned by VRA indicate a total potential of about 682MW at five (5) sites at Koulbi (68MW), Ntereso (64MW), Lanka (95MW), Bui (460MW) and Jambito (55MW) with an average energy generation potential of about 2,148 GWh. The most attractive of these sites is the Bui site where a potential of 400 MW has been planned for with an average energy generation capability of 1,000 GWh/year based on updated studies recently completed by Coyne et Ballier of France (C&B).

White Volta

The White Volta river basin covers an area of 105,540km² and contributes about 20% of the annual flows of the Volta River system. VRA Commissioned Nippon Koei of Japan in 1967, and recently Coyne et Ballier of France (C&B) in 1993 to study the hydro potentials of the

White Volta. The total potential of identified in this basin is about 133 MW and is made up of Pwalugu (50MW), Saboya (40MW) and Kulpaw (40 MW). The total potential annual energy generation is estimated at about 544 GWh.

Oti Tributary

The Oti river basin drains an area of 71,940km² and contributes about 25% of the annual flows in the Volta River system. The only potential hydropower site is located at Juale with a full scale potential of 300MW and a corresponding average annual energy generation capability of 405 GWh. Studies have however confirmed that in order to reduce environmental impacts, the recommended development potential will be reduced to only 90MW.

Challenges of Multi-purpose Management

The development of the additional hydro sites within the Volta basin however poses some challenges. The sites are located on tributaries of the Volta River. Their development will therefore have some negative effects on power generation from the existing Volta Lake. The designs so far under consideration are for storage schemes, which reduce flows into the Volta Lake due to evaporation from the reservoirs, created. This is particularly characteristic of the sites on the White Volta, which lie in areas of high evaporation and have modest potential heads. This drawback does not allow for the full-scale development of the potential identified at the sites.

Having allowed for this impact, however, the net addition to the Volta System's generating capabilities from these tributary sources is still substantial.

Secondly, the reservoir management for power operations directly impacts on other uses of the water body, such as transportation and irrigation. VRA tries to manage the reservoir so as not to adversely affect these other uses too seriously. It has been established that the level of the Volta Lake should not fall below the 74.63m (245ft.) mark if the waterway is to be navigable by commercial barges/vessels to the northern-most port of Buipe. Presently, however, VRA is constructing a 300MW Combined Cycle Thermal Plant to complement the hydro system. This will lead to a more aggressive run down of the reservoir for cheaper hydro-electric production and this minimal level will be exceeded in future.

Thirdly, to achieve a better management of the Volta Reservoir for other multiple uses, such as agriculture and forestry, there is the need to maintain fixed minimum lake levels. But the inflows into Volta Lake are characterised by high variability, which makes the maintenance of steady lake levels almost impossible.

Formally, the Bui project which VRA considers the most attractive, faces a number of challenges, one of which is its location in a national natural reserve. The mitigation of the environmental impacts of the Bui site involving resettlement of about 2,000 persons, fauna and flora represents a major challenge to its development and would require a carefully

planned environmental impact assessment and compensatory strategies.

Despite the challenges mentioned above, VRA still considers hydro-power as the cheapest source of energy and therefore the Authority is determined to continuously assess all the hydro resource potentials. The development of the most economically feasible site will be pursued as determined by the growth in the economy of the country and in demand for electrical energy. Proper consideration will at all times be given to all environmental issues including population, fauna and flora in these developments.

Development of Lake Fisheries

Formation of the Volta Lake brought about an enormous increase in the fish population. Immediately after inundation the fish catch estimated was about 60,000 tons per annum. Current estimates put the Volta Lake fish production at about 40,000 tons a year. This would form at least 10% of the national fish supply. The number of people employed in the industry is over 100,000. This number is made up of fishermen, fish processors, and fish traders. Thus, lake fishery has already become an important industry for the country.

To study the environmental impact of the lake and its potentials for development, as early as 1968 a multi-disciplinary project known as the Volta Lake Research and Development Project (VLR&DP) was jointly set up by the Government of Ghana and the United Nations Development Programme (UNDP). VRA was the

implementing and co-ordinating agency. Several agencies of Government and scientific institutions participated. Among these were the Fishery Department, Institute of Aquatic Biology of CSIR and the Volta Basin Research Project of the University of Ghana. Its aim was to study the impact of the reservoir, develop measures to control the negative effects and to exploit the positive potentials including development. Several scientific research studies were undertaken from which the size, variety, and characteristics of the fish and their environments were determined. Complementary, socio-economic studies were also carried out. The results of these studies were used to develop and introduce more efficient methods of fishing, stable fishing crafts, improved methods of processing and preservation of fish. Mono-filament nets capable of catching more fish than the traditional multi-filament nets were introduced to fishermen. New prototype canoes using outboard motors were designed and are now in use on the lake. Processing methods, which can keep, smoked fish on the shelf for at least 30 days were devised and introduced to fishermen. A stable transport boat with inboard engine capable of carrying both fish products and agricultural commodities was also designed and built by the Volta Lake Research and Development Project and prototypes were tested.

These studies also provided information, which was used to prepare a master plan for the development of the Lake fishery. The master plan provided for a number of fishery complexes to be built on the Lake. The first of these fishery complexes

was constructed at Kpando Torkor in 1975, as a pilot scheme. It established facilities for fish landing, marketing, boat building, fish processing and manpower training for various skills used in the fishing industry. Fishermen were expected to adopt the new techniques in inland fisheries developed by VLR&DP. The complex also served as a point from where fishermen purchased all the inputs necessary for the fishing industry.

By 1983, the impact of this pilot project had spread in the fishing community. Accordingly the VRA handed over the management of the Lake Fisheries to the Fisheries Department of the Ministry of Food and Agriculture. The expectation was that similar complexes would be developed. It was, however, not until 1993 that a follow up complex, the Yeji Complex, was developed in collaboration with the Fishery Department with assistance of UNDP. This scheme incorporated a component to develop wood-lots for fish processing. VRA is financing the cost of the afforestation component.

Development of Lake Transport

The Volta River has always been used as a waterway. As part of the Volta River development, the VRA also studied the water transport potential of the lake. Plans were developed for large-scale commercial transportation on the lake to link the commercial and industrial south with northern Ghana. To implement this a North-south route was chartered and buoyed for easy transportation of goods and passengers from the southern port of Akosombo to the

northern port of Buipe. In 1973, the VRA in an effort to ensure safety on the lake issued a Legislative Instrument (LI 862) to regulate and control the crafts, operators, protective devices and mode of transportation on the Lake.

From 1980, the VRA took steps to improve the port facilities of Akosombo and Buipe and develop additional ports at Kete-Krachi, Yeji and Makango to facilitate the North-South water transportation. Under this improvement programme, some old vessels were rehabilitated and new ones constructed. The functions of the ports of Akosombo and Buipe have been further enhanced by the construction of fuel Farms at these ports.

Volta Lake Transport Company (VLTC)

The authority set up a subsidiary, the Volta Lake Transport Company (VLTC), in 1970. This Company was charged to operate as a public carrier on the Lake and to operate other forms of complementary transport as may be necessary for its business. Through this company the authority sought to pioneer the development of a modern first class commercial water-borne transport of goods and passengers on the Lake. It was to set standards for private entrepreneurs to be licensed to invest in commercial transport on the Lake.

The VLTC currently has 13 river crafts with a carrying capacity of more than 4,000 tons. The vessels include dry and wet cargo barges, which transport industrial and construction materials as well as petro-

leum products from the more industrialised southern sector of Ghana to the northern sector. The company also provides cross ferry services at four landing points namely Adawso, Dambai, Kete-Krachi and Yeji to link the shoreline communities to road networks to enable them undertake their socio-economic activities.

Maritime Services

In addition to the operations of the VLTC, there are about 250 privately owned transport boats operating on the Lake. These complement the operations of VLTC but have not yet been specifically licensed to operate as franchised carriers. This is the next stage envisaged in this development to impose on them appropriate safety standards. The routes of these boats, are uncharted, the boat operators therefore sail among tree stumps which expose them to hazards during storms. To minimise the risk of accidents on the Lake, the VRA has started removing tree stumps at fairways to marketing centres around the Volta Lake.

In the area of ensuring safety among the small transport boats which operate on the Lake, the VRA will seek a more co-operative liaison with the various District Assemblies to ensure effective enforcement of the control and regulatory measures covering licensing, policing and safety as spelt out in the Lake Traffic Regulations, Legislative Instrument 862 of 1973.

Health Issues

The two main health hazards influenced by the construction of the Akosombo dam and the creation of

the Volta Lake were primarily Onchocerciasis and Schistosomiasis, albeit with completely different consequences. While the first was virtually eradicated from the area, unfortunately the second was enhanced to spread because bilharzia flourishes in still waters.

Onchocerciasis (River blindness)

Before the formation of the Volta Lake, Onchocerciasis was prevalent in the valleys of the Volta River. The fast flowing river provided the perfect habitat for the Simulium flies whose larvae prevailed on fast flowing sections of rivers. With the formation of the Volta Lake, the Simulium fly was completely eliminated from the Lake area. The fly moved to the rapids south of Akosombo especially in the areas around Kpong. However, the construction of the Kpong dam and the inundation of Kpong rapids further eliminated the fly from the Kpong area. Thus the construction of two dams have eliminated the Simulium fly in the Volta Basin.

Schistosomiasis (Bilharzia)

On the other hand, the formation of the Volta Lake has enhanced the spread of Schistosomiasis (bilharzia). There are two relevant snail vectors on the Volta Lake in connection with bilharzia - one is the urinary type and the other is the intestinal type. The lacustrine conditions have proved a haven for these vectors and prevalence rates of bilharzia among the lakeside population has risen steadily at specific spots of heavy population concentration to such an extent that in some of these settlements, the

prevalence rates among children are between 80 and 90 per cent. On the whole the prevalent type of Schistosomiasis is the urinary type.

Until 1980 intestinal bilharzia was unknown on the Lake but since then, there have been reports of this type from at least one tributary (Dayi) of the main Lake, and also from the Lower Volta areas, where both types prevail.

Control of Schistosomiasis

The simplest control method is avoidance of, or reduction in, water contact, and desisting from defecating and urinating into the water body. However, this involves changes in human behaviour which make the control more complex. The VRA is aware that bilharzia is a debilitating disease which makes the people living in the affected areas less productive. Its control or eradication therefore augurs well for increased productivity in these areas. VRA has therefore taken upon itself to search for measures to control this disease as much as possible. Unfortunately no serious effective methods of eradication are presently known anywhere in the world.

The method adopted by Volta River Authority to control the disease is an integrated approach, which includes:

- Chemotherapy which seeks to reduce the worm and egg load in the infected individual by the use of Praziquantel tablets (biltricide).
- Control of weeds and snail vector by manual and me-

chanical clearing. Molluscicides have been avoided due to its adverse effect on the ecology.

- Health education to reduce water contact and change general sanitary habits of the riparian communities.
- Environmental Sanitation where sanitary facilities like urinals and latrines have been provided.
- Provision of a medical boat on the Volta Lake which is used to provide therapy and general medical care to the communities, which are accessible, only by boat.

Irrigation

One of the major benefits expected from the Volta Lake was irrigation of the Accra Plains and the shore-line of the Lake. To this end the authority's Consultants (Kaiser *et al.*) identified the possibility of irrigating 200,000 hectares in the Accra Plains to produce food and fibre for the metropolitan areas of Accra/Tema and for export. Between the Food and Agriculture Organisation (FAO) and the University of Ghana, several studies have been undertaken over a three-decade period. It is only now that the Irrigation Development Authority is making some efforts to exploit this potential. The Authority's role here has been simply to assist the identification process but not to undertake the implementation as such.

The Volta Lake Research and Development Project carried out several

studies into Lakeside farming. The findings of such studies were used to develop pilot projects and demonstration farms to take optimum advantage of the residual moisture in the soil when the lake recedes between the months of November and May. This type of farming, referred to as drawdown farming, was encouraged on the Afram arm of the lake for short maturing crops such as tomatoes, okro, sweet potatoes, garden eggs, etc. Later, drawdown farming was complemented by sprinkler irrigation when it was realised that in the course of the growth of these crops residual soil moisture content often fell below optimum levels. VLR&DP successfully carried out drawdown demonstration farming complemented with sprinkler irrigation water from the Lake by use of small pumps at VRA's resettlement township of Ampem. The people living in the whole of the Afram arm of the Volta Lake have now adopted this method of farming. The Afram area has thus become important for the production of tomatoes and other short maturing crops during the dry months from November to about May.

A more focused effort at large scale irrigation was undertaken on the completion of the Kpong dam when VRA established the Kpong Farms Limited as a subsidiary company to promote leadership in agricultural systems, irrigation practices and food processing technologies. The objective of the authority was mainly to prove that this venture is economically viable and can be adopted to cover the Accra Plains. The project which is located downstream from the Akosombo dam utilising water

from the Kpong headpond was initiated with the construction of a mainly gravity irrigated scheme covering an area of approximately 100 hectares for the production of rice, beans, etc. The project has now developed into a fully vertically integrated agro-industry spanning rice, livestock and pasture production as well as feed milling, abattoir services and meat processing.

It is the hope of VRA that the positive demonstrations at the drawdown areas and the Kpong Farms Limited will encourage private entrepreneurs to move into irrigation farming in the Volta Basin especially in the Accra Plains and the Afram Plains. The Authority is happy that the Government has taken the initial step to irrigate the Asutuare lands for farmers using waters from the Kpong headpond.

Tourism

A lake of the size of the Volta reservoir provides tremendous opportunities for the development of tourism. The approach taken by Volta River Authority is to demonstrate the viability of tourist-related ventures to attract private capital for the full development of the facilities available on the lake and on its islands. To this end, Volta River authority has established another subsidiary company, the Akosombo Hotels Limited, which operates the Volta Hotel at Akosombo and also runs a regular weekend lake cruise to the Dodi Island which is 26 kilometres from Akosombo. The high patronage achieved during the five years of the operation of this cruise vessel has justified the feasibility of investment

in this type of venture. In the long term, Volta River Authority's objective is to see the islands developed into tourist resorts and the lake for water sports in an environmentally friendly manner. Private investors are showing a lot of interest in the development of various forms of infrastructure on the islands within the framework defined by Volta River Authority. These include:

- The construction of chalets for sale or rental on the Dodi Island, on other islands and attractive spots on the lake shores.
- The development of wildlife trails and hiking for nature lovers on Dwarf Island and Digya Game Reserve, and
- The development of the water front and beaches for all forms of water sporting activities such as water skiing, canoeing, fishing and regattas.

Other Environmental Issues

The Authority has noticed that over 30 years since the lake was formed, the activities of people living in uncontrolled human settlements are causing serious deforestation around the lake which is resulting in intensive erosion leading to siltation and sedimentation which will adversely affect the life span of the Lake. VRA is therefore taking serious measures to avoid eventual silting of the Lake. The Authority in collaboration with the Forestry Department and other related departments has embarked on afforestation programmes in the steep

and the low areas around the lake. However, it is necessary that the total extent of the environmental problem involving deforestation, erosion, siltation and sedimentation and any other related problem be fully identified.

Enhancement of Environmental Data Collection

VRA therefore intends to update and enhance its environmental data collection by using Satellite Remote Imagery/Aerial photography to define the extent of the environmental problems around the Lake and the lower Volta area and depict these problems in the form of maps and charts. The information obtained will indicate the intensity and extent of degradation both in the high and low slope areas around the Lake. This will help the Authority to identify in order of priority mitigative measures, like afforestation, that should be undertaken. It is hoped that these maps will also assist VRA to develop a master plan for Akosombo Township especially for development of industry and tourism. The use of Satellite Imagery and Aerial Photography is also expected to lead to the setting up of a Geographic Information System (G.I.S.) to monitor all features and activities in and around the Lake for the better management of the Lake environment.

Afforestation

Meanwhile, the Authority is sponsoring two afforestation projects intended to arrest erosion. In the Adjena Gorge, VRA is in collaboration with the Forestry Department to declare the steep areas bordering the

lake as protected lands. Farmers in these areas will be encouraged to adopt prescribed farming practices, which will provide tree cover as well as a source of livelihood to the farmers. To ensure the stability of the slopes bordering the Lake, only fruit trees like mangoes, cashew, etc. and agro-forestry practices will be encouraged. This project is on pilot basis and will be extended to other steep areas around the Lake after the full extent of the problem has been identified.

VRA is funding another pilot afforestation project in the low slope areas around Yeji in the Brong Ahafo region. The objective of this project is to encourage fisherfolk to plant wood lots and adopt the use of improved stoves, which use less fuel wood for fish smoking. It is hoped that this project will help restore some 1,422 acres of tree cover and reduce the dependency of fuel wood by 60% in the Yeji area. Fishermen and fishmongers would adopt wood lot farming and to control harvesting for the smoking of their fish. Wood lot farming will further encourage the production of charcoal on sustainable basis in the Volta Basin. This pilot project will also be extended to other similarly affected areas after the aforementioned data collection project.

Dredging of Sandbar at Estuary

One of the important effects of the construction of the dam was to stop the annual floods, which had been regular in the past in the areas below the dams. The seasonal floods in the past had played an important part in clearing the estuary of sandbars,

which might have started during the dry season. Due to the absence of the annual floods, sandbars gradually formed at the estuary and in time virtually blocked it. The effect of this was that saline water which during high tide flowed upstream into the river channel, at times up to 30 kilometres, completely ceased. With the absence of salt water flowing into the river channel, soon the areas even closer to the estuary started to experience the presence of the schistosome snail and bilharzia became prevalent. The result was that tourism, which flourished in the estuary area, was virtually killed. To restore salinity into the river channel and thus revive the tourist industry, the Volta River Authority procured, at considerable cost, a dredger permanently stationed at the estuary to cut a channel through the sandbar. This has allowed free flow of saline water into the channel up to about 20 kilometres upstream and as a result bilharzia has now been wiped out from these areas, and the tourist industry has been revitalised.

Lower Volta Fisheries

Again the flood control by the dam adversely affected the ponds and creeks found in the Lower Volta, which before the construction of the dam were fertile grounds for the breeding of fish after each flood. This lucrative fishing activity has now completely died out. In the same area, the interplay of fresh and saline water in the main channel provided a fertile ground for the production of clams. This in the past was a rich source of economic activity especially for women of the area. The dam has adversely affected this in-

dustry and clam fisheries has virtually died out.

In order to correct these problems and others in the Lower Volta area, VRA has recently commissioned the Volta Basin Research Project (VBRP) of the University of Ghana to study the socio-economic effects of the construction of the dams on the Lower Volta area. The study would also identify projects, which the people in the area can be encouraged to undertake to promote their well-being. It is the hope of the Volta River Authority that these studies will help design programmes, which can be implemented to reactivate economic activities in the Lower Volta area.

Conclusion

The most dramatic effect of the Volta River Project is the permanent flooding of 8,500km² of land right in the middle of the country. Some 80,000 people in 700 communities had to be moved causing permanent changes in their way of life. Animals big and small, birds, insects, trees and shrubs, soil and air have all been affected. It should, however, be noted that changes in the natural and socio-economic environment are inevitable in any development. Our approach in VRA has been to carry out comprehensive studies of these impacts, both positive and negative. As part of the Volta River development, the Authority has instituted various measures to restore what can be restored, enhance positive elements and mitigate undesirable effects.

For the human population and the communities affected, VRA's phi-

losophy has been to ensure that those who sacrificed to create these national assets, the dams and the Lake, are compensated in cash or kind, or in the creation of a better environment, so that no one is worse off as a result of our intervention in the Volta River development. I hope that the papers that will be presented in this seminar will help us in our continuous re-assessment of what role the

Volta River Authority should play in the development of the Volta River Basin. The main key in this quest is the guarantee of integrity in research work which we expect to get from scientists and scholars collaborating with us and the use of the results of their studies to prepare and implement imaginative programmes for the benefit of all.

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Public Health Aspects of the Volta Lake Dr. L.K.A. Derban

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Abstract

The paper gives an account of the Public Health situation in the Volta basin before and after the construction of the Akosombo dam. It highlights the health problems of the resettled people due to the rushed resettlement programme and also the effect of poor environmental sanitation on the health of the settlers. While the reduced incidence of Onchocerciasis was recognised as a benefit to health by the construction of the dam, the paper stresses the very serious and unsolved health problems needing urgent attention namely:

- 1. Increasing prevalence of urinary Schistosomiasis in the whole Volta Basin;*
- 2. Poor sanitation in the resettlement villages;*
- 3. Intestinal Schistosomiasis in the lower Volta riparian communities and;*
- 4. Onchocerciasis in Asukwakwaw area.*

The establishment of a statutory authority to ensure an integrated development programme has been suggested, which should include a comprehensive lakeside health programme. Water development projects whether for generating hydro-electric power, for irrigation, or for water supply are important in socio-economic development. However, such projects often do have impact on the health and well-being of the people including the well-being of the ecosystem on which the people's survival depends. As pointed out by PRINCE RUDOLF "The most valuable capital of the state and of the society is MAN, and to protect him is not merely the dictate of humanitarian sentiment but a duty imposed by self-interest on every community.

Introduction to the Volta River Project (1961-1964)

The Ghana Hydropower project has been described as the biggest and most ambitious single project ever implemented since Ghana's independence in 1957. The project was conceived as a symbol for sound as well as economic progress in the newly independent country. It was intended as a multi-purpose project and in addition to the generation of power for industrial as well as urban and rural households, it was to pro-

vide opportunities for wide scale irrigation, modernisation of agriculture, promotion of factory, industry and establishment of tourist facilities. The Preparatory Commission (1952-1956) under Commander R.G.A. JACKSON took into account the economic, financial, technical feasibility of the project and its socio-cultural and public health implication covering the areas behind the proposed dam, the on-site dam area and the area below the dam. It recommended a comprehensive environmental and feasibility study to ensure

an integrated programme for the best interest of the people, the environment and the totality of the economy.

The report has been described as one of the most extensive preliminary investigations for such a project and it was the hope of many that the long-term investment project would be carried out for the well-being of the present generation of people in Ghana and generation as yet unborn.

It appears that the need at that time for the country to have a cheap source of electricity did have overriding priority over and above any other consideration.

The Volta River Authority was established in 1961 and was assigned the responsibility of seeing to the construction of the dam at Akosombo and eventual generation of power and to plan, organise and implement by itself a resettlement programme.

The building of the dam (1961-64) on the Volta River and the consequent formation of the new Volta Lake with surface area of about 3275 square miles (8500 km²) 3.6% of the surface of Ghana and a shoreline exceeding 3000 miles (4800 km) did change the existing physical, biological socio-economic environment of the people above and below the Akosombo dam and the pattern of disease and created conditions in which explosive outbreaks of bilharzia (urinary-Schistosomiasis) were found to be very high. The human problems of resettlement were one of the earliest and by far the most serious impact of the Volta River project, which the Authority had to face.

Health Impact of the Volta River Project

The Development of the Volta River Basin began in 1961 with the start of the construction of the Akosombo Dam. The problems encountered in the Volta Basin, particularly in human health, resettlement and the environment were enormous. Several reasons have been given for this state of affairs including inadequate time schedule for planning and implementation and administrative capacity, insufficient political will and finance, absence of prior commitment and meaningful local involvement.

But from the scientific point of view, the most important contributory factors were:

- The failure to implement fully the recommendation of the preparatory commission;
- Failure to recognise the importance of multi-disciplinary teams in the development process not merely of writing reports but also implementing an integrated programme thus avoiding splitting the programme into two camps, engineering and social.

It was quite evident that the non-engineering aspects of the project did not receive the necessary full attention.

Prevailing Diseases before Dam Construction

David Scott in his account on the epidemic diseases in Ghana (1901-60) relied on the available sources of information which included published annual reports of the medical and sanitary departments and later Ministry of Health Annual Reports, personal experience of the small medical staff unevenly distributed in the country and the medical field units (mobile and fixed clinics). He considered those early reports very useful though they had severe limitations.

Among the many medical problems found in the area to be inundated, as in all rural Ghana, were the usual worm infections, particularly, round worms, hookworms, yaws, leprosy, tuberculosis, malaria, cerebrospinal meningitis, smallpox and malnutrition and poliomyelitis in children.

Endemic water-related infections which sometimes occurred in epidemic proportion were yellow fever, Trypanosomiasis (African sleeping sickness), Urinary Schistosomiasis (Bilharzia) and Onchocerciasis (River Blindness).

Post Construction Period

When the construction work on the dam at Akosombo started in 1961, the initial survey on the health of the population as recommended by the report of the Preparatory Commission (1956) had not been done

In 1968, the public health aspect of the Volta River project was assigned to the UNDP assisted Volta River Research and Development Project of the Volta River Authority. It was to research into the public health

situation and resettlement of the people displaced by the Volta Lake.

Attention was also paid particularly to the water-borne diseases associated with the lake and the means of their control. These were Onchocerciasis, Schistosomiasis, Trypanosomiasis and Malaria.

The immediate objective was the control of the major parasitic diseases as an essential step for the development of the economic potential.

Between 1968-77 (corresponding to the phase 1 to phase 3 of the project) much valuable health data were collected. These have made possible a realistic appraisal of the trend of the diseases in the resettlement villages particularly Schistosomiasis.

The major research findings have been embodied in the Volta Lake Research reports (U.N.D.P., FAO 1980) which form the basis of this chapter.

It reviews the effect of the Volta Lake on the major communicable diseases, which could be influenced by the creation of the Lake:

Health Problems of Resettlement

The Health problems of resettlement were by far the most serious impact of the Volta River Project. About 80,000 people had to be settled in 52 resettlement sites scattered around the Lake. They came from 4 regions of the country and had lived in the river basin for many years.

A total of 739 villages were destroyed, about 5000 households were disrupted and had to be moved with their belongings, they were mostly farmers.

VRA was responsible for the resettlement programme. The challenge was to provide dwelling house, work and recreation for the settlers, offer them opportunity for productive work, improve the physical appearance of the surrounding landscape and most importantly help the settlers to develop community spirit.

The resettlement programme did create socio-economic problems, which did affect the physical and mental health, safety and well-being of the settlers.

The psychological trauma caused by the sudden removal of the settlers gave way to depression in some people. They therefore needed a lot of encouragement and support to raise their economic status in order to boost their moral.

Environmental Sanitation and Health

The changing of familiar houses and environment to a new featureless, bleak resettlement village with core houses and limited room space caused overcrowding and discomfort and created conditions for the spread of communicable diseases such as yaws, measles and smallpox.

Lack of adequate farm lands and community life led to economic hardship and starvation and malnutrition in the children.

Ignorance, apathy and local customs and habits led to marked indifference to public health problems in the resettlements. The communal latrines provided (the aqua-privy variety) soon ceased to function due to lack of proper use and maintenance. Frequent breakdowns of the sewage collection and refuse disposal systems led to indiscriminate dumping of refuse and defecation. The pipe-borne water systems operated by diesel pumps soon failed. The pumps broke down. There were no funds for fuel and repair.

The public water standpipes were also soon in need of repairs due to misuse and lack of proper maintenance.

The rapid deterioration and breakdown of the sanitation facilities particularly the communal latrines and the pipe-borne water and refuse disposal systems led to environmental pollution of human and domestic wastes.

This general low standard of living is usually associated with the parasitic diseases such as malaria, dysentery, typhoid fever, hookworm and other intestinal worm diseases found in the resettlements.

Yellow fever and dengue were the most important of the arthropod-borne viral infections found during the early part of the resettlement programme and received serious attention due to the high fatality rates associated with these diseases. The diseases are transmitted from man to man by the bite of the mosquito (*Aedes aegypti*) which breeds in small collections of water in tins, earthen

jars, drums, coconut shells and discarded tyres. The breeding and the distribution of this mosquito were encouraged during the early part of the resettlement programme. This was due to the breakdown of the refuse collecting system and water supply pumps in the resettlement villages and the consequent storing of water in jars or drums providing breeding sites for the mosquito.

Water-Related Diseases in the Basin

Urinary Schistosomiasis (Bilharzia)

Bilharzia is a chronic snail-borne infection, which might be expected in water development schemes in tropical countries. The disease has been endemic in Ghana long before the creation of the Volta Lake but the endemicity was low along the Volta River. The prevalence in school children was 5% by an epidemiological survey made in 1960-61 before the Lake was formed.

The creating of the lake and the consequent biological explosion of aquatic weeds associated with the aquatic snail "the intermediate host" together with the mass migration into the area of fishing communities from areas where the disease was endemic led to a great increase in the prevalence of the disease in many localities around the lake.

Transmission occurs in the lake itself. Exposure to infection is high especially for fishermen who dive to set fish traps as well as for people particularly children who draw water from the lake or bathe in it. Surveys in 1964-77 after the construction of the Dam showed a 90% prevalence rate in school children with a ratio of

two boys to one girl. It has so far proved difficult to control the snail intermediate hosts by eliminating the aquatic weeds. The problem of bilharzia in the lake basin must be seen as a disease, which embraces both the lake and the Volta delta.

The migratory habits of the fishermen ensure the spread of the disease from endemic areas to other areas. Surveys of some localities have shown an increase prevalence, which points rather to a deteriorating situation, with the disease increasing in the areas where infection rates were previously found to be low.

The present situation of the disease in the Volta Lake cannot be viewed with optimism. It is realised that the prevention of the transmission of the disease requires long term active education campaign aimed at mobilising the people to participate in the control programme on a self-help basis and also surveillance and treatment of bilharzia patients. This should be combined with effective sanitary measures including an efficient disposal system for human excreta, a safe water supply and adequate bathing and washing facilities and the institution of a regular snail and weed control programme particularly at the boat landing stations on the lake.

There is evidence that the transmission of the disease has not stopped and the prevalence has increased in many lakeside villages. The fishermen are not using boat-landing sites. The receding shores in times of drought make them useless. Fishermen and children still have frequent water contact to fish and to swim.

Some people are still reluctant to present themselves for examinations and treatment in spite of intensive health education. To reach the villagers, the medical control teams have had to camp in the villages and work till nightfall for a number of days on several occasions. The lesson is once again learnt that human behaviour should never be taken for granted in any communicable disease control programme.

Onchocerciasis (River Blindness)

The disease is characterised by depigmentation of the skin, nodules and eye lesions that may lead to blindness. It is transmitted from man to man by the bite of the blackfly (*Simulium damnosium*) which breeds in rapidly flowing streams and rivers.

The disease and the blackfly were previously widespread along the Volta River. When the lake was formed in 1961, many of the major breeding sites north of the Akosombo dam were progressively inundated for some 250 miles, thus eliminating the blackfly in the Volta Basin.

The rapids of Senchi and Kpong some 20km south of the Akosombo dam continued to breed *Simulium* on a prolific scale until the construction of the second dam at Kpong completely eliminating the breeding site and therefore stopped the transmission of the disease in the vicinity.

However, in the Asukwakwaw area, north of the Akosombo dam, the incidence of Onchocerciasis is still high because the tributaries of the Volta Lake and the seasonal streams continue to support the breeding of the blackfly. Without an effective

local *Simulium* control programme, the Asukwakwaw area, being an important cocoa producing area, a busy market centre and a ferry point will continue to be a potential source of infection for farmers, market women and travellers who frequent the area.

The comprehensive and imaginative 20-year Onchocerciasis Eradication Programme in the entire Volta Basin area in West Africa started in March 1974. The programme was a combined effort of the seven West African countries - Ghana, Togo, Niger, Burkina-Faso, Benin and Ivory Coast and the Food and Agricultural Organisation, The World Health Organisation and the United Nations Development Programme (U.N.D.P.). The programme has achieved much success using modern techniques and pesticides. The discovery of Ivermectin® for mass treatment has increased the hope for a total eradication of the disease in affected areas. In Ghana, the programme was limited to the north of the country and did not reach the resettlement towns in the Asukwakwaw area in the south which together with other localised areas in southern Ghana continue to be areas of hyperendemicity and therefore a vigorous sustained Onchocerciasis control programme should be pursued.

Trypanosomiasis (African Sleeping Sickness)

The formation of the lake has been beneficial in that it drowned large areas of forest, which once harboured tsetse flies.

With the vegetation pattern round the lake changing and evolving during

the early years of the formation of the lake, the population movements and water transportation on the increase, attention has been paid to the probable development of new endemic foci and the appearance of clinical cases of the disease. Since 1973, no new cases have been diagnosed. There is however the need for continuous surveillance.

Prospects for the Future

From the reports available, it can be concluded that from the public health point of view, the Volta River Project helped to solve some health problems but created other serious health and sanitation problems which are still unsolved particularly those related to the resettlement towns and Schistosomiasis in the Volta Basin. The benefit to health by the construction of the Akosombo dam in 1965 and the Kpong dam in 1981 is undoubtedly the reduced incidence of Onchocerciasis in the Volta Basin.

The Asukwakwaw area still awaits an effective control programme. The most serious implication is that of Urinary Schistosomiasis, the control of which requires comprehensive national planning, sufficient funds, trained personnel and community participation. The disease embraces both the lake and the lower Volta. Intestinal Schistosomiasis, which was not known in the Volta Basin before the dam construction, has now started to appear, especially in the lower Volta which is an indication of the low standard of living of the people. On the sanitation in the resettlement, the appropriate technology to be adapted should be acceptable to the

users, easy to maintain and repair. This requires education.

An important component of integrated Volta Basin Development is a comprehensive lakeside health programme which should be integrated with community development and planned to suit the prevailing social and economic conditions and the availability of resources in personnel, facilities and finance.

The recent introduction of the medical boat (Onipanua) in the Volta Lake is a serious attempt to bring more health services to the lakeside population. An important aim of the resettlement policy was for the resettlement villages to be absorbed into the normal hierarchy of towns and villages in the country as a whole. That it is hoped would eliminate the attitude of dependency on the Volta River Authority (VRA) and government for all the needs of the resettlement communities.

Recently, some researchers have observed that there is still the difficulty in achieving this aim in some of the resettlement communities.

The transfer of responsibility by the VRA to the local authorities and technical departments had its cultural problems but had improved the situation especially in the areas of organisation and administration and the provision of infrastructural services in some resettlement villages, for the well-being of the communities.

There is increasing awareness that resettlements are part of their underdeveloped surroundings and their future would best be seen in the con-

test of the district in which they are a part and should be depended on the economy of the region - their function and services, transport network and accessibility.

The Establishment of A Volta Basin Commission

The Volta River Project was conceived as an integrated exercise and

should be an ongoing developmental process covering the entire Volta Basin, including the area below the dam to the estuary.

It is therefore suggested that a statutory authority should be set-up and be responsible for the overall implementation of a sustainable integrated developmental programme in the Volta Basin.

Overview of Microbiological studies on The Volta Lake

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Introduction

In May 1964, the dam across the Volta River was completed. Behind this was formed the Volta Lake, which stretches some 400 kilometres inland. The numerous tributaries that drain into the lake give it a complex dendritic form.

In 1963, before the Volta dam was completed, the University of Ghana established the Volta Basin Research Project (V. B. R. P.) to undertake basic research on most aspects of lake development. The research included the question of aquatic weed growth, preservation of items of archaeological interest and a variety of other medical and biological problems that would arise from the creation of the lake (Moxon, 1984).

One line of the research was to carry out investigations into the microbiology of the developing lake with the view to:

- Documenting the ecological conditions of microorganisms present in the water.
- Following up the development of different physiological groups of microorganisms within the newly formed lake.

- Studying the microbial decomposition and mineralization processes in the lake.
- Enumerating presumptive coliform organisms (pollution indicators) in the relatively unpolluted developing lake.

Like all tropical inland waters, the knowledge of the microbiology of the Volta Lake appears to be scanty during the pre-impoundment period. This paper reviews past and present research on the lake and the lower Volta. It identifies the information gaps that can be researched into, in the future programmes of the VBRP.

Pre-impoundment studies.

Pre-impoundment studies by Bannerman (1983) on the distribution patterns of various bacteria in the Lower Volta between Atimpoku and the estuary at Ada showed the number of total coliforms between 0 - 100 l⁻¹ in the river water, and faecal coliforms between 0 and 20 l⁻¹ of river water. High numbers of these pollution indicator bacteria were at Asutwari and Sogakope due to a lot of human interaction with the water. In addition, the effluent of Asutwari sugar factory is discharged into the Lomi stream, which is a tributary of the Volta. This stream is polluted

with indicator bacterial organisms and thus increases the microbial load of the river. This situation was however found not to persist for a long time because of dilution effect of the river when the effluents enter the river.

The number of heterotrophic bacteria ranged between 65 - 4500 l⁻¹ of water. The lower reaches of the river near the estuary recorded low counts of bacteria. All the physiological groups of bacteria were recorded.

Starch, proteins and cellulose decomposing bacteria were isolated mostly in the upper 10 m of water (Table 1). The sulphur - degrading species were found in slightly deeper waters. The most predominant group of bacteria was the protein degrading species. *Chromogens* formed about 70% of the total population of bacteria recorded in the Lower Volta. Spore formers did not appear to be particularly abundant (Bannerman 1983).

Table 1: Distribution of Carbohydrate and Protein Degrading Bacteria in Volta Lake.

Depth(m)	Total No. of Coliforms. ml ⁻¹	Percentage of bacteria showing Hydrolysis		
		Starch	Cellulose	Protein
0-1	63	21	1	9
5	149	26	5	7
10	231	23	11	13
15	204	23	12	15
20	233	45	15	18
25	328	28	17	22
46-45	342	26	20	26

Source Biswas (1969)

Table 2a. Vertical Distribution of heterotrophic bacteria in the Volta lake at Ajena over a 20 year period.

Depth (m)	Total number of Colonies		
	1967*	1977**	1987***
0-1	611	63	83
5	614	149	112
10	354	231	167
15	-	204	197
20	-	233	244
25	239	328	288
46-65	321	-	432

Table 2b. Vertical Distribution of heterotrophic bacteria on the Afram arm of the Volta lake over a 20 year period.

Depth (m)	Total number of Colonies		
	1967*	1977**	1987***
0-1	180	80	84
5	171	131	207
10	170	269	236
15	-	248	244
20	157	261	271
25	360	273	390

* (Biswas, 1969) ** (Amoah, 1977) *** (Amoah, 1987)

Post-impoundment studies.

Initial studies on the microbiology of the Volta Lake during the formation period was carried out by Biswas (1969) at Ajena, 1 km. from the dam site. She showed that bacterial counts were highest at the surface in 1964 and 1965. A change in the vertical distribution of the heterotrophic bacteria was recorded in the subsequent years (Table 2 a & b above).

The colony counts at the bottom layers remained unchanged whilst the surface layers showed considerable reduction in numbers. Presumptive coliform organisms, (which are pollution indicators) were fewer and seem to be confined mainly to the shoreline. The shoreline bank surfaces supported about 2 - 3 times bacterial density and presumptive coliform organisms than the mid-lake between 1964 – 1971. The rainy seasons in 1969 – 1970, i.e., the major (April -July) and the minor (August - September/October) were attended by high bacteria counts which thereafter declined. Presumably, upwelling floodwater entering the lake in the rainy season caused an increase in the bacteria which were ‘trans-

ported’ to the shoreline by the currents. Biswas (1972) and Amoah (1979) found a general decrease in bacteria numbers in the top 10m of the water in 1972 and 1979 respectively. The highest counts were obtained below 20m as compared to Biswas (1969) who recorded high numbers of bacteria in surface waters. This indicates a much greater population of anaerobic bacteria in subsequent years. Ten years later Amoah (1987) obtained the same trend in the distribution of heterotrophic bacteria in the lake. The deeper parts, 20m and below supported higher counts with two peaks coinciding with the major and minor rainy seasons.

About 25% of the bacteria colonies were chromogenic, usually yellow, pink or orange occasionally deep red or brown rarely diffusing into the medium. Microscopy showed the species to be predominantly Gram negative rods in the main body of the water. Gram positive spore forming rods were mainly found near the water/ mud interface; in the main water body they were found in high proportion over limited period during the dry season. This may be because the spore formers appear to flourish on

the plate media and grow more profusely than the other organisms.

The major physiological groups were all isolated from the water, presumably resulting in full decomposition of organic compounds. Their population also increased with depth. The percentage of general heterotrophic bacteria showing hydrolysis of starch at the following depths 0-1, 5, 10, 15, 20 and 25m at Afram were: 18, 13, 23, 62, 66 and 69 % respectively; at Apaasu near Ajena they constitute 29, 24, 32, 75, 64, and 78% respectively (Amoah, 1977). The bacteria isolated from the water belong to the genera *Chromobacterium*, *Pseudomonas*, *Favobacterium*, *Escherichia*, *Cellulomonas*, *Cellvibrio*, *Clostridium*. Slight seasonal changes in temperature did not have any effect on the bacteria counts.

Public Health Microbiology.

The knowledge of microbiology of inland waters in the tropics is mainly confined to public health aspects and the Volta Lake is no exception. Settlers along the banks of the lake use the water for drinking, cooking, transportation, bathing and cattle-watering purposes; unfortunately there is also dumping of human waste (Table 3). Coliform bacteria at the banks range from log cfu/ml 1.9-2.5; in mid-lake log cfu/ml. 1.95-2.5. Total heterotrophic bacteria at the banks were higher (log cfu/ml. 2.9-3.2) (Amoah, 1989).

Approximately one -third of the bacteria isolated from the mid-lake portion of the lake were chromogenes of non-faecal origin. These were *Cellulomonas* spp., *Chromobacterium violaceum*, *Flavobacterium* spp., *Serratia* spp., (Amoah, 1989). Predominantly enteric non-sporing bacteria species namely *Aeromonas sobria*, *Citrobacter freundii* *Enterobacter agglomerans*, *E. cloaca*, *Escherichia coli* *Proteus* spp., *Serratia* spp., *Shigella* spp., *Klebsiella pneumoniae* and *K. aerogenes* were found in the water at the bank of the lake indicative of faecal pollution. Medical records of inhabitants of this area also show preponderance of diarrhoea and gastro-intestinal diseases associated with the prevalence of these bacteria. Shellfish have been a readily available source of protein for the inhabitants of the lower Volta. The pre-impoundment microbiology report of Bannerman (1979) indicated bacterial pollution of the river water which might be taken up by the filter feeders such as shellfish in that area and thus constitute a major health hazard for consumers.

Research carried out by Amoah *et al* (1989) indicated the presence of some pathogenic organisms in clam (*Egeria radiata*) and prawns (*Macrobrachium* spp.) harvested from these areas. Potentially pathogenic bacteria isolated, included *Salmonella* spp. and, *Shigella* spp. Two organisms *Morganella mogani* and *Plesiomonas shigelloides* were encountered in shellfish for the first time in Ghana.

Table 3: Vertical Distribution of Pollution indicator Bacteria at Ajena

Depth (m)	Most Probable number of Presumptive Coliforms Presumptive Coliform Bacteria / 100 ml.		
	1967	1977	1987
0-1	25	13	17
5	82	20	11
10	-	75	25
15	112	35	25
25	233	45	20
46-65	46	95	25

Factory Effluents and Water Quality

The building of the dam at Akosombo brought with it some commercial and industrial activities and its attendant problems. Akosombo Textiles Ltd. situated on the Lower Volta discharges its factory effluents into the river; as did the Asutsuare sugar factory and the Akosombo sewage treatment plant. This adversely affected the bacteriological quality of the drinking water and that of shellfish (Bannerman, 1981; Amoah, 1989). The effluents from these factories lowered the dissolved oxygen of the river, increased suspended solids making the water more turbid. Effluents from sewage and sugar factories encouraged the growth and multiplication of pollution indicator bacteria when discharged into the river.

Recreation and Water Quality

The Volta River estuary is used extensively for water sports like swimming, fishing, water-skiing and boating. The Institute of Aquatic Biology (IAB, 1980) recorded total coliform bacteria ranging between 0 - 3,000

MPN/100ml with evidence of faecal pollution. With regards to its suitability for total body contact sports, approximately one half of the area would not be regarded as suitable whilst about 90% of the area may be suitable for partial body contact sports.

Future Research

From the aforementioned it is clear that the work carried out to date is only a scratch at the surface. Complementary studies required should include the following:

- Microbiological quality of the Lower Volta water should be continued in order to document the possible sources of contamination which may pose as a potential health hazard for inhabitants.
- The pathogenicity of microorganisms isolated from the water and foods should be established in order to relate various diseases recorded in the Lower Volta Basin to their eating and drinking habits.

- Alternative sources of drinking water should be sought for the inhabitants and ways of purifying the water found to make it potable.
- Aquatic weeds are known to support and harbour pathogenic microorganisms. It will be worthwhile to investigate whether such relationships exist in the Lower Volta Basin.

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Discussion on Health Issues

- Question: Mr. Kofi Lawer (Rep. Dangme East District Assembly, Ada-Foah)
Which health problems can be resolved and which ones could not?
- Answer: Dr. L.K. Derban: Drawing a line here is not possible as certain health problems would always prevail (unavoidable) but their harmful impacts could be minimised through effective management.
- Suggestion: Chairman: Environmental education should be a priority to sensitise local communities on the contribution of their life patterns to their health needs.
- Contribution: Togbe Kwao Anipati IV: The river had always been a source of water for the people even before the dams were constructed and certain diseases were prevalent. These have, however, become more serious since the construction of the dams. The VRA should be held responsible for this unfortunate situation. Access to portable water and teaching of good fishing techniques to the riparian communities should be the responsibility of the VRA.
- Remarks: Chairman: There were, apparently, no research work before the creation of the dams to prove Togbui's assertion. Also, the people should be educated on the idea that Man is a vector of Schistosomiasis. Contact with the waster could help in its prevalence.
- Contribution Mr. C. Asafo: Provision of good drinking water. Since there is difficulty in changing attitudes of the people, some other solutions could be sought.
- Question: Mr. Hunnuor T.K. Bobobee; (Farmer Fisherman, Lower Volta).
What are the possible causes of urine retention (one of the problems in the area) in males, since he is of the opinion that, the dams have brought about this situation.
- Answer: Dr. Derban: These are developmental problems and Bilharzia could be a possible cause. People should stop the recrimination and rather help find integrated means on solving the problems in the Basin including researchers and the local communities.

The Role of the Fisheries Department of the Ministry of Food and Agriculture in the Volta Basin C.K. Asafo

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Abstract

The Fisheries Department, in collaboration with the Fisheries commission, has responsibility for policy formulation, management and development of fisheries of the Volta Basin. Earlier activities centred on the precautionary management of the fish stocks of the Volta and their main tributaries and culture-based fisheries development of multi-purpose small reservoirs in Northern and Upper Regions. The focus of the Department's activity in the Volta Basin now revolves around the Volta Lake, especially in Yeji area where models for integrated development and management of the fisheries are being developed. The models are to be applied in a World Bank funded fisheries Sub-sector Capacity Building Project 1996-2000, to lay a firm foundation for sustainable fish production in the Volta Basin generally.

Introduction

The Fisheries department of the Ministry of Food and agriculture is primarily concerned with the development and management of the fisheries of Ghana. Accordingly, the Department in collaboration with other agencies notably the Fisheries Commission undertakes the formulation of policies and strategies pertinent to the successful execution of those tasks. Current Government policy in the fisheries sub-sector aims at increased fish production for domestic consumption and export, in a manner consistent with the long-term sustainability of the fisheries resources, sound environmental practices and alleviation of poverty in the fishing communities.

The pursuit of these policy objectives within the Volta Basin is effected in

three rather distinct sections of the Basin namely:

- the lower Volta River
- the Volta Lake and Kpong Headpond
- tributaries of the Volta Lake and the Upper Volta system

Each of the three sections has its own peculiar problems. The destruction of the clam and flood plain fisheries in the lower Volta Basin because of the construction of the Volta dams has brought considerable economic hardship to the communities there. Alternative fishery and other development options must be applied to restore the economy of the area. The Kpong Headpond and the Volta Lake however support very vibrant fishery operations, which need strong and radical management to ensure their sustainability. The northern sections

of the basin nourish riverine and small reservoir fisheries that are threatened by environmental degradation especially deforestation.

History

In order to appreciate the traditional role of the Fisheries Department in the Volta Basin it is necessary to recount some of its past performances and redefine its current status in the Basin.

Regulation of Lower Volta Fisheries

In the 1940s, the Department monitored the Volta fisheries between Amedeka near Akuse and Ada at the estuary. This resulted in the introduction of the earliest regulations at controlling the use of seine nets in the area as means of conserving the fish stocks.

Fishery Training Camps

The Department then carried out a survey of the fishery resources of the Volta and its main tributaries and established the presence of favourable resources in the Oti River, the Black and White Volta's. This led to the opening of the Lawra Fisheries Station and the establishment of a Fishery Training Camp at Sabare near Yendi. Both stations were for the purpose of training the local populations to enable them exploit the fisheries since they did not have a fishing tradition.

Reservoir Fisheries

Between 1950 and 1970, Government agencies and local communities constructed several hundred small reservoirs and dugouts in the Northern and Upper Regions for various purposes such as soil conservation,

stock-watering, domestic water supply and irrigation. In order to tap the fishery potential of the new water bodies, the Fisheries Department introduced a program of culture-based fisheries in the area. By this means the Department planted compatible species of fish in the reservoirs and managed the stocks for sustainable harvesting by the communities to whom the fishery-training programme had been extended.

Volta Lake Fisheries

The creation of the Volta Lake in 1964 suddenly transformed the Volta fisheries into an important national asset. The Fisheries Department reacted appropriately and posted an officer to Akosombo in the very first year of the Lake to chronicle, as it were, the early history of one of the world's largest reservoir fisheries. Later, the Department participated in the Volta Lake Research and Development Project, which pioneered the multi-sectoral development of the Lake Basin. Presently the Department has become the focus of the multi-sectoral effort in the Lake Basin, directed this time, at the development and management of the fisheries of the Lake.

Lessons

In the execution of its tasks in the Volta Basin, the Department had to work with or be assisted by other agencies at nearly every stage. In the small reservoir fishery programme other organisations (Irrigation Development Authority) constructed all the dams on which the Departments activities depended, even the nursery ponds of the Department.

The Department of Social Welfare and Community Development assisted the Department by teaching the communities how to use the fish caught from the reservoirs in preparing local dishes. As the utilisation of the fish increased, production from the reservoirs short up and attendance of trainees at the training camps/stations also increased.

The most striking lessons establishing the necessity for integrated or multi-sectoral development in the Basin were revealed in the Integrated Development of Artisanal Fisheries (IDAF) Project at Yeji. The project is funded by the UNDP, the Governments of Ghana and Japan and executed by the FAO with the Fisheries Department as the co-operating agency. The Project commenced in 1989 and will end in December 1996. Studies carried out by the project establish that:

- All fishing villages (over 340) in the project area are severely disadvantaged i.e. without schools, portable water, electricity, clinics, markets, recreational facilities or alternative employment opportunities. Generally the only means of reaching the villages is by boat.
- The fishermen by virtue of their location are invariably not targeted for development by their District Assemblies.
- The fishing communities are major cause of tree cover depletion in the basin. About 2/3 of the fuelwood used in the communities is for normal domestic activity such as cooking; only 1/3 goes into fish processing - Depletion of

vegetative cover can lead to extreme erosion, pollution and silting of the Volta Lake which would reduce the active life of the Dam as well as drastically depress the productivity of the fishery.

- The unavailability of suitable fishing inputs or the high cost of appropriate inputs has resulted in the use of illegal and often destructive gear in the Lake.

It is observed that under these harsh living conditions many of the fishers exploit the Lake merely for survival; in the fight for survival, they are not keen on obeying fishery laws. It is obvious that many of the external factors, water, clinics etc., which militate against responsible fishing are the results of policies initiated outside the fishery sub-sector or the Ministry of Food and Agriculture. Clearly, a meaningful development of these fishing communities and sustainable exploitation of the fisheries can best be achieved in a multi-sectoral approach to the development of the basin. Decentralised local administrations would also aid the process.

Other important lessons learned in the management of the fisheries are:

- Research and development in the fisheries must keep pace with or be ahead of the fishers' needs in order to avoid the use of illegal fishing methods.
- Fishery law and regulations must be formulated with the full participation of the fishers. Similarly the enforcement of the laws must be a co-operative effort between

government and the communities to ensure compliance.

Conclusion and the way forward

The IDAF Project at Yeji has demonstrated that the bio-technical management of fisheries in the Volta Basin can be severely impaired by social, economic and other factors, which are external to the fisheries. A multi-sectoral or integrated development approach may therefore be applied to the problem.

In order to achieve sustainable fish production in the Basin, the World Bank funded fishery Subsector Capacity Building Project (1996 -2000) has provided for a community-based fishery management within mutually acceptable regulatory framework.

Stock assessments or monitoring will be carried out, resource management plans prepared and diligently implemented while monitoring control and surveillance operations will cover the entire lake. Co-operation in fishery research with the Institute of Aquatic Biology other CSIR Institutes and the Universities will be maintained.

In addition, the Department is being strengthened through reorganisation, recruitment, training and provision of resources to meet its expanded role in policy formulation, stock assessment, management and socio-economic studies. Above all the Fisheries Department will nurture the special role of attracting other agencies to join the multi-sectoral scheme for the development and management of the fisheries and related sub-sectors in the Volta Basin.

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Abstract

It is noted that the United Nations University established in 1973 is a unique academic institution which operates as one of the organs of the United Nations as a global community of scholars focusing on research, training and dissemination of knowledge on pressing global problems of human survival, development and welfare, peace and security related to the provisions of the Charter of the United Nations. The University's headquarters in Tokyo is a programming centre for research and training centres (RTCs) and research and training programmes (RTPs) in which priority is given to the problems of developing countries. The United Nations University Institute for Natural Resources in Africa (UNU/INRA) located on the Legon campus of the University of Ghana with a mineral resources unit (MRU) located at the School of Mines, University of Zambia has as its objective human resources development and institutional capacity building in the conservation and management of Africa's natural resources for development through collaboration and networking with African universities and research institutes. The original six programme priority areas are listed and it is observed that as a result of limitations in available resources these have been consolidated into three, namely:

- *land use, soil and water resources management;*
- *indigenous African food crops and useful plants and,*
- *mineral resources.*

Past activities of the Institute since the preliminary programme was launched in 1990 are reviewed and future areas of emphasis in the next 5 - 10 years are briefly considered. Finally, possible areas of collaboration between UNU/INRA and VBRP are considered.

Introduction

The UNU was established on the basis of a Charter adopted by the United Nations (UN) General assembly in December 1973. It operates as one of the autonomous organs of the UN General Assembly, as a unique academic institution that functions as a global community of scholars en-

gaged in advanced research, training and dissemination of knowledge on pressing global problems of human survival, development and welfare, peace and security that are the concerns of the United Nations and its agencies. The University executes a broad agenda through networking by promoting collaborative efforts which through multidisciplinary ap-

proaches tackles global problems that contribute to expansion of the frontiers of knowledge, sharing and exchange of information. In the advanced research, training and dissemination of knowledge in its mandate priority areas, emphasis is given to the problems of developing countries. The activities of the University are executed through research and training programmes and research and training centres (RTPs/RTCs).

The Headquarters of the University, which is the key programming and co-ordinating centre, is in Tokyo, Japan. The research and training centres (RTCs) and a few programmes are located outside Tokyo. These include the world Institute for Development Economics Research (WIDER) located in Helsinki, Finland; the Institute for New Technology (INTECH) in Maastricht, The Netherlands; the United Nations University International Institute for Software Technology (UNUIIST) in Macau; the UNU Institute for Natural Resources in Africa (UNU/INRA) in Accra, Ghana and recently Institute for Advanced studies (IAS) in Tokyo, Japan and several programmes including the Programme on Biotechnology for Latin America (BIOLAC).

The major programme priority areas of the UNU during the 1990s are as follows:

- Universal Human Values and Global Responsibilities
- New Directions for the World Economy
- Sustaining Global Life support Systems

- Advances in Science and Technology
- Population Dynamics and Human Welfare.

The UNU/INRA was established within the University's Programme priority area of Sustainable Global Life support Systems.

The United Nations University, Institute For Natural Resources In Africa (UNU/INRA)

The UNU/INRA's establishment in 1986 resulted from multidisciplinary extensive and in-depth feasibility studies by African scientists and scholars and consultations with various institutions, international organisations and governments. The Institute started operating as a programme in April 1990 from temporary sites in the United Nations University Office of North America (UNU/ONA) (1990-1991) and the UNESCO Regional Office for science and Technology in Africa, Nairobi (UNESCO/ROSTA) in 1991-1993 before the transfer on 1st December 1993 and the opening of the Institute proper at its permanent site here on the Legon Campus of the University of Ghana on 1 December 1994. The Mineral Resources Unit (MRU) of UNU/INRA is located in the School of Mines of the University of Zambia at Lusaka.

Objectives

Specifically, the main objective of UNU/INRA is human resources development and institutional capacity building through networking with scientists and scholars in African universities and associated research

institutions in research, training and dissemination of knowledge in such a way as to innovatively apply science and technology to the conservation, management, policy formulation and decision-making that enhance rational utilisation of natural resources for sustainable development in Africa.

Other specific objectives of UNU/INRA include:

- to undertake work in the area of natural resources within the overall UNU programme;
- to help African and other developing countries better appreciate and mobilize their natural resources endowment for the benefit of their people;
- to promote the development of natural resources through the generation and application of scientific knowledge, innovative technology approaches for productive work, and the formulation of planning and policy options;
- to increase understanding of the socio-economic and other aspects of natural resources in the context of self-reliant development;
- to contribute to strengthening of national and other institutions and building endogenous research, development and consultancy capabilities in Africa and other developing countries with respect to their natural resources endowment;
- to encourage inter-disciplinary research and dissemination of knowledge in the area of natural resources; and
- to make the knowledge available to scientific communities every-

where, particularly in the developing countries.

The major concern in the establishment of UNU/INRA is that, Africa, which is a continent richly endowed with natural resources continues to lag behind in almost all economic development indicators with the result that, of the 47 least developed countries in the world, 38 of them are in Africa.

Programme Priority Areas of UNU/INRA

The six original programme priority in the Institute's mandate areas of natural resources consist of:

Land Use with respect to conservation of land resources and improved integrated management of the physical and biological resources of major ecological zones to satisfy multiple land-use requirements.

Water Resources, including ground and surface waters in various ecological zones, in relation to integrated river basin development and water transfers and alternative management strategies to satisfy diverse uses of water.

Plant Resources in relation to the management and utilization of plants to satisfy nutritional, economic and social needs, including their uses for drugs; various industrial purposes; and to satisfy environmental and agroforestry requirements, in addition to the use of biotechnology to achieve objectives in the most cost-effective and innovative manner.

Animal Resources, with respect to pasture ecosystems studies, conservation, improved management and rational utilization of wildlife, and fisheries resources including their genetic manipulation to enhance their uses as sources of food and other useful products.

Mineral Resources, with high priority given to mineral exploration, mineral law, mining development, mineral processing for internal use and industrialization as well as mineral policy and training related to these; and

Energy with particular emphasis on fuelwood and efficient afforestation, development of integrated hydroelectric projects, energy conservation schemes and promotion and support of building alternative energy planning, research and development capabilities. Due to limitations in resources, when the UNU/INRA Programme was launched in 1990, a re-assessment of the economic, cultural and political realities of Africa resulted in the six programme priority areas being consolidated into the following three:

- Land use, soil and water resources, conservation and management;
- Indigenous African food crops and useful plants, and
- Mineral resources conservation and management.

Mode of Operation

In some of the earlier papers, I have presented on the operational and organizational structure of UNU/INRA, I have emphasized that an institute

established to work on natural resources must in its operational structure give due consideration to the facts that these resources

- usually interphase into each other,
- are involved in complex processes that regulate the environment, and
- are involved in global cycles that create the environmental conditions necessary for life on earth

For this reason, it is necessary in research, training and information dissemination as well as technology generation, adaptation and testing to adopt a holistic and multidisciplinary approach. a major group of institutions that have adopted this approach are international agricultural research centres (IARCs) of the Consultative Group on International Agricultural Research (CGIAR). Budgets of these centres each of which is concerned with only a few components of natural resources consisting of one or few commodities (staple food crops and/or livestock) or problems encountered in agricultural production range from about US\$10 to 23 million. For this reason, it was decided that UNU/INRA shall:

- have a lean administrative structure;
- be based on networking and collaboration among scientists and scholars in existing institutions (mainly universities and research institutes);
- organise its network around university professors and scientists who are well qualified and experienced and have an excellent track record in areas of natural

resources in UNU/INRA mandate;

- require few staff at the permanent site in Accra consisting of a Director, Co-ordinators of programme priority areas, Co-ordinator of the Mineral Resources Unit (MRU) in Lusaka, Zambia and small number of administrative and other support staff;
- Involve few infrastructural facilities at Accra consisting of:
 - a reference pedological and soil, plant and water analytical laboratory;
 - a reference herbarium tissue culture and germplasm conservation facility, and
 - library, documentation, data-bank and information management facility for use by members of UNU/INRA college of research associates (CRA), visiting professors and their students.
- In addition require linking of the facilities in Accra with the strengthening of the research facilities in departments, facilities and institutes where participants in the network are located.
- Require establishment of linkages not only among UNU/INRA collaborators but also between collaborating universities in each country with ministerial research institutes.
- Involve collaboration with international agricultural research centres (IARCS), United Nations R & D agencies such as

UNESCO and FAO, developed and developing countries' specialized-research institutions (e.g. WRI, NRI, ICIPE, etc.) and as far as possible also NGOs and rural peoples (farmers, craftsmen, hunters, fishermen etc.).

- Develop mechanism for ensuring that African universities' research and training activities do not continue to be from development and from the global scientific community endeavours.

For more details on the operational and organizational structure of UNU/INRA reference should be made to Okigbo (1994 and 1996) and the draft UNU/INRA brochure (UNU/INRA. 1995).

Training will constitute a vital element in UNU/INRA activities as the means for human resources development and partly also as contributor to institutional capacity building. Training shall consist of specialized training of a few weeks to two or three months and degree-related research that will constitute components of post-graduate (Masters or Doctorate) degree courses of African universities in the Institute's programme priority areas.

Dissemination of information or knowledge shall be through publications (books, bulletins, special reports, conference proceedings, etc.) that emanate from the Institute's supported research, conferences, seminars, symposia or other meetings. Field and laboratory demonstrations, documentary films, etc. shall also be used in dissemination of results of the Institute's work. High

priority will be given to participatory approaches in R & D, training and dissemination of information in which farmers, rural communities and other clients are involved in such a way that they participate in all stages of planning of research, execution, monitoring and evaluation of results which enhance adoption and feed-back thereby linking research, extension and the farmer or other clients. At the same time researchers are exposed to situations in which they interact and also learn from farmers and rural peoples.

With the above background, it is in order hereunder to review past and proposed future activities of UNU/INRA based on the draft Institute's flyer and details provided in the brochure.

Past UNU/INRA Activities

The activities that were executed during the UNU/INRA Programme phase 1990 - 1993 are briefly reviewed hereunder:

Institutional Capacity Assessment: This was conducted in order to determine the scope, organization and status of research and training in African universities and research institutions working on natural resources. Altogether thirty (30) universities were visited in 21 countries.

Consultative Meetings: These were held in Lusaka, Zambia for Eastern and Southern Africa in March 1991 and in Accra, Ghana in April 1992 for Western and Central Africa to deliberate on papers on natural resources and recommend priorities

and strategies in research and training.

Orientation/Training Courses and Field Surveys: The orientation & training courses were conducted for selected prospective members of the College of Research Associates in Nairobi and Lusaka in August 1992 to acquaint participants with:

- mode of operation of UNU and UNU/INRA
- the implications of the current concern about the environment and sustainability in development in the conservation and management of natural resources, and
- the status of land, soil and water resources, indigenous Africa crops and useful plants and mineral resources in Africa. These courses constituted a necessary background for conducting the field surveys on the relevant natural resources by participants.

Altogether forty-three (43) field surveys were conducted twenty-three (23) on indigenous food crops, eleven (11) on soils and water, six (6) on the utilization of indigenous food crops, introduced food crops grown/produced in Africa and imported foods items in commercial eating places, five (5) on mineral resources and three (3) on medicinal plants in Eastern, Central and Western Africa.

Special Training Course on the Legal and Economic Aspects of Mineral Resources: This was conducted by the Institute's MRU in Lusaka to deliberate on the legal and economic ramifications of the mining industry -

a potential area for future training and capacity building.

The above activities provided results and experiences that are useful in ensuring relevance of UNU/INRA to the needs and circumstances of Africa.

Immediate and Short-Term Priorities

- Special ad hoc advisory panels will be appointed to advise on the nature, scope, strategies and priorities of the Institute's work in crucial areas of regional concern such as biodiversity and germplasm conservation and subsequent genetic improvement of indigenous African food crops and useful plants so as to enhance utilization of these neglected plant resources, and women and gender issues in the management of natural resources for sustainable development.
- Establishment of a collaborative network of institutions involved in research and training in Africa's natural resources.

Medium and Long-Term Concerns

The chief concerns of UNU/INRA in research, training and dissemination of knowledge and information are summarized below.

Research and Related Activities: These will be conducted in each of the programme priority areas with emphasis on:

- Indigenous African Food Crops and Useful Plants including basic studies,
- monitoring and inventorying of plant genetic resources and their conservation;
- Evaluation of potential indigenous agroforestry species such as the African pear (*Dacryodes edulis*), (the African breadfruit (*Treculia africana*) and sheabutter (*Vitellaria paradoxa*);
- Collection, evaluation, establishment of gardens of medicinal plants and their commercialization;
- Collection, evaluation, improvement and increased production of indigenous vegetables for combating Vitamin-A deficiency in dry and semi-arid areas.

Landuse, Soil Conservation and Management: In addition to assisting in efforts to find ways of rehabilitating large areas of Africa that are already highly degraded and desertified, priority will be given to:

- Establishment of a databank of Africa's land resources, land tenure and related issues.
- Setting up of soil and land degradation monitoring network in the region based on standardized methods.
- Determining indices of sustainability for soils under different landuse and production systems, etc.

Water Resources: Many countries in Africa suffer from inadequate water supplies including clean water for drinking, domestic use and irrigation. The Institute will focus on:

- Data collection and analysis including improvement of rainfall data collection in many locations, monitoring of pollution, water quality, evaporation and other losses.
- Evaluation of current river basin development and management authorities and determining how to eliminate deficiencies in policies, and sharing of transboundary water resources.
- Comparative studies on traditional and “modern” or conventional water harvesting technologies as a basis for developing more innovative technologies.

Mineral Resources: Here high priority is given to:

- Data collection, analysis and establishment of a data bank.
- Review and assessment of mineral resources exploration, conservation, management and manufacturing capabilities.
- Assessment of economic, social and environmental effects of the mining industry and determining how to eliminate adverse effects.
- Research on mineral resources policy, legislation, etc.

Energy and Animal Resources: These two components of the six original programme priority areas are not being addressed in the UNU/INRA activities now because of limitations in available resources. They will, however, be included in future work programmes and resources permit.

In an age of sustainable development, priority will be given to education involving transmission of knowledge about natural resources and training

which involves the transmission of skills used in their study, conservation and management.

In education, emphasis will be given to supporting of and participation in co-operative projects in curriculum changes related to:

- Introduction of environmental education into general education.
- Development of new courses in ecological economics, natural resource economics, environmental accounting and wild life management.
- Popularisation of taxonomy and systematics of plants and animals.

In training, priority will be given to transmission of skills and building of public awareness and orientation necessary for implementation of UNCED Agenda 21 including:

- The promotion of public awareness of the need to integrate environment and development.
- Re-orientation of politicians, planners and decision makers,
- Techniques for inventorying and monitoring of biodiversity.
- Participatory on-farm rapid appraisal methodologies and indigenous knowledge in natural resources management.

Specialised Training Courses: These will be organised in relation to progress being made in research activities in land use and soil resources management, water resources conservation and management, indigenous Africa food crops, medicinal plants and mineral resources. Examples of topics for these training

courses in specific aspects of natural resources include:

- Land use and Soil Management - Integrated land-use planning and remote sensing.
- Standardised methods of land degradation monitoring.
- Water Resources Management - Water quality assessment methods and monitoring
- Trans-boundary water management.
- Mineral Resources Management - Mineral resources exploration and design implementation. Environmental impacts of mining and their assessment.

Consultancy Services

Based on current practice and experience, it seems that African countries have more confidence in foreign or expatriate consultants than in local ones staffed by African experts most of whom are still members or retired staff of their universities and research institutes. UNU/INRA will give high priority to development of endogenous African consultancy capabilities in natural resources conservation and management. This will be more cost-effective since it constitutes savings in millions of dollars lavished on expatriate consultants and foreign experts.

Possible Areas of Collaboration between VBRP and UNU/INRA

The VBRP has as its goal the sustainable development of the Volta river basin to satisfy the diverse local requirements of the communities in the basin and the national needs and aspirations of the people of Ghana.

If it accomplishes these goals it will constitute a shining example and case study that will assist countries of the Africa region in development of their river basins many of which can boast of no larger man-made lake than that behind the Akosombo dam.

UNU/INRA has as its focus human resources development and institutional capacity building in the conservation, management and rational utilisation of Africa's natural resources for sustainable development through partnership and networking with existing institutions consisting mainly of universities and research institutes UNU/INRA. The key programme priority areas of the Institutes include land use, soil and water resources conservation and management and conservation of biodiversity with emphasis on indigenous African food crops and useful plants. Two major UNU/INRA projects related to these include (1) degraded land restoration/rehabilitation and integrated watershed research, development and management project and (2) biodiversity conservation of indigenous African food crops with emphasis on the use of home gardens for in situ conservation. Since the VBRP will be adopting integrated approaches to land use planning that encompass diverse ecological zones, there is considerable opportunity for UNU/INRA to join hands with it to attract funds to support research, training and related activities dealing with problems of mutual concern. Furthermore, the fact that the University of Ghana is involved and UNU/INRA is located on the University's campus and already collaborates with Prof. Gyasi and colleagues in the PLEC project will facilitate

expansion of collaboration in other related projects. Such collaboration is bound to attract donor support more easily than if we were both going it alone. The task before all of us

is how to pool our resources together in harmonising our activities so that synergistic interaction can be achieved in a manner that ensures rapid progress.

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Overview of the Weed Problems in the Volta Basin

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Abstract

The Volta Dams were built to produce hydro-energy to enhance socio-economic development and bring prosperity to the peoples of Ghana. However, following events after the building of the Dams are pointers to the fact that they were built at great costs to the environment of Ghana. One of the major environmental costs was the invasion, development and spread of aquatic plants to nuisance conditions in the lakes created and rivers upstream and downstream of the lakes. The aquatic weeds invasions had negative affects on water transport, power generation health irrigated agriculture and fisheries. The major weeds included free floating (Pistia, Salvinia and Azolla); Submerged (Ceratophyllum, Potamogeton and Vallisneria). Emergents (Typha, Cyperus, Phragmites, Polygonum), Sudd formers (Oxycaryam (Scirpus), Echinochloa, Vossia, Learsia). The recent invasion of the Black, Red and White Voltas in Burkina-Faso has added a new dimension to the threat by aquatic weeds. Efforts at managing weeds in the Volta system using Physical and Chemical Control have been on ad hoc basis and have yielded little positive results. A concerted integrated control approach could prove useful for the management of aquatic weeds in the Volta Basin

Introduction

Ghana has abundant water resources, which is dominated by the Volta system. The harnessing and rational development of water resources has often been used as a measure of the level of socio-economic development of countries world-wide. However, harnessing water resources such as the building of dams have often been carried out at great socio-economic, environmental and health costs to the very peoples whose lives the projects were to benefit.

One such environmental costs is that of the invasion development and spread of aquatic weeds into nuisance conditions in harnessed water

bodies such as dams. In Ghana studies on the aquatic flora began during the implementation stages of the Volta River Project at Akosombo by the Volta Basin Research Project (VBRP) of the University of Ghana in 1963. The initiation of the studies resulted from the lessons learnt from the explosive development of *Salvinia molesta* on Lake Kariba soon after its formation (Boughey 1963). Since these initial studies the Volta system has been plagued by aquatic weed infestations which have adversely affected not only its use for hydro-energy generation, water transport and irrigated agriculture but also its inherent resources like the living organisms (shell and fin fishes) and its quality.

In the course of time various studies have been conducted on the Volta system including that of Lawson (1964), Lawson (1967), Hall et al (1969), Hall and Pople (1969), Odei (1973), Okali and Hall (1974), 1974b), Ennin and de Graft-Johnson (1977), Opoku (1977), Lawson et al (1979), Gyimah Amoako (1988). These studies have given an insight into the development of hydro-macrophytes in the Volta Basin prior to the building of the Akosombo dam through to the formation of the Kpong Head pond and the present.

Classification of Water Plants

Hydrophytes are plants growing in water, in soil covered with water or in soil that is usually saturated (Weaver and Clements, 1938), using the physical position of water plants they can be classified as follows:

Emergents: occur at the landward edge of a wetland and in shallower waters. All produce aerial reproductive organs e.g. the bulrush *Typha*, the reed *Cyperus articulatus* and grasses *Vossia*, *Echinochloa*.

Floating-leafed: occur with roots in inundated soils in water depths of about 0.3 to 3.8 metres. Have some leaves (and often flowers) floating on or above the water surface (aerial) e.g. water Lily *Nymphaea*.

Submerged: usually have all their parts in water below the surface and then roots in the soil e.g. *Vallisneria*, *Potamogeton*, *Ceratophyllum*.

Free-floating: occur mainly in sheltered soils on lentic and slow lotic

waters, e.g. *Pistia*, *Salvinia*, *Eichhornia*, *Azolla*, *Lemna*.

Normal Role of Aquatic Plants

In nature aquatic plants play various important roles in the aquatic ecosystem in which they occur.

Submerged Plants

- reduce erosion by reducing flow rate and trapping sediment
- add dissolved oxygen
- act as food
- strip nutrients from water
- habitat for organisms (flora and fauna)
- help maintain habitat diversity leading to increases in the richness of flora and fauna.

Emergent/Floating Plants

- stabilise streams and lakes banks
- act as food and harbour fauna
- habitat for organisms that improve water quality
- reduce evaporation
- uptake of nutrients
- reduce turbidity through slowing down flow and sedimentation
- aesthetic appeal.

Aquatic Weeds

“Weeds are usually plants that appear amongst a natural or cultivated plant community and grow profusely to the detriment of other species often depriving them of space, nutrients or light” Concise Oxford Dictionary. An aquatic weed is “a water plant growing where it is not wanted thus interfering with the intended uses of the water body e.g. for human or livestock consumption, fisheries, transportation, irrigation, hydropower

generation and wildlife conservation". It may also be described as "a hydrophyte, which has become a weed because of its new position in relation to other water plants or activities of man". Numerous species in all life forms (emergent, submerged, floating-leafed and free-floating) have been classified as weeds world-wide because of their luxuriant vegetative and vigorous adventive spread in various water bodies. The most severe problems have inadvertently been caused by free-floating species normally occurring as extensive pure (one species) colonies or as constituents of "Sudd" communities ('Sudd' - an impenetrable mass of floating vegetation).

Weeds Development in Volta Basin

Prior to the closure of the Akosombo dam the Volta Basin Research Project (VBRP) studied the distribution of aquatic weeds in the Volta Basin. The important aquatic and marsh plants recorded are presented in Table 1. In that survey the VBRP did not find the world's most noxious aquatic weed the water hyacinth *Eichhornia crassipes*. Neither did they record the Kariba weed, *Salvinia molesta* nor the papyrus reed, *Cyperus papyrus*. However, they found a species of *Eichhornia*, *E. natans* and *Heteranthera callifolia* both belonging to the same Pontederiaceae family as water hyacinth. In addition four (4) species of 'water nymph' *Najas*, a species previously unknown in Ghana including the widespread *N. pectinata* were discovered in that survey. Furthermore, 'hippograss'

Vossia cuspidata was found in some creeks both in the lower Volta River as well as above the dam in feeder streams in the area around Yeji.

After the formation of the lake in 1964, thick water lettuce (*Pistia stratiotes*) mats developed especially in the sheltered areas of the Afram and Pawn Pawn arms of the lake. However, these *Pistia* mats were not persistent. By 1964 an estimated not more than 1% of the surface of the lake was weed covered (Hall, *et al*, 1969) as against 10% for the Kariba lake two years after its formation (Boughey, 1963).

In December 1965 *Vossia* was found floating in lake Volta itself. The *Vossia* mats were said to be capable of supporting the weight of a child (Lawson, 1967). The *Vossia* mats or 'Sudd' - (an impenetrable mass of floating vegetation), began to spread. Other species included in the 'Sudd' were *Leersia hexandray*, *Oryza barthii*, *Ipomoea aquatica*, *Ludwigia stolonifera*, *Fuirena umbellata* with *Utricularia inflexa* and *Ceratophyllum demersum* as associates. The climax 'Sudd' mats included trees such as the leguminous *Aeschynomene elaphroxylon* and *Ficus congensis*. Pure stands of *Vossia* mats, which did not use other species as substratum, were later found growing in the lake. These *Vossia* stands were not part of a succession as was also the case in Lake Bangweulu, Zambia where Wild (1961) reported it to be a pioneer 'Sudd' species and in Lake Kariba where Boughey (1963) reported it to be the only species able to exist as free floating colonies without the support from the 'Kariba weed' *Salvinia*.

In 1966 pure *Scirpus* stands were found west of Ampem in the Afram arm of the lake. This inhibited boat movement. Furthermore, *Pistia* had by then become well established in the southern parts of the lake. These *Pistia* mats were often made more permanent by the invasion and binding action of *Scirpus* (*Oxycaryum*). Meanwhile as at 1966 some 4% of the lake's surface was covered by weeds (Okali and Hall 1974).

However, by 1968 the *Pistia* mats were restricted to the upper reaches of the Afram and Pawn Pawn arms whilst *Echinochloa* had also developed and spread to become a major lake shore weed. In the more savanna parts of the lake *Polygonum*, *Mimosa pigra* and *Mitragyna enermis* grew on the wet margins. However, *Polygonum* also adopted of floating habit in some sheltered parts of the Pawn and Afram arms.

Meanwhile, the new hydrological regime created in the 80km long Lower Volta river is a result of the Akosombo dam encouraged the establishment, growth and spread of the submerged weeds *Vallisneria*, *Ceratophyllum* and *Potamogeton* as well

as the emergents *Echinochloa*, *Phragmites*, *Vossia* and *Typha* (Hall and Pople 1969, Ennin and deGraft-Johnson, 1977). Other weeds included the water lettuce *Pistia*, herbs (*Alternanthera*, *Ipomoea*), 'Sudd' formers (*Leersia*, *Cyclosorus*) and the reed *Cyperus articulatus*.

In May 1981 the Kpong dam was closed for filling. It flooded some 2,605ha of land and created the headpond with a surface area of some 37.4km². The clarity of the water in the headpond, its general shallowness (15 metres max. depth) and numerous islets encouraged the development of submerged weeds (*Potamogeton*, *Vallisneria*, *Ceratophyllum*), free-floating weeds (*Pistia*, *Azolla*, *Lemna*) emergent macrophytes (*Typha*, *Echinochloa*, *Enydra*, *Mariscus*, *Phragmites*) 'Sudd' formers (*Vossia*, *Leersia*, *Cyclosorus*, *Scirpus*) soon after the lakes formation.

A list of the aquatic macrophytes growing in the headpond region as at 1985 is presented in Table 2.

Table 1. Potentially troublesome aquatic plants in the Ghanaian portion of the Volta Basin (after Hall et al. 1969) Plants known from only below the dam are marked (B)

Free-floating on the surface

Pistia stratiotes
Azolla africana
Salvinia nymphellula (not *auriculata*)
Lemna paucicostata

Spirodela polyrrhyza
Wolffiella welwitschii
Ricciocarpus natans (B)
Wolffia arrhiza

Free-floating below the surface

Ceratophyllum demersum
Utricularia inflexa

Ceratophyllum submersum
Utricularia reflexa

Utricularia gibba

Aldrovanda vesiculosa

Table 1. cont.

Floating on surface and rooted

Nymphaea lotus

Nymphaea maculata

Eichhornia natans (not *crassipes*)

Nymphaea rufescens

Heteranthera callifolia

Nymphaea micrantha

Nymoides indica

Sagittaria guyanensis

Floating below surface and rooted

Vallisneria spiralis

Najas meikleii

Ottelia ulvifolia

Nitella mucronata

Najas pectinata

Nitella microcarpa

'sudd' formers

Vossia cuspidata

Ludwigia leptocarpa

Scirpus cubensis

Pycreus mundtii

Cyperus nudicaulis

Torulinium confertum

Leersia hexandra

Cyclosorus striatus

Oryza barthii

Aeschynomene elaphroxylon (B)

Echinochloa stagnina

Rooted and emergent

Cyperus articulatus

Eleocharis fistulosa

Cyperus digitatus

Polygonum senegalense

Typha australis

Polygonum tomentosum

Echinochloa pyramidalis

Ficus congensis

Weeds of wet margins

Mimosa pigra

(some of these also occur in 'sudd')

Eclipta alba

Aeschynomene indica

Enydra fluctuans

Neptunia oleracea

Sphenoclea zeylanica

Ludwigia stolonifera (= *Jussiaea repens*)

Eriochloa meyeriana

Alternanthera sessilis

Pycreus albo-marginatus

Fimbristylis dichotoma

However, in a pre-impoundment study of the hydro-macrophytes of the area Opoku (1977) identified 46 aquatic and semi-aquatic species growing mostly in patches except for the extensive mats of *Pistia* and *Scirpus*. The two were reportedly generally restricted to the peripheries of the islands/islets. Gyimah Amoako (1988) estimated the vascular macrophyte weed cover to be between 20-25% of the headpond's surface area. However, as at 1955 the weeds cover was about 35% of the surface area.

In contrast in the lower Volta river at present about 30% of the surface is covered by weeds whilst between 70 and 100% of the bottom has been taken over by submerged weeds (*Ceratophyllum*, *Vallisneria*, *Potamogeton*). Meanwhile, in the Volta Lake the weeds cover is estimated at between 1 to 10% just like it was during its formative years.

The Volta Lake faces the threat of an invasion by the world's most noxious aquatic weed, water hyacinth, because the Black, and White Volta in Burkina-Faso have been reported to

be infested by this dreaded weed (Ouedraogo pers. com). In addition, the threat of an invasion of the Volta system by the 'Kariba' weed, which now occurs in the Tano/Ehy lagoon complex, is also real. This is because

of its possible introduction by the Tongu fishermen who move from water body to water body going about their vocation.

Table 2. List of Aquatic Macrophytes growing in the Kpong Headpond region as at August 1985 (Modified after Gyimah Amoako, 1988)

(a) FLOATING SPECIES

Azolla africana
Cyperus nudicaulis
Lemna paucicostata
Pistia stratiotes
Salvinia nymphellula
Scirpus cubensis (Oxycaryum cubense)
Spirodella polyrhiza

(c) EMERGENT SPECIES

Acroceras zizarioides
Alternanthera sessilis
Aponogeton pectinatus
Brachiara mutica
Burnatia emeandra
Ceratopteris cornuta
Chasmopodium candatum
Chloris robusta
Commelina diffusa
Crinum sp
Cyclosorus striatus
Cyperus articulatus
Cyperus distans
Echinochloa pyramidalis
Echinochloa stagnina
Eichhornia natans
Polygonum salicifolium
Enydra fluctans
Fuirena umbellata
Heteranthera callifolia
Hydroba glabra
Vallisneria aethiopica (rooted)

(b) SUBMERGED SPECIES

Ceratophyllum demersum
Potamogeton octandrus (rooted)
Utricularia inflexa

Ipomoea aquatica
Ipomoea azarifolia
Leersia hexandra
Ludwigia hyssopifolia
Ludwigia leptocarpa
Ludwigia stolonifera
Mariscus lingularis
Paspalum orbiculare
Pentodon pentandrus
Eleocharis acutangula
Polygonum senegalense, (albotomentosum)
Phragmites karka
Pycreus mundtii
Pycreus polystachyos
Pycreus pseudodiaphanus
Rhynchospora corymbosa
Sphenoclea zeylanica
Struchium spargonophorum
Torulinium odoratum
Typha domingensis
Vossia cuspidata

Finally, the effects of the aquatic weeds on the socio-economy, environment and health of especially the riverine and lake shore communities has been catastrophic. There has been increased incidence of malaria,

urinary and intestinal Schistosomiasis, drastic decrease in the once fledgling "Volta Clam" *Egeria radiata* industry, reduced fish catches due to restricted gear use impediments to boat movement for tourism

and water transport, and the choking of feeder streams and lagoons to death especially those in the lower Volta area. The result is the mass migration of people in especially the Tongu areas to seek greener pastures elsewhere in the country.

Conclusions

In conclusion the development of aquatic weeds in the Volta Basin has been enhanced by the changing regime of the hydrology, the lacustrine conditions and stoppage of the annual scouring by floods. The incidence of weeds have been more dramatic and its effects more severe in the lower Volta river and Kpong headpond than on the main Volta lake. To manage the aquatic weeds in their present stage calls for public education and constant surveys of the Volta system to assess and map out the weeds cover. An integrated weed management using Physical and Mechanical, Chemical (Herbicidal) and Biological control methods or a

combination of methods where appropriate should follow this. The necessary human and material resources to enable a sustainable integrated control programme to be effected should back this.

Though some of the consequences of the building of the dams including those of the development and spread of aquatic weeds were anticipated during their implementation stages, it appears Ghana did not prepare well to counter them. Hopefully, the lessons learnt from the Volta system will help us to develop better strategies to manage aquatic weeds in future water development projects in Ghana.

To do this, it is paramount to have effective collaboration between policy makers and planners, engineers, architects, information media, ecologists, ecosystem managers and the general populace if we want to save the huge investments spent on water resources development project.

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Management of Fisheries Resources of Lake Volta L.I. Braimah

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Introduction

Fisheries management is the integrated process of information gathering, analysis, planning, decision-making, allocation of resources, formulation and enforcement of fishery regulations which govern the present and future fishing activities, in order to ensure the continued productivity of the resources.

Historically the main objective of fisheries management has been the conservation of fish stocks. Modern fisheries management often will address social, political, legal, economic and biological factors therefore the overall objectives of fisheries management will almost always involve compromise. Nevertheless the main task of fisheries managers is to follow strategies which ensure the long term sustainability of fisheries resources and which prevent both biological and economic over fishing as well as minimising disruption to the ecosystem.

A well-managed fisheries must have a management plan which generally should contain a description of:

- The present state of development and exploitation of the fishery
- The policy aims or objectives, of managing the fishery
- The management strategies which would achieve the objectives

- The regulations which may be applied to the fishery under various strategies.

The detailed concept of a fisheries management plan is discussed in FAO Fisheries Report No. 519 (Guidelines for responsible Fisheries Management).

Lake Volta

Limnology and Fisheries

Ghana has a total area of 238, 539 km² with inland waters covering an area of about 9,500 km² of which Lake Volta, the largest man-made Lake in Africa, alone is about 8482 km² (848,192 ha)

Lake Volta has an average depth of 18.8m, a maximum depth of 90m and a maximum storage capacity of 190 km³. After the closure of the dam in 1964, the maximum controllable level of 84m contour mark was reached in 1968.

Nutrient content of the lake generally is low, only traces of phosphates, nitrates, nitrites, ammonia and sulphates are present in the surface layers (0-40m) of the lake. However in the bottom waters, measurable quantities of these compounds are recorded (Biswas 1966, Antwi 1990).

Phytoplankton development is sparse but occasionally algal blooms occur in local areas Obeng-Asamoah

1983). The number of species is a little over twenty, confined to not more than ten genera. The most abundant are *Synedra*, *Melosira* and *Oscillatoria*. Rotifiers form the major constituent (about 90%) of the zooplankton. Fish catches from Lake Volta show an initial steady rise from 3,000 tonnes in 1964 to a maximum of 62,000 tonnes in 1969 and then followed by a decline and stabilization at around 40,000 tonnes.

The fish species list for the entire Lake shows 27 families, 67 genera and 138 species (IDAF Report 1991). Of these, the Tilapiine species are most dominant followed by *Chrysichthys* species and *Synodontis* species in commercial catches.

In the seventies and early eighties, the dominant fishing gears were gill nets (produced 80% of catch), cast nets, hook and lines and traps, recently more efficient and illegal fishing gears have been introduced into the fishery which include, purse seines, beach seines and bamboo pipes.

Previous Fisheries Management Schemes for Lake Volta.

Between 1968 and 1971 the Volta Lake Research Project Phase I undertook a complete Frame Survey. The results of the frame survey were used to conduct a preliminary catch assessment using the stratified sampling technique. Biological parameters related to stock assessment were studied including feeding habits, reproduction and growth. These culminated in a stock assessment programme using gill nets.

In the period 1971 - 1977, The Volta Lake Research Project Phase II, carried out a second frame survey in 1975 which showed that fishing effort increased by nearly 12% since the first survey (1970). Also the catch assessment programme was intensified and annual estimates of fish landings were made. The fish stock assessment programme based on regular sampling with a set of gill nets (mesh sizes 12.5 to 200mm) concluded then that there was no over fishing of fish stocks and advised effort to be increased. A management (development) plan was therefore drawn with the objective of expansion of effort through introduction of improved netting materials (mono filament nets), training of fishermen on improved fishing techniques etc.

A processed fish landing monitoring programme was developed to assess the volume of processed fish landings passing through the fish markets. Conversion factors were established for processed fish and are still being used today.

The Integrated Development of Artisanal fisheries (I and II) became operational in 1989 and as part of the strengthening of the capability of the department of Fisheries is developing a management system on a scientific basis for Lake Volta.

Management of Lake Volta Fisheries Resources

Schematic Management Plan

The relationship between fish stock assessment, fisheries research, management objectives, strategies and

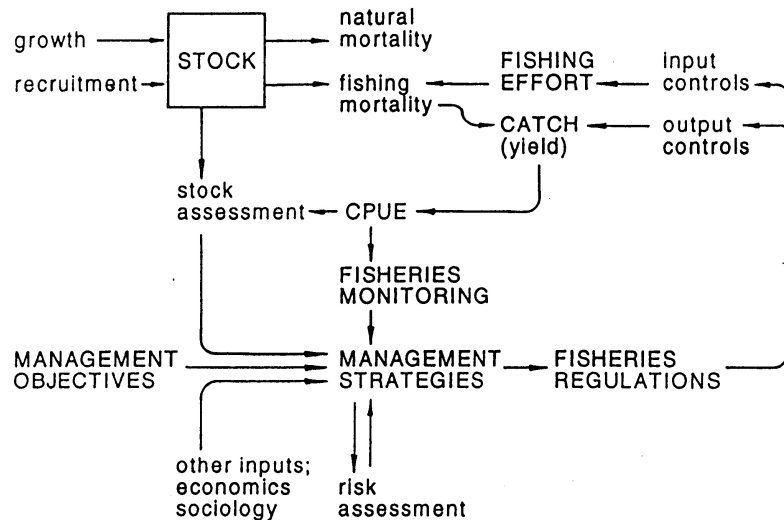
fisheries regulations are shown in Fig. 1.

Once the objectives or policy aims of managing a particular fishery have been defined, the range of management strategies capable of achieving these objectives is considered. Fisheries research and stock assessment provide the probable biological, economic and environmental outcomes for the range of management strate-

gies in the form of advice. This advice includes the assessment of risks associated with each alternative strategy and a summary of the particular controls or regulations required to achieve the objectives.

Cost benefit analyses are done to take into account the enforcement costs of controls and regulations associated with each strategy.

Fig.1 The relationship between fish stock assessment, fisheries research, management objectives, strategies and fisheries regulations



Application to Lake Volta situation

Management Objectives

The objectives set are based on a recommended Total Allowable Catch (TAC) framed in terms of:

- Retracting of Fishing Mortality (F) to F0.1, if studies indicate that dominant fish species are single spawners.
- Maximum sustainable Yield (MSY), if studies show that dominant fish species are multi-

spawners. The estimation of MSY will be regarded as the Upper Limit to the catch that can be taken from a stock.

Fish Stock Assessment

Stock assessment activities and their relationship with other research activities are summarised in Fig. 2.

i. Frame Survey

This will provide the present state of development and exploitation of the fishery.

A recent frame survey was conducted based on the following stratification:

- Large size village, more than 51 canoes
- Medium size village, 11-50 canoes
- Small size village, 0-10 canoes

The following were of importance;

- No. of canoes
- No. of winch boat
- No. of gill nets
- Type of gill nets

Satellite imagery is being explored to enhance the frame survey.

Data are being stored on D-base and Access Programmes.

ii. Catch Assessment Survey

The total number of villages in each stratum from the frame survey will determine the number, which will be used for the Catch Assessment Survey in a stratified sampling technique.

Between 80-90% of the catch landed at Yeji consists of 5-7 species;

O. niloticus, *S. galileus*, *T. zilli*, *C. nigrodigitalus*, *C. auratus* *H. membranaceus*, *S. schall* and *L. coubie*.

Catches of these species are being monitored to provide CPUE values for canoes, which boats and gill nets.

iii. Stock Assessment Survey

Length frequency measurements are being undertaken for the 7 species listed above and the following programmes will be employed in the analyses of the data, FISAT, CEDA, LFDA, BEAM.

Single spawning species population will be determined by Virtual Population Analysis (Pope or Jones) and prediction of future fishing mortalities can be achieved by Thompson and Bell models.

Multi-spawning species, which will not fit into the cohort analyses (VPA), will be subjected to the MSY models.

Fisheries Research

i. Biological studies related to stock assessment

Biological parameters of 20 fish species are being studied by the Institute of Aquatic Biology under a contractual service agreement with the IDAF Project. The following will be achieved:

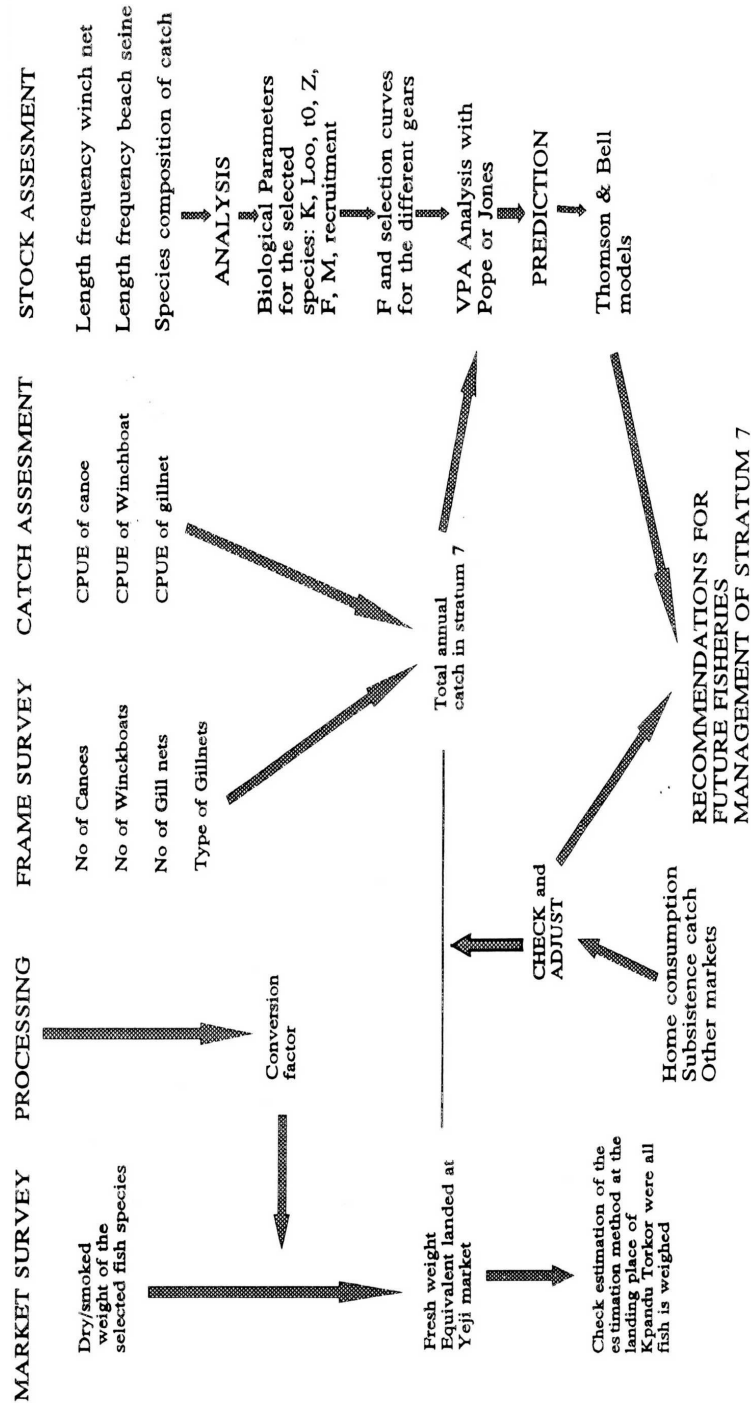
- Size and age at maturity
- reproduction season and number of spawning times
- feeding habits
- prey-predator relations
- food webs

ii. Length Frequency Measures

At regular periods the 7 selected species are measured from catches of non-selective gears. For a minimal period of 1 year the data will be used for the determination of the following biological parameters:

- Length at infinity L_{∞}
- Growth rates (K)
- Time (to)
- Total mortality (Z)
- Natural Mortality (m)

Fig. 2 Relational diagram of the recommended Fisheries Monitoring Programme (source De Graaf (1995)



iii. Processed Fish Landings

Less than 10% of Lake Volta fish is eaten fresh (Maembe 1991). This means that most of the fish landings is processed and pass through lake-side fish markets. Effective monitoring of Processed fish landings at marketing centres can provide accurate catch figures for the lake.

Research is actively being undertaken to obtain reasonable indices for catch assessment figures and processed fish landings.

iv. Determination of conversion Factors

Because nearly 90% of fish from the lake is in processed form, it is pertinent to determine accurate conversion factors to convert processed weight to the fresh weight equivalence. This will allow at all times comparisons to be made of yield from processed fish monitoring programmes and actual yields from the lake.

Environmental Considerations

The limnological status of the Volta Lake is being assessed as part of a programme to provide information for establishment of management strategies.

Vertical profile of the lake water and the benthos are monitored along side studies on the stomach contents of some selected commercially important fish species.

The object of this aquatic environment study is to establish suitable conditions for fish growth and reproduction in the Lake and to provide a monitoring mechanism for early detection of deleterious changes in the

critical aquatic parameters i.e., oxygen, temperature, nutrients, benthos, Aufwuchs, periphyton, phytoplankton, zooplankton etc.

Limnological studies will augment biological and stock assessment studies on carrying capacities.

Economics and Sociology

i. Economics

The fish price survey programme seeks to monitor the economic importance of the fish trade. In addition, essential studies include costs of production, total revenues and total effort employed on yearly basis. The result is to develop the conventional model of fisheries development, Fig. 3.

Fish distribution is also another component given serious consideration as demand affects prices.

ii. Socio-Economic Studies

Various baseline studies have revealed tribal associations with some methods of fishing.

The socio-economic implications of the tribe-fishing method association must be considered in the formulation of management strategies. Management measures, which will affect the livelihood of some tribes, must have alternative options for their survival. Appropriate options must establish the mechanisms for development of horizontal integrated activities. Some revenue generation activities already being promoted by the IDAF Project at Yeji, include Draw down farming, development of woodlots and orchards, pottery, sheabutter extraction, gari processing etc.

iii. Peoples participatory approach.

Activities on formation of co-operatives are actively being pursued. The essence is to involve well-organised groups in management. Active participation of fishing groups will reduce costs of enforcement and surveillance, which normally constitute nearly 80% of total cost of fisheries management.

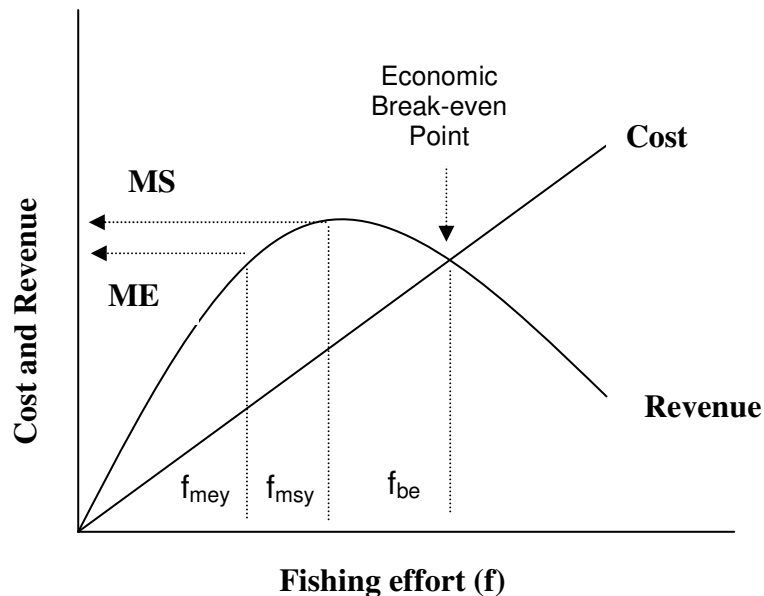
Tools such as RRA techniques are being employed to determine the degree of involvement in management of various lakeside fishing communities.

Management strategies to achieve the management objectives will be formulated after the Fish Stock Assessment Programme, the assessment of the status of water quality and benthos and the conclusion of the various research activities (biological parameters and conversion factors determination, price survey etc.).

One strategy which is obvious already is to reduce effort by removing from the fishery all banned gear, the principal being purse seines, beach seines and bamboo pipes. These highly efficient gears will drastically reduce fishing mortality to an extent that real effort can even be increased.

Management Strategies

Fig 3. A fishing revenue curve and a fishing cost line for a commercial fishery.



Risk Assessment

It is proposed that selected strategies will be framed in terms of an acceptable level of deleterious effects. 10% risk factor is being considered. Repeated runs of a stochastic simulation model will be used in the risk assessments.

Fisheries Regulations

Fisheries regulations are imposed on a fishery to support a strategy designed to achieve predefined objectives.

Even though the management strategies have not yet been formulated it is obvious from experience that the following controls will be generally useful.

i Input Control (Direct control)

- Licensing of all fishing units will be a priority and through this fishing effort can be fixed.
- Limiting the efficiency and types of gear cannot be ruled out and targets the beach seines, purse seines and bamboo pipe fishing

ii. Conservation Measures (Indirect Control)

- This may include protection of near inshore and riverine areas which are breeding areas of the lake. Banning of beach seines will improve these areas as breeding grounds.
- Application of minimum mesh size regulation will be more effectively enforced.

Enforcement and Surveillance

Education will be a priority but enforcement will be adopted if the need arises.

Public education appears to be an important method of ensuring that the use of illegal fishing methods is seen as contrary to the long-term interests of the community. If public attitudes are turned against illegal fishing, the practice will be self-policing at the community level.

Educational Methods proposed include:

- a series of talks given to community groups
- distribution of posters emphasizing the antisocial nature of some activities.

The establishment of the inland MCS Unit will very much effectively tackle encroachment and criminal issues.

The cost of enforcing regulations will be considered when formulating the alternative management strategies.

Management Oriented Research

Spawning Patterns

Knowledge of seasonality and number of times spawning occurs for the major species in Lake Volta will determine stock assessment strategies. Single spawners produce cohorts and therefore Virtual Population Analyses (Pope or Jones) can be employed for assessment of stocks. Multiple spawners create problems and if the major species fall in this category then surplus production Models like

Maximum Sustainable Yield Model is the only option.

Stock-recruitment relationships

The decline of many fisheries has been due to reduced recruitment caused by low levels of the spawning stock. The problem is that the minimal level of spawning stock required to maintain recruitment is not known in most species.

Whether or not a species can maintain recruitment levels in the face of a low spawning stock biomass depends on the shape of the stock-recruitment relationship. Determination of this relationship is crucial for the major species.

Yield per recruit curves

This is important if particularly $F_{0.1}$ will be used as reference points. Yield per recruit curves are necessary also for estimating F_{msy} or F_{max} .

Conclusion

Fisheries management policies for Lake Volta initially were geared towards expansion and development of the fisheries. However the inception of active gears, the principal being purse seines and beach seines coupled with the increase in fishermen populations who use passive gears require a review of the previous management strategies.

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The Integrated Development of Artisanal Fisheries is adopting a scientific approach to management of fish stocks through the development of a fisheries management plan. So far, a stock assessment programme (which includes frame and catch assessment surveys), fisheries research programmes, socio-economic studies, environmental (limnological) studies are being actively undertaken.

The fisheries research programmes include, biological studies related to stock assessment which comprise determination of size and age at maturity, reproduction seasons and number of spawning times, feeding habits, prey-predator relationship food webs e.g. Length frequency measurements are also regularly taken for determination of growth parameters and also for use in VPA analysis.

Important studies on economic aspects will enable modelling on conventional fisheries development.

When the results of research activities, stock assessment and environmental studies are obtained, management strategies will be formulated. Following these will be determination of risks associated with the alternative strategies and cost benefit analyses, eventually leading to a management plan, the bases for modern fisheries management.

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An Overview of the Fish and Fisheries of the Volta Basin Dr C. Gordon

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Introduction

Fish and fisheries play an important role in the lives of most Ghanaians. It is by far the most important source of animal protein providing up to 90% in the diet of some of the coastal communities. It provides employment to an important proportion of the work force either as full time employment or as a part time activity. There are numerous secondary benefits, such as the role it creates for women as artisanal processors and traders. In addition, many species of fish and their habitats have special cultural importance. The inland fisheries provide about 20% of the annual catch and most of this is from the Volta Lake. The value of the fishery is estimated to be more than US \$ 120 million.

The entire Volta basin spans six countries, (Togo, Burkina Faso, Benin, Mali, Côte d'Ivoire and Ghana) and has a catchment of 165,700 square kilometres. The basin stretches across all the major ecological zones found in West Africa with the exception of the high rain forest. Its main rivers, the Black Volta, the seasonal Red Volta and the Oti River, flow into the man-made Volta lake which was formed in 1964 and was until quite recently, the largest man-made lake in the world. From the dam, the outflow enters almost immediately into the Kpong

Head pond, a smaller hydroelectric scheme which was constructed in 1981; from Kpong, the Lower Volta river flows 80 kilometres into the sea through the Ada estuary which lies between two large salt water lagoons the Songor lagoon to the west and the Keta lagoon complex to the east.

The construction of the Volta and Kpong impoundments resulted in significant changes to the environment and in the lives of the people both above and below the dam. It is anticipated that in the near future there will be major changes in the rate of implementation of development activities in the basin, which could in turn, have negative and lasting effects on the coastal zone of Ghana, an area which has been identified as being susceptible to environmental change (Ntiamoah-Baidu and Gordon, 1991), and an area where the lives of many of the local inhabitants are closely linked with their surroundings.

The general objective of this paper is to briefly describe the status of fisheries in the Ghanaian section of the Volta basin and to identify possible developments that are compatible with the sustainable use of resources. The paper also seeks to present an overview of the fisheries of the Volta, describing the existing situation, possible future developments and their likely environmental im-

pact; identify the data gaps and information requirements that need to be addressed for the sustainable management of the system.

Overview of fisheries research in the Volta basin

Pre-impoundment studies

Very little work on fisheries was carried out on the Volta system before the first of the two dams were built. In the pre-colonial and colonial periods, a number of collectors sent material from the then Gold Coast to western museums. Irvine (1947) was the first researcher to make extensive studies on the fish fauna, though Hilton (1947) had examined aspects of the fish and fisheries from a geographer's perspective. Roberts (1967) also made a qualitative assessment of the ichthyofauna of Ghana. The output of these studies was species lists and geographical ranges of the species found. The diversity of the ichthyofauna of the Volta system is high. Roberts (1967) has recorded 122 fish species in the Volta basin, this can be compared to the 134 species found in the much larger Niger basin. It must be pointed out that since the work of Roberts (1967) there have been no comprehensive basin wide faunal surveys of fish species. Due to the size of the area and the time available these workers did not visit many of the smaller tributaries.

Lawson (1963) investigated the clam fishery of the lower Volta, which employed 1500 - 2000 people, mainly women and provided an income of £100,000 (1963 Pounds). Before the creation of the Kpong Headpond, Vanderpuye (1982) as-

essed the fish fauna of the area that was to be impounded and presented species list and food habits of some of the fish found. Agadzi (1980) carried out a frame survey of the fishing industry in the area below the Akosombo dam, while Mensah (1978) investigated the fishing activities in the pre-impoundment area.

Post-impoundment studies

The Volta Lake was created over thirty years ago and, under a UNDP programme in its first ten years, was one of the best-studied African man-made lakes. When the UNDP Volta study ended in the 1970s, work was continued by the Volta River Authority (Volta Lake Research and Development Project - VLRDP); the University of Ghana (Volta Basin Research Project - VBRP) and the Institute of Aquatic Biology (IAB), a unit of the Council for Scientific and Industrial Research (CSIR). Unfortunately not much of this work has entered the available literature database, reports were produced and published as mimeographed reports with limited print runs and distribution.

The Volta Lake: In the past, a great deal of work was done on all aspects of the fisheries of the Volta lake. Most of these were carried out in the period 1967 - 1977 when there was active research into the Volta lake fisheries, and much of the work published since then on the fisheries of the lake are based on the data collected during this time.

Kpong: There have been several studies related to the fisheries of the Kpong Headpond after impoundment, though not as many as in the

case of the Volta. The overall potential and the constraints on the inland fisheries have been examined by Amatekpor et al. (1989).

The present fisheries resource base

Volta Estuary

The Volta estuary is made up of a 3 kilometre wide canal, from Big Ada down to the sea, which contains a number of islands. Since the regulation of the flow of the Volta River, there has been development of a sandbar at Azizanya which prevented sea water intrusion into the estuary. This resulted in extensive growth of freshwater macrophytes and the appearance of snail hosts of *Schistosomiasis*. This disease became endemic to the area, threatening the health and lives of the local inhabitants and tourists. In April 1989, a portion of the sandbar opened through natural causes and in 1990, the VRA commissioned a dredging company to enlarge the breach. This has allowed sea water to penetrate nine kilometres to reach Big Ada.

The important fish species and habitat requirements: Currently, because of the dredging, the composition of the local catch has changed to a more marine mix; mainly anadromous fish, which use the river for breeding. The common species are *Caranx hippos*, *Mugil cephallus*, *Ethmalosa fimbriata*, *Sphyraena sphyraena*, *Eucinostomus melanopterus*, *Macrobranchium spp.* and *Callinectes latimanus*. The numbers of *Macrobranchium spp.* have dropped since the canal was dredged.

Special fishing methods: Fishing in the estuary is mainly by conventional methods such as cast nets, gill nets and traps. There are different types of traps for the different species. Some of the traps are baited such as those for prawns (*Macrobranchium spp.*), baits range from just palm nuts to elaborate concoctions based on cassava and maize dough. When the clam fishery was operational, simple diving gear using airlines and boat based compressors were used by a few of the fishermen.

Catch estimates: It is practically impossible to get any idea of the size of the fishery, which is mostly a part time activity. The extensive growth of reed beds and aquatic macrophytes has created a very complex system of small channels and canals which makes it impossible to use morphometric features to estimate the potential catch. Attipoe (1991) reports that about 120 people were actively fishing *Callinectes* in the last quarter of 1990 with an income of 720,000 cedis per month. Using market prices, this is roughly equivalent to between 300 - 600 kilograms of crab harvested each month.

The Lower Volta River

The lower Volta is defined as the 80 kilometre stretch of river between the Kpong Head pond and Big Ada. Before the closure of the Volta dam, this stretch of water would have been described as a typical low land floodplain with a gently meandering river channel and a number of small seasonally flooded water bodies along its banks. Due to the regulation of river flows by the dam, the seasonal inundation of the margins has ended, which has caused many

problems for the Tongu people who inhabit the area (T-Vieta, 1989). There have been a number of proposals for freshwater prawn farming in the area below the Kpong dam e.g., Gordon (1989a, b), Hynes, (1989)

The important fish species and habitat requirement: The lower Volta had a very intensive clam fishery before the damming of the Volta river as reported by Lawson (1963), sadly the changes in limnology and hydrology caused the demise of the fishery. With the opening of the canal at the Volta mouth, the prawns found in the estuary have now moved back upstream to this area.

Special fishing methods: Clams, (*Galatea paradoxa* = *Egeria radiata*) are the speciality of the area, usually fished by women these were caught by wading in the shallow (1 -1.5 m) in areas of the river with a sandy bottom and feeling for the clams with the feet. Balarin (1988) describes how the young clams were harvested in December to January and stocked in demarcated areas at densities up to 1500 per m² and then harvested when grown in May - June. Traps are used extensively in the creeks and small water bodies that border the main channel

Catch estimates: As with the Volta estuary, there has been no comprehensive assessment of the fishery in this area. An estimate using expected yields from large slow flowing tropical rivers (Dunn, 1989) give a potential catch of between 240 - 800 tons per year. This does not take into account the contribution made by the creeks and other small water bodies. Small water bodies can have

quite a significant contribution to overall yields (Gordon, 1991).

Kpong Head Pond

The Kpong Headpond is 3600 ha. in area, with a mean depth of just 5 metres, effectively the headpond functions as a slow moving river fed by the flow through the penstocks of the main dam and the Akosombo gorge. The water is very clear due to sediment entrapment by the Akosombo dam and as a result there are large quantities of rooted and submerged aquatic macrophytes such as *Ceratophyllum demersum* and *Vallisneria aegyptica*.

In the Kpong Headpond the most abundant groups were the cichlids and the bagrids; in the gorge area the characids dominated (Ofori-Danso, 1990). This is to be expected; characids as a group prefer a more riverine habitat. Large quantities of small clupids *Pellonula afzeliusi* and *Sierrathrissa leonensis* are also found in the area.

Special fishing methods: The standard methods of fishing are used on the Kpong Headpond, two of the methods do deserve special mention; these are the use of mosquito netting to catch the small clupids (which are known as "one man thousand" and the wangara method. Clupids are caught with a net made of standard nylon mosquito or fly netting which is pulled through the water, usually near the banks and near the surface. In the wangara method, a standard gill net is set in a semicircle from a canoe and then the sides of the canoe and the water surface is beaten so as to drive the fish into the net. Nets are removed immediately, catch sorted

and reset. This technique is usually practised in teams of two.

Catch estimates: The catch from the Kpong Headpond has been estimated at between 300 to 600 tons per year (Futa, 1983), i.e. about 80 to 160 kg/ha/yr. which is in the range of shallow lakes given in Appendix B. Again the lack of reliable and up to date records preclude the precise estimation of actual yields.

Volta Lake

The Volta lake has a dendritic shape with a number of important arms and branches. The overall length of this vast water body is 410 kilometres with a maximum width of 25 kilometres. The extreme length of the lake means that it bridges two climatic zones, the northern part of the lake having a single peak of rainfall while the south part has a bimodal rainfall pattern. The maximum depth of the lake is found just behind the dam, (79 metres) and the mean depth is 19 metres. The maximum operating height is 84.1 metres a.m.s.l. and at this level the lake covers an area of 8,480 square kilometres, and has a volume of 165 cubic kilometres. The annual drawdown caused by dam operation is between 3-4 metres which, in turn creates a drawdown area of approximately 85,000 hectares. The mean annual discharge from the lake is 1,150 cubic metres per second. Some interest has been expressed on the use of the drawdown area for aquaculture (Gordon, 1988).

The important fish species and habitat requirement: A very diverse fish fauna exists in the lake ranging from remnants of the original riverine fish which are found in the upper reaches

of the arms, to several lacustrine communities occupying the littoral and deep water niches. Data from the Fishery Department indicate that the most important fish species (those occurring as more than 5% of landings) are Labeo, tilapia, Heterotis, Citharinus, Clarias and Synodontis.

Special fishing methods: All the usual fishing methods are used in the Volta lake: gill nets, cast nets, lines and traps, drive in gear - wangara, bamboo tube fishing for *Chrysichthys*, combinations of gill nets and fish traps - nifa as well as active gear such as beach seines - adranyi and purse seines - winch nets. It must be pointed out that the use of active gear is illegal but does produce 65 - 70% of fish landings (Brammah, 1992). Other fishing methods are in use including the acadja system which has been introduced by migrant fishermen from the coastal lagoons (Gordon, 1988).

Catch estimates: The sheer size of the Volta lake presents a major logistic problem in the collection of accurate fishery statistics. All the estimates are based on extrapolation from landed catches at marketing centres. These estimates indicate that there was a rapid increase in catch from the Volta which then fell and is now stable at around 40,000 metric tons per annum. The validity of the 40,000 ton estimate has become enshrined in the literature and must be questioned due to the huge increases in number of fishermen on the lake, but in the absence of any up to date information this estimate must hold for the time being.

Key fisheries issues

The issues here are defined as matters in dispute, and opportunities that may motivate or influence the creation and implementation of a basin wide fisheries resource management program. Such an action plan must aim at stabilising the supply of fish by the following measures: enforcement of legislation, improvements in capture technology, establishment of a fish information and marketing network, creation of preservation and transport infrastructure, provision of credit lines and investment packages and training. An over-riding issue is the lack of information, in the aquaculture sector, the use of Geographical Information Systems has proved valuable in resource mapping and in decision making (Gordon & Kapet-sky, 1991) and such techniques may very well be applied here.

Over-exploitation of Stocks

Over the years, the number of fishermen on the Volta Lake has grown steadily, from 18,358 in 1970; 20,615 in 1975 to over 80,000 in 1991. The key issue is, if the stocks are large enough to support the fishery. Henderson and Welcomme (1974) estimate that fishing effort of 1 - 3 fishermen per km² produces the maximum sustainable yields, more fishermen result in over-exploitation and consequent fishery collapse. At present the density of fishermen on the Volta lake is in excess of 9 per km², and it must also be noted that due to poor rainfall, the area of the lake is less than its quoted 8,500 km². Using the Henderson and Welcomme estimate - the fishery could be in danger of imminent collapse.

Fishing Gear and Methods

The major problem facing the fishermen is the lack of inputs (Bobobee, Chairman NICFC, pers. comm.). Among their requirements are hooks, netting materials, ropes, floats and lead as well as outboard motors. On the other hand the Fishery Department is concerned with the use of small mesh nets (down to 3 mm stretched mesh in some cases), the use of active gear and the spread of the acadja system into the lake. The concern regarding the use of acadjas is due to unknown side effects of the environmental change that the acadjas cause, coupled with the tree cutting, which is needed to provide the branches, used in the method. The supply of appropriate fishing gear (larger mesh sizes at subsidised prices?) can greatly influence the management of a fishery, but again not enough current information is available on the utilisation of fishing gear to give clear indications.

Aquaculture and Habitat Modification

There have been a few proposals for exotic shrimp culture in the coastal plain near the Volta estuary. Most attention has been focused on the exotic Black Tiger Shrimp *Peneaus monodon*. One venture, by the Ghana Prawn Company has carried out growth trials at Ada on this species using imported post-larvae. Due to high local costs of pond construction, some proposals have suggested the use of existing storage reservoirs at Songor lagoon for the culture of *P. japonicus*, which tolerates higher salinities than *P. monodon* (Gordon, 1989; Scura, 1989). Interest in large-scale ventures by local/foreign investors is keen and in

addition to the Ghana Prawn Co., which intends to develop 500 ha of pond area, the Managing Director of Kiku Co. Ltd. (the largest exporter of shrimp and prawn) also wants to expand his operations into shrimp culture (Addae, pers. comm.). The major environmental problem in shrimp farming is the destruction of coastal wetland habitat (Gordon, 1992b). The areas that are targeted first are salt marshes and mangroves. A farm of 500 ha. Water area, requires an additional quantity of land to provide for pond bunds, access roads and buildings. The coastal wetlands harbour large numbers of birds and other vertebrates. Mangroves and lagoons act as an important breeding area for many species of commercially valuable fish, including shrimp and prawn.

As large data gaps exist in the knowledge of coastal and littoral ecosystem functioning in the Volta basin, great care must be taken in site selection. It must be noted that the two areas most favoured as sites for shrimp culture (Keta lagoon and Songor lagoon) hold internationally significant populations of waders (Gordon, 1992b; Ntiamoa-Baidu, 1991; Ntiamoa-Baidu & Gordon, 1991). Though there are no fish farms currently operational in this sector, interest is great and it is only a matter of time before the first large scale shrimp farm begins to operate in the country. The potential environmental problems that may arise depend very much on the scale of operations, the species used and the level of management.

Fish Processing, Preservation and Marketing

Maembe (1991) estimated that about 10% of the fish caught from the Volta lake was eaten fresh, the remainder was either salted, smoked, sun dried or fermented. Most of this processing is carried out by women. The preferred method of smoking was by the rather inefficient round oven, which uses far more fuel wood than the Kagan, or Chorkor oven, which has been introduced with great success along the coast. One should take care not to upset the balance of fisherman/processor/fuel wood supplier, but with due attention the latter more efficient oven could be introduced to the lake side communities. At present fish caught are transported by whatever means available to the various market centres to be sold on the market days. The price is determined to a large extent by the purchaser. A formal marketing information network could perhaps help the sellers. Braimah (1992) presents a description of some aspects of fish marketing in the northern sector of the lake.

Capital and credit facilities

The NICFC cites the lack of capital as one of the major worries of their members. The need to raise capital to purchase fishing gear and for credit to tide them over periods of poor catch often places the fisherman in the hands of middlemen who then dictate to the fishermen prices of landed catch.

Institutional constraints

The Volta River Development Act (1961) effectively placed the ownership of the Volta lake and its immediate surrounds in the hands of the

Volta River Authority i.e. - to plan, execute and manage the Volta river development. Initially the VRA was active in the role of fishery development, distributing gear and outboard motors as well as supporting research. In the early eighties due to reduced revenues because of low water flows, the VRA cut back on its non-income generating activities. Most of the problems hampering sustainable fisheries development within the region can be linked with the serious underfunding of the Fisheries Department (MoA) and of the research institutions such as the VBRP. This has led to a situation where staff do not have even the most basic equipment and means of movement so as to carry out their duties. There was also a lack of co-operation and communication between the various organisations with interests in the area. The legal and policy framework is also quite vague in regard to inland fishery, the Fisheries Law 1991 excludes the operation of industrial or commercial fleets on the inland waters of the country which implies by definition, that all the fisheries must be artisanal. This does not do justice to the highly organised nature of some of the fisheries.

The lack of up to date information on an industry of the size and importance of the inland fisheries of the Volta basin is very serious. Even basic data on the biology of most of the commercial species is unknown, as is the extent of stocks, precise number of fishermen and the types and efficiency of their gear. Basic limnological and ecological data on the Volta is also seriously out of date as it is decades since the last full survey was carried out. The habitat re-

quirements of the commercial species are also an unknown - some work has been carried out on food organisms but nothing on the ecotoxicology of the fish. No work has been done to gather the information needed to carry out risk assessment of developments in the area. There many other data gaps but some of the questions that need to be answered can not even be framed due to lack of baseline information.

From the foregoing, it can be seen that there are serious data gaps, which coupled with institutional constraints, prevent the development of fisheries in the Volta system. The winding down of the VRA Volta Lake Development and Research Project, and the underfunding of the University of Ghana Volta Basin Research Project and the Fishery Department has resulted in a lack of any real player in the field of fisheries, and fisheries research of the Volta basin.

The Fisheries Department (FD) is the government designated body in charge of fisheries management. As mentioned earlier, underfunding and lack of resources have prevented the department from functioning effectively. A series of interventions are required to overcome the constraints that limit the department. These include the following:

- a redefinition of the role and function of FD staff in inland fisheries, with emphasis placed on an advisory role in the technical support of the extension staff of other departments

- greater support to the extension staff working on small water bodies and on coastal lagoons
- upgrading of the FD by incountry training at all levels in inland fisheries management and development.
- preparation of manuals, identification guides and teaching aids as an integral part of its extension efforts.
- improvement of the liaison between FD and other institutions involved in the utilisation of inland waters (IDA, GWSC, VRA, AESC etc.).

In conclusion, the need for integrated basin management for the Volta system is paramount. The FAO/IDAF Yeji project is a step in the right direction, fish and fisheries play a very important role in the lives of the people of the basin but development and management of fisheries without attention to internal migration and health, the reduction of pollutants into the lake and infrastructure development is doomed to failure. It is hoped that this document will make a useful contribution to the preparation of such an integrated management plan.

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Discussion on Aquatic Resources

- Question: Hon. Thomas Havor, (Adidome District Assembly): What relationship presently exists between District Assemblies in the basin and Fisheries Department in Fisheries development in the basin?
- Answer: Mr. C. Asafo: All decentralised departments have been empowered to closely collaborate with the local communities to determine how best resources could be utilised to the advantage of the local communities. In addition, the department of fisheries advises the communities to organise the fishermen into co-operatives to gain from supplies of inputs and other extension services.
- Suggestion Chairman: Fora like workshops could be organised for selected officials and fishermen, to formulate integrated development packages for adoption.
- Question: Hunnuor T.K. Bobobee, (Farmer/Fisherman, Lower Volta): What plans are in place to preserve the Clam industry?
What compensation is being planned for owners of creeks that were lost through the creation of the dam?
Fisheries Department should organise training of local fishermen (if possible with the help of the Navy) on how to effectively use diving gear. This is to help the use of the harpoon to fish matured fish in deep waters, to save the juveniles.
- Response: Mr. Kalitsi: There are no immediate plans to compensate individuals since it was done previously. The best forum for formulation of means of preserving the Clam is the present gathering. Everybody here should therefore help with ideas as to how this could be achieved.
- Question: Togbe Kwabla Avovuuttorii (E.K. Gamedogbae) wanted to know whether the assertion, that a basket put in the river turned out to be filled with Clam was true.
- Response: Mr. K.A.A. de Graft-Johnson The organism in question was not a clam but a different kind of bivalve. This was confirmed by the Institute of Aquatic Biology and Zoology Department of University of Ghana.
- Suggestion: Chairman :Control of water weeds is a big problem in Africa. Elsewhere they are being controlled by converting them into some useful forms. Researchers should go on study-tours of such areas to see what new solutions are being developed to address the water weed problem.

- Suggestion: Dr. Odei: Water hyacinth is being used as animal feed in Benin. nobody should be encouraged to breed it for ornamental purposes.
- Contribution: Prof. Okigbo: Researchers can review the literature to find out which particular method suits our needs to enable us apply some of such methods. This is in view of the observation that control measures seem to be regionalised.
- Question: Dr. S. T. Wen (Ministry of Health): Can we also try to utilise the water weeds especially Water hyacinth as sources of animal feed, energy, fertiliser, etc.?
- Answer: de Graft-Johnson: Most findings on these uses have been on experimental basis. No large-scale use has been an effective control. Anyway, the dangers involved in breeding outweigh the uses.
- Contribution: Chairman : No one should encourage breeding of Water hyacinth, since its infestation is becoming a problem everywhere it is found. Encouraging its uses means encouraging its continued growth and the potential dangers. Lucky it is not yet in our artificial lakes.
- Contribution: Togbe Anipati: There is the need for scientists/Researchers to be bold and tell what methods could be used to get rid of the weeds. He suggested physical means to provide jobs. He was also of the opinion that presence of weed has affected the clam industry.
- Response: de Graft-Johnson: Weed clearing (control) is very expensive and adequate funding must be provided for it.
- Contribution : Mr. Kalitsi: A gathering like this is mainly for collective identification of problems and collective solution. Let's work together to solve these problems, VRA will offer full support.
- Question: Mr. Kalitsi: What can be done to nip in the bud the eventual invasion of water hyacinth from Burkina Faso?
- Answer: de Graft-Johnson: It is necessary to educate and put everybody, especially the riverine people, on the alert. Any of it seen should be reported immediately for identification and immediate removal.
- Suggestion: Togbe Kwabla Avoruuttorii II: If removing the water weeds would be expensive, will it not be helpful to remove them gradually to enable the people to go about their clam fishing? This is in view of the resumption of fishing at Ada after the removal of the sand bars at Ada. He also suggested the dredging of river Korlor to help breed the clam and help the Tongu people.

Soils and Land-Use in the Volta Basin: State of the Art. Prof. J.K. Amatekpor

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Abstract

The basis of all land-use planning is the soil. For prudent land-use planning for agricultural and non-agricultural development, it is indispensable to have a reliable and detailed information on the soils, the climatic and socio-economic conditions of the area to be developed. This paper reviews the present available data on soils and land-use in the Volta basin, points out the deficiencies in the data and suggests the future research on soils and land-use that needs to be carried out to provide a sound basis for judicious land-use planning for sustainable integrated development in the basin.

Introduction

The soil is the basis of all land-use planning. According to the Soil Survey Staff (1993), land-use planning is the formulation of policies and programs for guiding public and private land-use in areas where different uses compete for the land.

A good knowledge of the characteristics and spatial distribution of soils in a given area is an important prerequisite for judicious land-use planning. Pedologists have always emphasised the fact that crop plants are sensitive to differences in soil properties and that different kinds of soil have unlike management requirements for economic sustained production. The selection and location of the right land-use in an available space depend wholly or partly on the proper interpretation of the soil conditions as they relate to climatic and socio-economic conditions in the area.

With regards to agricultural land-use Ahlgren (1948) stated, “The soil comes first; it is the basis, the foundation of any farming. Without it nothing: with poor soil, poor farming, poor living; with good soil, good farming and living. An understanding of good farming begins with an understanding of the soil”. In fact this statement is true with regards to any type of land-use.

The broad categories of land-use recognised by the Soil Survey Staff (1951) and FAO (1990) are:

- cropping (rainfed or irrigated).
- grazing
- forestry
- recreation
- mining
- urban development/settlements
- public services (e.g. roads, airports, electric power lines and cemeteries)
- wildlife/aesthetic preservation
- protected land; and
- reservoirs (natural or artificial).

All these broad categories of land-use exist in the Volta basin. Some of these land-use activities are quite compatible with the types of soil and climatic conditions in the area but some of the activities are incompatible with the soils resulting in land degradation, the extent of which is unknown in most parts of the Volta basin, at present.

The objectives of this paper, therefore, are:

- to review the present level of knowledge of soils and land-use in the Volta basin, and
- to discuss the future research on soils and land-use that has to be carried out to provide a sound basis for judicious land-use planning and sustainable development in the basin

Extent of the Volta Basin

The Volta Basin as a geographic unit, may be viewed in two ways. It could be seen as either

- the geological formations in Ghana known as the Voltaian Formations, or
- all the geographical area in Ghana drained by the Volta River and its tributaries.

The Voltaian Formations occupy about 40% of the total area of Ghana (i.e., about 95,415 km²) whilst the Volta Drainage Basin has, within the political boundaries of Ghana, a total catchment area of about 165,700 km² (i.e. about 70% of the total area of Ghana). The entire drainage basin of the Volta river, however, extends far beyond the political boundaries of

Ghana and spans six countries (Ghana, Côte d'Ivoire, Burkina Faso, Togo, Benin and Mali).

Within the Volta Drainage Basin (simply called the Volta Basin) of Ghana occur a variety of soils and various land-use activities.

Soils of the Volta Basin

Soil Survey in the Basin

Considerable data of varying quality exist on soils of the Volta basin. In fact, soil survey in Ghana was started almost half a century ago by the Soils and Land-Use Survey Department of the Gold Coast, now the Soil Research Institute of Ghana (SRI). According to Obeng *et. al.* (1962) the soil survey of Ghana started at a time when very little systematic soil surveying had been carried out in the Tropics. Ghana thus was far ahead of most African countries as far as systematic soil surveying is concerned.

The Soil Research Institute has divided the Volta Basin, as done for the rest of the country, into survey regions and basins. The survey regions within the Volta Basin are Lawra-Wa, Bole-Bamboi, Kitampo-Yeji, Tamale and Navrongo-Bawku, and the basins are Upper and Lower Kulpawn, Sisili, Nasia, Upper and Lower Oti, Daka, Dayi-Asukawkaw, Sene-Obosum, Lower and Upper Afram, Pru, Tain and Mole.

The soils in all these survey regions and basins have been inventorised and mapped. The intensity of these soil surveys are at the reconnaissance or the detailed-reconnaissance level

and the resultant generalised soil association maps are published at a scale of 1:125,000 or 1:250,000. Some of these detailed-reconnaissance soil surveys are published as Memoirs by the SRI, Kumasi, but most are still in draft forms, yet to be published. Examples of the published Memoirs are Adu (1969), Smith (1962), Brammer (1967), Adu and Stobbs (1981).

Some special public and private agricultural project sites in the Volta Basin are, however, covered by detailed soil surveys, using the soil series as the mapping unit, and the maps published at scale of 1:7,920 or 1:5,000 or larger. Examples of these detailed soil surveys are the Wenchi, Ejura, Tano, Wiaga, Atebubu, Nyankpala, Manga, Zuarungu, Kpong and Asutsuare Agricultural Stations. These detailed soil survey areas are generally small and far apart thus leaving extensive gaps that are covered by only reconnaissance surveys. Most of the detailed soil surveys of the agricultural project sites within the Volta Basin are published as Technical Reports and Miscellaneous Papers by the SRI, Kumasi and by some other pedologists and consultants. Examples of these Technical Reports are Adu and Jongerius (1963), Obeng (1963), Hammond and Ansah. (1970) Amatekpor (1970,1981), Obeng and Acquah (1973), Titriku (1982), Asiamah (1984,1985). Asiamah, and Senayah (1987) and Asiamah et. al. (1993).

Schematic/Generalised Soil Map of Ghana

From the climatic, topographic and soil maps available at the Soil Re-

search Institute, Obeng in 1971 compiled a generalised soil map of Ghana on a scale of 1:the Soil Research Institute published 1,500,000 and this. (See Fig. 1) The legend was based on the prevailing local Charter's (Brammer, 1962) classification system with the approximate USDA (1960, 1967), FAO (1968, 1970) and the French (1965) soil classification equivalents provided in the legend. This soil map of Ghana published by SRI, Kumasi, is too cartographically and categorically generalised to be used for any intensive land-use planning. At the scale of 1:1,500,000, one square centimetre (1 cm²) on the map represents 225 km² on the ground and, obviously, a lot of detail has been sacrificed.

It may be pointed out that since the publication of the generalised soil map of Ghana, both the USDA classification system and the FAO legend have undergone many revisions and thus most of the USDA and the FAO legends, as provided on the generalized soil map, are now obsolete, if not misleading. This statement applies equally to the USDA and the FAO soil classifications given in the SRI Memoirs and Technical Reports published in the 1960's.

As could be seen from Fig. 1, extensive areas, marked No. 1, are classified as Savanna Ochrosols and the USDA (1960, 1967) classification equivalent is given as Oxisols. The USDA equivalent is quite misleading. By present knowledge, the Savanna Ochrosols, at the high categorical levels of the USDA (1994) classification system, consist mostly of Alfisols (Ustalfs, Aqualfs), Inceptisols (Tropepts, Ochrepts, Aquepts)

and Entisols (Aquepts, Psamments, Orthents) and the true Oxisols are in fact of very limited extent in the area. Thus at the lower USDA categorical levels, the Savanna Ochrosols include a wide variety of soils each of which has its own peculiar characteristics and management requirements.

Also, in Fig. 1, the areas Southeast and Northeast of Bolgatanga, marked No. 8, are classified as Tropical Black and Brown Earths and the USDA (1960, 1967) classification equivalent is given as Vertisols. A recent field work in the Bolgatanga area by the University of Ghana, Department of Soil Science, Legon, revealed that less than 5% of the area mapped as Vertisol is occupied by true Vertisols according to the USDA (1994) system. The true Vertisols in the area occur in small-scattered patches on the bottom slopes of the rolling topography; the greater part of the area are occupied by Lithic and Vertic subgroups of Ustorthents.

Geology and Soil Associations in the Volta Basin

Soils within the Volta Basin vary mainly according to the variations in the climatic conditions and in the geological formations or deposits as modified by local topography over a period of time. The geology of the basin has been described by Junner and Hirst (1946) and Bates (1962). The geological formations from North to South of the basin are: the Birrimian (Middle Pre-Cambrian), the Voltaian (Lower Paleozoic), the Buem and Togo (Upper Pre-Cambrian), the Dahomeyan (Lower

Pre-Cambrian) and the Volta Alluvium (Recent). The weathered products of all these rock formations constitute the parent materials in which the various soils of the basin develop.

From the available generalised soil association maps and the detailed soil maps of the special agricultural project sites, the Soil Research Institute has been able to establish virtually all the local soil series names for all the geological formations and the climatic zones within the Volta Basin and these provide ready legends for any detailed soil survey that needs to be carried out in the basin.

International Classification of the Soil Series

In the following sections few examples of the soil associations or complexes as they relate to the pedoscape over each of the geological formations in the various ecological zones of the basin are described. An attempt is made to classify the soil series of the various associations according to the USDA Soil Taxonomy (Soil Survey Staff, 1994) for the purpose of international correlation. But, as pointed out elsewhere (Amatekpor 1993), present available data on most of the soil series of Ghana are so woefully inadequate as to enable precise international (USDA) classification of the soils. Therefore, the attempted classifications of most of the soil series according to the USDA system given in the following sections are to be regarded as only tentative.

Fig 1 to be inserted

Fig 1 key

Soils Developed over Birrimian Rocks

Soils over mafic Birrimian rocks, Interior Savanna Zone:

Over the mafic Birrimian rocks (e.g. greenstones/amphibolites) in the Interior Savanna Zone occurs, for example, the Mogo-Nangodi-Yagha-Kalini Association. The Mogo and the Nangodi series on the summit and upper slope respectively, are the skeletal and shallow members of the association (Lithic/Vertic Ustorthents) and the Yagha and the Kalini series on the lower and bottom slopes are the deeper swelling-cracking clays (Typic Calcicusterts and Ustic Epiaquerts/Endoaquerts).

Soils over Granitic Birrimian Rocks, Interior Savanna Zone:

Over the sialic Birrimian rocks (e.g. Bongo granites), occurs, for example, the Tongo-Bongo-Vea-Yorogo Association. The soil series of this association are light textured, usually coarse sandy loams to gravelly (ironstone concretionary) loamy sands. The Tongo and Bongo series are the skeletal/shallow members (Lithic Ustorthents), the Vea series, the deep member (Typic/Arenic Haplustalf) and the Yorogo series, the ironstone concretionary lower slope member (Typic Plinthaqualf) of the association.

Soils Developed over Voltaian Formations:

Soils over Voltaian Sandstones, Interior Savanna Zone:

An example of the soil associations, which develop over the Voltaian sandstones in the Interior Savanna

Zone, is the Damongo-Murugu-Dentenso-Tanoso Association. The Damongo Series (Rhodic Paleustalf) is the well-drained sandy loam to sandy clay loam developed mostly on the upper slope and partially on the middle slope of the gently undulating topography. The Murugu series (Typic Paleustalf), the Dentenso series (Arenic Paleustalf) and the Tanoso series (Grossarenic Endoaqualf) occur on the middle, lower and bottom slopes respectively.

Soils over Voltaian Shales, Interior Savanna Zone:

Over the Voltaian Shales in the Interior savanna, develops, for example, the Sambu-Kpelesawgu-Changnalili-Volta Association. The upland soil of this association, the Sambu series (Typic Plinthustalf), is an ironstone concretionary soil with frequent ironpan boulders occurring on and in the profile. The middle slope soil, Kpelesawgu series (Typic Plinthaqualf), is a yellow-brown, porous fine sand over imperfectly drained ferruginous gravelly clay; the lower to bottom slope soil, Changnalili series (Typic Plinthaquept), consists of grey and brown mottled loamy sand or sandy clay loam containing massive ironstone at relatively shallow depth; and on the wet bottom site occurs the Volta Series (Typic Fluvaquept) which is the deep alluvial grey and brown mottled clay or silty clay member of the association.

Soils developed over the Dahomeyan rocks, Coastal Savanna Zone:

Soils over Basic Gneisses and Schists:

Over the mafic Dahomeyan rocks (e.g. garnetiferous hornblende gneiss) in the Coastal Savanna Zone of the Volta basin occurs, for example, the Kloyo-Prampram-Akuse Association/Complex. On the steep slopes of the inselbergs occurs the skeletal Kloyo series (Lithic Ustorthent). On the undulating peneplain, the shallow (<75 cm) Prampram series (Vertic Ustorthent) and the relatively deeper swelling-cracking clay, the Akuse series (Typic Calciustert), occur on the upper to middle and the lower slopes of the gently undulating topography respectively. The spatial distribution of the Akuse and the Prampram series is usually complex.

Soils over Acidic Gneiss:

The Agawtaw series (Albic Natraqualf) develops over the acidic gneisses in the coastal savanna zone in the Lower Volta basin. The Agawtaw series consists generally of 15-20 cm thick of loamy sand topsoil underlain by compact clay-pan. Below the clay-pan lies a 100-150 cm thick pale grey clay containing frequent CaCO₃ nodules. The Agawtaw consociation normally occupies all topsites of the gently undulating topography over the acidic gneiss.

Soils Developed over Volta Alluvium, Coastal Savanna Zone:

Lower Volta Alluvium (Akuse-Ada):

Over Lower Volta Alluvium, occurs the Chichiwere-Amo-Tefle-Aveyime Association. The Chichiwere series (Oxyaquic Quartzipsamment) is the pale brown or yellow sandy soil developed on the levees along the lower Volta banks and on the abandoned levees alongside the cut-off channels. The Amo series (Vertic Dystropept) is the acid gray mottled silty clay occurring behind the high river bank on almost level land between the high river bank and the bottom lands or depressions. The Tefle series (Alic Dystraquert) is the gray clay in the depressions on the floodplain. The Aveyime series (Rhodic Paleustalf) is the well-drained red sandy clay to gravelly sandy clay developed on the old river terraces in the Lower Volta Basin.

Coastal marshes and lagoons

In this area occurs the Ada-Oyibi-Muni-Goi/Keta Association. The Ada series (Glossic Natraqualf) is the seasonally ill-drained, extremely acid, strongly mottled clay which is silty or silty clay at the surface with heavy compact clay subsoil, and may be underlain by loose yellow sand at 1.5-2.0 m depth. Gypsum crystals usually occur in the profile. The Ada series develops on ancient lagoonal deposits.

The Oyibi series (Vertic Halaquept) is the gray massive clay usually mottled orange and black in the subsoil and contains variable amounts of sand and is occasionally flooded with slightly saline water.

The Muni series (Fluventic Ha-laquept) is the alluvial lagoon sandy loams or sandy clays developed on the almost bare salt flats periodically flooded by highly saline water. It is often strongly mottled red, purple and black and contains abundant shells. The Keta series (Aquic Quartzispammments) is the pale brown to pale yellow loose sand soil developed on the coastal sand dunes.

Spatial distribution of soil series in the Volta Basin

From the preceding sections, it could be seen that there is a wide variety of soil series in the Volta basin. Although the Soil Research Institute has established soil series for all the geological formations in the various ecological zones within the basin, the actual spatial distribution of the various soil series in most parts of the basin is yet to be mapped. Apart from the few special agricultural project areas (less than 5% of the basin) where detailed soil mapping (using the soil series as the mapping units) has been carried out, the greater part of the basin is only mapped at reconnaissance or detailed-reconnaissance level and the resultant soil maps are only soil association maps. There is, therefore, the need to conduct detailed soil survey each time an area in the basin is selected for an intensive agricultural or non-agricultural project.

Land-Use in the Volta Basin

General situation:

All categories of land-use occur in the Volta basin, viz: cropping (rain-fed and irrigated), grazing, forestry, settlements, public services, wildlife

preservation, reservoirs (man-made and natural), protected lands, etc., but the current spatial distribution or pattern of these categories of land-use within the basin is not yet mapped and published in a single document for easy reference and for use by planners and decision makers.

Land-use Map of Ghana, including the Volta Basin:

As at present, the only land-use map covering the Volta basin is a generalised map on a scale of 1:2,500,000 (See Fig. 2). This generalised map was compiled in 1959 using mostly 1949-50 aerial photographs as the base map. In fact, the 1959 generalised land-use/cover map is nothing more than a vegetation map of Ghana at the higher categorical level, subdivided at a lower categorical level according to the type and intensity of farming (cropping and grazing); no other categories of land-use is indicated on the map.

Apart from the 1959 land-use map, information on past land-use and current land-use could be found in bits and pieces in various documents at varying scales and details. For example, most of the reconnaissance, detailed-reconnaissance and detailed soil survey reports published by the Soil Research Institute, Kumasi (formerly Soil and Land-Use Survey Department) contain land-use/cover maps which are essentially vegetation maps. Other institutions, such as the Forestry Department and the Game and Wildlife Department have also published partial land-use/cover maps covering their areas of concern, e.g. Maps of Forest Reserves and Wildlife Protected Areas of Ghana.

The land-use maps in most of the soil survey reports published by SRI are often supported by narrative statements which describes some of the other land-use categories and socio-economic activities in the area, but the actual spatial distribution of these other categories of land-use can only be imagined.

With regards to the distribution of settlements and public services (e.g. roads, airports, power lines), the Ghana Survey (Geodetic) Department published in 1973/74, topographical maps on a scale of 1:50,000 covering most parts of the Volta basin. Other parts are covered by topo sheets on a smaller scale of 1:63360. These topo sheets accurately show the spatial distribution of forest reserves, settlements, roads and other public utilities in the basin as at the time of publishing. These topo sheets therefore, constitute useful base maps for mapping and updating current land-use/cover map of the basin bearing in mind that a lot of changes in land-use/cover have taken place between 1974 and the present.

State of Present Land-use in the Volta Basin

Since the completion of the main Volta dam in 1964 and the Kpong subsidiary dam in 1981, drastic changes in land-use/cover have occurred in the Volta basin. The most significant change is the formation, behind the dam, of a 8,500 km² lake, the Volta lake, which in terms of area is the largest man-made lake in the world and, in terms of capacity, is the fourth largest after Kariba, Bratsk and Aswan.

According to Jopp (1965) the formation of this large artificial lake caused the inundation of some 738 villages with an estimated total population of about 80,000 people. Farmlands, estimated to be about 22,680 ha, cultivated to such staple foods as cassava, maize, guinea corn and yam and to commercial crops such as cocoa were all inundated. Apart from the cultivated lands, forest lands, including forest reserves, were inundated.

The 80,000 people displaced were resettled in 52 new resettlement townships. New farmlands were established and new roads were built to link these resettled townships. The creation of the 12 km² Kpong headpond also caused the displacement of some 7,000 people which were resettled in 6 new townships.

The regulated river flow downstream from the Akosombo dam has caused a sharp decline in the vibrant pre-dam river, creek and pond fishing industry in the Lower Volta basin. This led to migration of many fishermen, especially from the Tongu districts, to the lake area. According to T-Vieta (1989) in 1963 alone about 20,000 people migrated from the lower Volta area to the Volta Lake area upstream. At present, it is estimated that some 60,000 fishermen have moved to the Volta lakeshores since the formation of the lake and there are about 1,500 post-dam fishing villages dotted along the entire 4,800-km shoreline of the lake.

These fishermen use wood from the forest around the lake for smoking fish and for domestic cooking. The indiscriminate firewood collection

coupled with the increased shifting and rotation cultivation have caused extensive land degradation (deforestation and soil erosion) along the periphery of the lake. Thus the massive inundations, the new resettlement townships and fishing villages, the new roads, the increased farming and other land-use activities have all together changed considerably the pattern of the pre-dam land-use/cover in the basin, making the 1959 land-use map of Ghana very obsolete and of little or no use for present and future judicious land-use planning in the basin. It might be pointed out that the Volta lake shown in Fig. 2 was superimposed on the 1959 land-use map by the author to show the extent of land, including forest reserves, that has been inundated by the formation of the Volta lake.

Updating Soils and Land-Use Inventories in the Basin

Soil Inventories

As stated earlier, considerable data of varying quality are available on soils of the Volta basin. Soil series names have been established for practically all the geological formations in the various climatic zones of the basin, but detailed soil maps, using the soil series as mapping units, are available for only a few scattered special agricultural project sites in the basin.

Detailed soil maps in relation to the climatic and socio-economic conditions in the basin are the basic tools for land evaluation for any intensive land-use planning in the area. The long term soil survey action plan for Ghana should, therefore, aim at mapping the whole country, including the Volta basin, at a detail scale of

1:20,000, if aerial photographs are used as the base map, or at 1:50,000, if the current topographical sheets are used as the base map. The use of aerial photographs as base maps for detailed soil mapping in the field has advantages over the use of topographical sheets. Aerial photographs make stereoscopic viewing of the landscape possible thus aiding more accurate demarcation of the soil series boundaries in the laboratory and in the field. In New York State (USA), for example, the detailed soil map of every county has been mapped on aerial photographs and the final soil series maps are printed over subdued images of the aerial photographs mosaic. Thus, the soil series can easily be identified with the landscape cover making the maps very useful for all practical purposes.

Land-Use/Cover Inventories

It is no exaggeration to state that Ghana, at present, has no land-use map. The 1959 land-use map is not only obsolete but of little or no use for intensive land-use planning. With the latest developments in Remote Sensing (RS) and Geographic Information System (GIS) technology, Ghana should now embark on mapping a detailed land-use map of the Volta basin and the whole country for that matter. The intensity of the land-use map should be at the same scale suggested for the detailed soil map of the country, i.e. 1:20,000 or 1:50,000. The use of Landsat TM, or preferably, SPOT-XS images is ideal for the production of the detailed land-use/cover map at the desired scale. The digitized land-use map should be stored in a GIS for easy retrieval and updating as and when needed.

Conclusion

The soil is the basis of all land-use planning. At this stage in Ghana's developmental process there is an urgent need for a reliable detailed soil map and land-use map covering the whole country. The data obtained could be stored in a Geographic Information System. The digitized soil and land-use maps, stored with adequate climatic and socio-economic data, in a geographic information system for easy retrieval and manipulation, will provide decision makers and town and country planners with the necessary tools for judicious land evaluation for any development project, in the Volta basin. The initial cost of producing the digitized detailed soil and land-use maps and their storage in a GIS data base may seem prohibitive but, considering the ease with which retrieval and future updating of the maps could be done, the initial high cost of production of the maps will be more than justified.

Fig 2

Fig2 b

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Agriculture in the Volta Basin: Problems and Prospects. P.K. Titriku

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Accra).

Abstract

Agricultural activities within the Volta basin fall under four major land use or land utilisation types namely, rain-fed agriculture, irrigated agriculture, livestock rearing and fishing. The basin has a high potential for the production of some of the common staple foods and livestock in the country as is evidenced by production figures for some districts in Brong Ahafo, Northern, Eastern and Volta Regions. As an industry, agricultural production within the basin has its own peculiar problems especially those related to aspects of environmental degradation with emphasis on declining soil fertility and accelerated erosion with its attendant soil related constraints of compaction, surface crusting, high soil erodibility. As a result of intensified soil erosion, the lake is affected by downstream sedimentation and water eutrophication. Abiotic problems of soil moisture deficit as a result of variability of annual rainfall and inaccessibility to tracts of productive agricultural lands are also discussed. The Volta basin holds a high potential for the establishment of irrigation schemes that could alleviate the problem of moisture deficits and ensure continuous supply of agricultural commodities produced in the basin. The facilities as at now are woefully inadequate. The paper discusses development strategies that are being put in place by Ministry of Food and Agriculture to enhance the prospects for the full realisation of the agricultural potential of the basin in a manner that will guarantee environmental integrity and continuous supply of agricultural commodities - two prerequisites for the export markets.

INTRODUCTION

Agriculture is the principal industry within the Volta Basin and its practice follows the general pattern of Agricultural Land Use in the country. The Basin includes some of the most important agricultural districts noted for the production of cereals (mostly maize) and tuber crops such as yam and cassava.

In the Lower Volta Basin comprising the Accra and parts of the Ho-Keta Plains, livestock rearing constitute a very important agricultural activity. As an industry, agricultural produc-

tion has its own peculiar problems especially those related to land degradation and general production constraints. Agricultural activities in the basin fall under four main land use or land utilisation types namely; rainfed agriculture, irrigated agriculture, animal husbandry and fishing.

Agricultural Potentials of the Basin

Rainfed Agriculture

By far the most common type of land use is rainfed agriculture based on the Land Rotation farming system, also known as bush fallow system.

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The majority of the farms are small subsistence-type farms (0.5 to 3 ha) which produce the common food crops of the country.

Production figures for three major food crops - maize, yam and cassava - in some of the districts immediately

bordering the lake as presented in Tables 1,2, and 3 illustrate the agricultural potential of the basin. The source of the data in the Tables is PPMED, MOFA, Annual Sample Survey of Agriculture 1994.

Table 1 Maize production figures of districts within the Volta basin.

Districts	Area cropped (ha.)	Production (MT)	% of regions production.
Atebubu	4,000	3,370	2.4
Kintampo	10,600	27,560	26.9
Bimbilla	6,400	7,680	19.5
Salaga	9,960	9,048	6.4
Kwahu north	11,500	21,850	9.7
Asogyaman	6,300	15,120	6.7
Nkwanta	4,700	8,460	13.8
Kete-Krachi	3,500	6,300	10.0

Table 2 Yam production figures of districts within the Volta basin

Districts	Area cropped (ha.)	Production (MT)	% of regions production.
Atebubu	13,160	94,752	26.6
Kintampo	4,100	59,276	16.8
Bimbilla	6,000	78,000	20.7
Salaga	6,100	61,000	16.2
Kwahu north	19,800	366,300	90.9
Asogyaman	-	-	-
Nkwanta	4,500	49,500	31.8
Kete-Krachi	5,200	67,600	43.4

Table 3 Cassava production figures of districts within the Volta basin

Districts	Area cropped (ha.)	Production (MT)	% of regions production.
Atebubu	14,000	132,540	11.5
Kintampo	2,2900	22,900	2.0
Bimbilla	4,200	31,500	24.1
Salaga	3,100	14,570	11.2
Kwahu north	9,900	120,780	6.5
Asogyaman	10,000	182,000	9.8
Nkwanta	13,000	234,000	32.0
Kete-Krachi	8,000	144,000	19.7

Livestock Production

Similarly, livestock production figures for selected districts in the basin indicate that there is a great potential for livestock development. Population figures for cattle, sheep, goat and pig for some of the districts located within the basin are presented in Table 4.

Fishing

The bulk of freshwater fish consumed in areas around the Volta Lake and beyond is got from the Volta Lake. The amount of fish caught from the Volta Lake ranges between 0.9 to 1.8 per cent of the total fish catch in the region between 1989 to 1994 (Fisheries Dept. Volta Region, 1994). The breakdown of total amount of fish caught from the Volta Lake as compared with those from marine and other sources is presented in Table 5.

Irrigated Agriculture

In spite of the vast areas in the basin suitable for irrigated agriculture, there are only a few schemes dotted along the lake. These are the Kpando Torkor scheme in the Volta region noted for its okro and other vegetable production. The Amate and Dedeso schemes which are no longer viable because of recession of the lake from the original sites coupled with lack of easy access to the sites and, in the Lower Volta Basin, are the Kpong Irrigation Project at Akuse (the single largest scheme within the basin) which specialises in rice production and the Asutsuare Irrigation Scheme. Apart from the above, there are some private irrigation schemes found within the basin. Notable amongst

them is the Volta Farms on the flood plains of the Volta river below Akosombo which is producing banana for export.

Problems

The major problem affecting agricultural production in the basin like in any other part of the country are those related to land degradation resulting from poor land and water management. Other equally important problems can be classified as Natural and Human. Under the Natural factors is rainfall variability and unreliability leading to moisture deficits - a major limiting factor to agricultural production. The Human factors include poor accessibility to productive agricultural lands, low input use due to lack of credit to farmers, inefficient farming methods and finally institutional problems such as inadequate extension services to the local farmers.

Agriculture and the Environment

There is an increasing conflict between agricultural production and the environment in Ghana. This is due to the accelerated demand for agricultural land due to population growth and lack of alternative employment opportunities in the rural areas. There is now a crises situation as a result of deforestation, overgrazing, increased cultivation frequency in densely populated areas, loss of biological diversity and various forms of pollution and contamination (Ofori, 1995).

Table 4 Livestock production figures for districts within the Volta basin.

District	Cattle	Sheep	Goat	Pig	% of regions production
Atebubu	13,796	14,946	17,338	8,889	10.7
Kintampo	19,689	30,218	19,800	3,182	14.1
Kwahu North	19,300	16,581	13,290	4,132	13.2
Manya-Krobo	18,065	8,879	8,312	2,764	9.4
Bimbilla	28,094	19,960	17,762	7,841	6.0
Salaga	22,371	14,969	9,646	1,127	3.9
Juapong	31,754	5,653	2,773	813	4.0
Adidome	20,191	12,017	16,635	2,119	5.0

Table 5 Comparison of fish production figures from the Volta lake with those from marine and other sources in the Volta region between 1989 and 1993.

Year	Marine (MT)	Volta lake (MT)	Small dams (MT)	% produced from Volta lake
1989	15,392.11	158.44	0.65	1.0
1990	16,236.08	156.38	6.77	0.9
1991	10,200.78	147.00	4.10	1.4
1992	16,297.79	198.10	3.20	1.2
1993	9,690.12	179.40	2.80	1.8

In the Volta Basin, the problem has been aggravated by the formation of the lake which forced people to encroach on marginal farming lands including the steep hill slopes on the Eastern flanks of the lake.

The problems of land degradation in the basin are two-fold:

- i) declining soil fertility and
- ii) accelerated soil erosion on bare lands.

Declining Soil Fertility

The Volta basin has the greatest potential for farming because of the vast and extensive soil resources, which are generally suitable for both mechanised farming and hand tools.

However, over the decades these agricultural lands have been subjected to arable crop farming under land rotation cultivation, which is commonly associated with shifting cultivation. Due to improper farming and cultural practices such as bush burning and deforestation, the soils have been "mined" to such an extent that crop yields are on the decline. Traditional methods of restoring soil fertility under shifting cultivation where cropping for short periods was followed by long fallows are no longer sustainable.

The evidence of declining soil fertility could be deduced from yield estimates in some of the agricultural districts in the basin. For instance, yield estimates for cassava in Ate-

bubu district which ranks second in the production of the crop in Brong Ahafo Region is 9.40 metric tons/hectare and for maize it is less than 1 (0.83) metric ton/ha. Under optimum conditions of climate and soil type yields of 25-30 tons per hectare could be obtained for cassava and 4.5 metric tons/ha for maize.

Such shortfalls in yield under traditional agricultural practice could be attributed partly to low fertility. The maintenance and management of soil organic matter is a critical factor for the amelioration of all soil related constraints limiting crop yields.

Accelerated Soil Erosion

In almost all cases, traditional farming methods involve the removal of natural vegetation as part of land preparation. This practice in addition to fuelwood extraction, and the cutting of young trees and shrubs by fishermen for the "Atidza" fishing methods make the soils in the basin vulnerable to various hazardous processes that can have negative effects on agricultural land and other human resources. Some of these effects include compaction, surface crusting and accelerated erosion. Soil erosion caused by rainfall runoff results in downstream sedimentation and water eutrophication. With these conditions prevailing in the basin, water quality degradation in the lake is increased as an off-site effect in which the upstream runoff entering it is loaded with pollutants from agricultural areas.

Similarly, non-point source discharges into the lake occur primarily during rainfall events when storm

runoff from the land surface carries sediment, pathogens, absorbed chemicals, dissolved metals and easily oxidizable organic matter.

Land degradation due to accelerated erosion through improper land use practices is one of the greatest problems in the basin today.

Moisture Deficits as a result of Variability of Rainfall

Water is just as important to agriculture as land, capital and labour. It is the limiting factor in agricultural production in Ghana, and the Volta basin is no exception in this respect. The greater part of the Volta basin lies in the middle belt of the country otherwise referred to as the Transitional belt. There is a great variation in total rainfall which occur within the area. The magnitude of the rainfall variations for both monthly and annual amounts is one of the most important factors in crop production in the basin. Smith G. K. (1962) observed that the annual rainfall extremes range from 1920 mm to 1128 mm at Ejura; from 1776 mm to 764 mm at Kete Krachi; from 1848 mm to 960 mm at Akokoa; and from 1536 mm to 936 mm at Atebubu.

Monthly rainfall extremes are of an even greater magnitude than yearly extremes. He further noted that it is not unusual for an entire month in a season customarily regarded as too rainy, to be without any significant amount of rain. This phenomenon is of great consequences to agricultural production in the basin since most of the soils are sandy in texture and become draughty in the absence of adequate moisture. Therefore, in order

to harness the full agricultural potential of the vast lands in the basin, there is the need to improve on the infrastructure facilities for irrigation.

Irrigated Agriculture

There are extensive lands within the Volta basin very suitable for the establishment of irrigation schemes. Mpaha area for instance was identified as far back as the colonial period as very suitable for irrigation. The Irrigation Development Authority has identified stretches of irrigable land from Kintampo to New Longoro. Within the white Volta basin about 100,000 hectares of land has been identified for possible investment in irrigation schemes.

The major problems militating against the investing in the schemes are sources of power, accessibility to the sites and the sparse population or lack of human settlement to benefit from the schemes.

Electrification of the country has not been very favourable to the rural areas like the areas identified for irrigation schemes. This means that most of the projects if they are to be implemented, will have to depend on diesel power. The cost of diesel to run the engines will not allow for cost effective operation of the project. Until such time that solar energy could become a possibility for such schemes and at a cheaper cost, it will be difficult to expand irrigation within the basin.

There is the problem of communication, in terms of lack of access roads to possible irrigation sites. Irrigation schemes should be for people. Since some of the potential areas are thinly

populated, siting the schemes should be carefully done in order that they do not become white elephants.

Animal Husbandry

The Volta Basin again holds a bright future for animal husbandry in view of the fact that a greater part is under the savanna vegetation. In spite of the production in the districts referred to above, there is evidence that there is low production performance, probably due to the following: few farmers own livestock, poor husbandry skill, parasites and diseases. Grazing areas are not limited but the nutritional value of the grasses and herbage is low.

There is also the problem of limited extension and veterinary supplies and services. The absence of improved pastures necessitates husbandry men to start early burning in the dry season in order to accelerate the regrowth of fresh vegetation for livestock. This is also a problem which in a way contribute to land degradation and wanton destruction of farms and lands.

Socio-Economic Constraints Militating against Land and Water Management in the Traditional Farming System

The problem of land degradation as it is prevalent in the basin presently is not a new phenomenon. In the late forties and early fifties, due to concentration of population in the North-Eastern parts of the then Northern Territories (now Upper East), pressure on the land, primitive farming methods and annual burning of the grass led to widespread soil erosion

and soil deterioration. There is always the tendency for Government authorities to take drastic decisions to prevent further land degradation under such circumstances. For instance in 1947, a conference of Administrative, Agriculture and Forest Officers together with representatives of other interested Departments was convened to discuss the problems which had arisen in the North-Eastern Territory as the result of circumstances described above. At this conference, it was decided that wholesale eviction of the population from vital watersheds however desirable in theory was not practicable, Clacey *et al* (1950). It was therefore agreed that the watersheds concerned be declared Land Planning Areas.

In the same way, it will be very difficult to prevent populations on the mountain fringes of the lake from practising any form of agriculture because of the adverse effects on the lake.

Farmers perceive land degradation as a problem, however, soil conservation is not a priority for them. It is natural that people use their labour, time and resources to an activity only if they clearly see that the activity is beneficial to them. In the case of activities like growing maize, raising chicken, keeping dairy cows, the link between effort and benefit is very clear. However, there are areas where the link between effort and benefit are blurred. Village woodlot, preventing bush fires, contour ridging etc., are some of the examples.

Prospects

The prospects for realising the full agricultural potential of the Volta

basin will depend on development strategies that are put in place to enhance agricultural sustainability and soil resilience.

There are a multitude of interacting factors that affect soil resilience. These are broadly grouped into two categories: a) endogenous and b) exogenous. Endogenous factors are related to inherent soil properties and micro - and - meso climate. Land use, soil, crop and livestock management are important exogenous factors. Lal R. (1993).

The choice of an appropriate use for the land and the adoption of science-based, improved technology play a major role in restoring soil productivity. Together they can enhance and sustain high productivity and accentuate the resilience of even fragile soils in ecologically sensitive regions. Adopting an appropriate land use and implementing science-based, improved technology are particularly crucial to sustainable use and resilience of soils which have either been degraded due to past misuse, or which have inherent constraints, such as shallow depth, steep terrain or high erodibility.

Sustainability of Farming Systems

Sustainability is determined by the complex interactions of the biological, physical and socio-economic factors that underlie production systems. Any development strategy or option to enhance sustainable agricultural development in the basin must aim at an ideal regenerative agricultural system that will integrate crop-livestock systems. This calls for an intensive and integrated crop-

ping systems that will entail recycling of organic matter, crop rotations, alley cropping as practised in agroforestry.

The success of regenerative agriculture will solve the problem of soil fertility decline, and minimise the use of chemical inputs such as fertilizer or pesticides. However, it may not be feasible to eliminate chemicals on a farm scale under our tropical conditions due to heavy rainfall (leaching) and high humidity, which promote the incidence of diseases. Inorganic fertilizers, coupled with the effective management of organic matter are critical for the intensification of traditional farming systems to meet immediate demand for food production.

Promoting Regenerative Agriculture

There are plans or proposals for the establishment of sedentary or organic farming in some parts of the Brong Ahafo Region. Also, there is a programme under the Agricultural Development Bank (ADB) for the establishment of Block farms. The conditions in the Volta basin are quite ideal for such a venture, but its success will depend largely on the effective land-use planning based on the inventory of soil resources in the basin. It will be easier to promote intensive and ecologically appropriate agriculture on block farming system than in the present traditional shifting cultivation.

Effective Land and Water Management

Hitherto, there had not been any conscious effort at disseminating infor-

mation to farmers with regard to soil and water conservation. Farmers are aware of the problems but have no immediate solutions to them. The high rate of illiteracy among small-scale farmers is yet another constraint in delivering land and water management extension packages.

The Land and Water Management component of the intersectoral Ghana Environmental Resource Management Project being sponsored by the World Bank/Danida and implemented by MOFA aims at solving land degradation problems at community and individual levels. The community-focused approach of the project component aims at improving the management of village land and water resources in order to promote sustainable rural and agricultural development. The strong community-based approach involves building community awareness, planning and deciding with them on how to manage the land for sustainable use. The project, which is being introduced into the regions in phases, will benefit districts and regions within the basin.

In general, however, soil conservation efforts become futile when people do not have title to land. One big problem that will negate any land and water management in Ghana is the Land Tenure System. Links between effort and benefit can be made in a number of ways: by encouraging ownership, improving tenancy policies and promoting traditional individual user rights.

Expansion of Irrigation Infrastructure

It is now a common fact that Ghana can no longer depend on rainfed agriculture alone if she is to meet her domestic food demands at the same time develop the capacity for the export market. The Government realising this has put in place proposals to develop small-scale irrigation projects wherever feasible and to be managed by the local people. In Nkwanta and the Kete Krachi districts in the Volta Region about 200 hectares each have been identified and the schemes are on the drawing board and will be implemented when funds are available. Similar schemes have identified in the Hohoe, Kintampo and Atebubu districts, Togbor H. A. (pers. Comm., 1996).

There is however the need to shift from arable crop and vegetable production under these schemes to tree crops, such as mango, cashew, avocado to add value to the country's agriculture and to expand the market for the non-traditional export crops.

Conclusion

The greatest problem in the Volta Basin with regard to agriculture is that of land degradation in all forms.

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There is the need to formulate programmes that aim at environmental sustainability and integrity. In order to achieve this, there must be proposals to manage the Volta Basin as a watershed. The management of the basin as a watershed will entail the process of planning and carrying out courses of action to mitigate the degradation of the soil and water resources. In this way, all aspects of its physical-biologic, socio-economic and political functions will be fully explored for planning and management purposes. In selecting the most effective management options, considerations must be given to: agronomic and environmental effectiveness; practices that promote productivity and commodity quality, in addition to their effect in conserving soil and controlling pollutants loads, sediments, nutrients and pesticides. Economic and social feasibility; selected practices should be within their success. Implementability should insure that the proposed practices are technically feasible legal and simple in administrative requirements.

It is gratifying to note that the Land and Water project being implemented by the Ministry of Food and Agriculture is community-based and on micro-catchment basis.

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Discussion on Agriculture/Soils and Land Use

Contribution: T.W. Havor (Adidome District Assembly): The Volta River Authority should help initiate an irrigation project especially between Dafor and Adidome, by re-channelling the Korlor and Alabo streams. This would help provide enough farmlands. People drifting to the Upper areas will descend to the Lower, to farm and settle.

There should also be the construction of fish ponds in these areas.

Question: B. O. Antwi (Soil Res. Institute): How can detailed soil survey be made affordable to the poor farmer? Are there any alternatives?

Answer: Prof. Amatekpor: Reconnaissance survey methods could be used to cut down costs but these will give only approximate results.

Question: Chairman: Considering the traditional ways of knowing which soil type was good for a particular crop, what is the need for this modern, sophisticated and expensive soil survey?

Answer: Prof. Amatekpor: Detailed study of the soil properties is indispensable for sustainable use of the soil resource.

Comment: B. O. Antwi: Farmers should be encouraged to cultivate hillslopes if there is scarcity of flat land. Hillslope farming is safe if it combines trees and grasses. Roots of trees loosen the soil and the grass act as barrier or filter units. On the reduction in rainfall amount, a catchment planning could be initiated where water is harvested at a higher elevation and channelled through canals at lower levels. This should be done with our social set-up in mind. Also small impoundments (ponds) to regulate water flow.

Question: Mrs. M. L. Kumekpor (Res. Fellow, I.S.S.E.R., Legon): It is obvious that the problem is beyond soil. Climatic change and population agglomerations also impact on soil conditions. Can there be a policy intervention?

Answer: Prof. Amatekpor: This calls for a multidisciplinary approach to the solution to include especially farmers socio-economists and soil scientists.

Question: H.T.K. Bobobee, (Farmer/Fisherman, Lower Volta): Before the creation of the Dam, the river was overflowing its banks regularly each year. This flooding left alluvial soil for farming. This is not so now. Can fertilisers be given out at subsidised rate?

Response: Mr. Titriku: Farmers could water crops and supplement with organic manure. They should not rely only on synthetic fertilizer.

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Contribution: Matthew Adombire (G.W.S.C.) :The development of the Volta Basin must be on an integrated and sustainable basis. The G.W.S.C. has finalised preparations for the construction of water supply treatment facilities at Ada and Sogakope en-route to Keta. Fears now are possible intrusion of sea water following dredging of the lake. The dredging is supposed to be beneficial in all aspects. We need to look at this conflict of interest.

Contribution: Mr. Peter Kpordugbe (N.S.S.): What prevents the utilisation of students (undergraduate and post-graduate) to solve some of these problems at a reduced cost? Large numbers of students could be made to support extensive development work.

Response: Prof. Amatekpor: These utilisation of students is being done. The problem is the provision of adequate funds for its sustenance.

Response: Mr. Titriku: Soil conservation would require the services of “front-line” farmers, who must be involved in addition to deployed youth and students.

The Effects of the Volta Dam on the People of the Lower Volta **Dr. Joe Geker (Togbi Anipati III)**

Department of Agric Extension
University of Ghana
Legon

Introduction

The effects of the Volta dam on the people of the Lower Volta are well known and have been articulated by citizens of the area on many occasions - in the news media and on public occasions. The Volta dam was completed in 1964. The completion of the dam led to the formation of a lake, which was projected to be the largest man-made stretch of water in the world. The Volta scheme was primarily to provide hydro-electric power for an aluminium smelter at the port city of Tema. The availability of cheap electricity would, as envisaged, create a rapid industrial revolution with inevitable rise in standards of living throughout the country. Additional benefits from the Volta scheme included a large freshwater fishery and a cheap inland water transport system and availability of water for irrigation of farmlands.

The Lower Volta area, between Akuse/Amedeka and Ada, is inhabited by the Tongus made up of Thirteen (13) Traditional Areas: Fodzoku, Torgorme, Dorfor, Volo Battor, Mepe, Mafi, Bakpa, Vume, Tefle, Sokpoe, Fieve and Agave. The main sources of income for a large proportion of the population are farming, fishing and clam picking. Agriculture production in the area consists mostly of crops such as

maize, cassava, sweet potatoes and groundnuts.

Before the dam was built the Volta River was characterized by its annual flood that began to rise in July reaching its peak in August and falling by October. The annual floods watered low lands and creeks. The floods also deposited fertile alluvium. Agricultural productivity was significantly greater when crops were produced on land which had been flooded by the previous flood, than when crops were on uplands not affected by the flood.

Production in the Lower Volta post Construction of the Dam **Crops**

Crop yield was greatly reduced; creek agriculture diminished because there is no longer natural irrigation by flooding. Production fell due to the lower yields obtained from upland farms.

Fishing

There were three sources of income from fishing in the lower Volta.

- from river fishing
- from creek fishing and
- from clam picking.

Of the three, the most important source of income was from clam production undertaken mostly by women. The loss of income from fishing and clam picking seriously

affected the livelihood of the people. The fishermen including many of youth have left the area some permanently to the lake fisheries.

Economic Growth

In 1954 an economic survey was made of the lower Volta by one Lawson who pointed out that "The people in the area between Akuse and Tefle depend on the river for their livelihood. The annual floods largely afford natural irrigation and also fill the numerous creeks which, after the floods subside, yield large quantities of fish". Lawson further predicted that "after 1964 the annual flooding will cease. The area will consequently undergo further changes which must alter the entire economy". That is what has actually happened. It is clear that the Volta River Authority knew what would happen to the people of the Lower Volta Area but did nothing about it. The authority focused its attention to the area up the dam leaving the people down the dam uncatered for.

The Impact of the Dams on Local People

The Akosombo Dam with its sister Kpong Dam has brought hardship to the people of the Lower Volta. Not only has the economy of the area declined but also have brought water borne diseases to the people especially bilharzia. The river is also choked with river weeds and grasses which harbour snakes and other dangerous reptiles.

The people have been shouting and appealing for help. For a long time nothing was done to help them. Even the electricity generated by the dams was not extended to them. It is now

that help in the form of electricity and roads have started coming to the area.

The Tongu Union in a position paper addressed to the Chief Executive of the Volta River authority, dated 3rd July 1987 on the Volta River Authority, Ministry of Agriculture and settler farmer/Fisherman relations And some problems Down stream, pointed out issues involving Tongu citizens living Upstream who were being harassed by the former landowners. On the issue of using unapproved fishing gears, the Union asked the Ministry of Agriculture to clarify its position on the use of those fishing gears as the directives from the Ministry and the fisheries coordinator were not only unclear but contrary to Fisheries regulations made by the MOA itself. These unclear directives had led to the harassment of the Tongu Settlers by the local people and the police. It had also led to the death of some of the settlers.

On the problems of people living downstream-Lower Volta, the Tongu Union had this to say "The Tongu District stands astride the last 110km about (70 miles) stretch of the river Volta before it drains into the sea. It is the main location south of both the Akosombo and Kpong dams, and the negative effects on downstream locations of such huge dams have been overwhelming the district's development, health of its people and the prestige of Tongu's ever since.

The Tongu District can be singled out to date as having made the greatest sacrifice towards Ghana's development of the Akosombo and Kpong

hydro-electric projects. Viewed in terms of communal loss and continuing deprivation without any compensatory relief and alternative measures, the district's excellent drinking water source and prosperous economic life which centered in the past on the seasonal regime of the Volta have been disrupted and destroyed. It therefore becomes true to say that if electricity has been the backbone of Ghana's industrialisation and social advancement, then it is currently being done at the expense of Tongu's good drinking water, health and economic life. As an integral part of Ghana, Tongu should be assisted to progress with the rest of the country. It therefore becomes national issue for which natural resources should be directed to redress the deprivations we have suffered for too long.

The position paper summarized the problems as follows:

- The almost stagnant water in the river has resulted in water-borne diseases such as bilharzia along the Tongu stretch of the River;
- The increasing incidence of guinea worm is noticeable in much of Tongu;
- Farming and fishing activities along the River have been seriously disrupted;
- The very profitable oyster (clam) fishing has almost ceased.
- Most of the many lagoons and creeks have dried up since there are no floods to replenish the water and fish stock;
- Migration of about 20,000 people in 1962-63 alone followed the damming of the river.
- The once cheap and reliable river transportation between Tongu

towns and villages has been crippled;

- There is loss of dignity of the Tongu people caused by their exodus to fishing grounds along Volta Lake, characterised by hostile reception and continued resistance from, and degradation by the indigenous people.
- With the drying up of the water-source, many stock-farmers have been forced to abandon animal rearing in the area.
- The migration of elders and those who uphold tradition and maintain discipline resulted in juvenile delinquency, poor school attendance and decline in moral standards.
- The District Council loses considerable revenue due to the absence of some many citizens.

In the event of the two dams overflowing or breaking, Tongu alone stands to lose most. This is a real scare that should compel the government to help improve the living conditions of the inhabitants there.

Recommendations

The Volta River Authority and the Government need to come in a big way to help the people by:

- Improving the roads in the area.
- Building, rehabilitation and equipping schools in the area.
- Giving the people portable drinking water.
- Giving the people health and sanitation facilities.
- Setting up agro-industries in the area.
- Removing the river weeds.

Mitigative Actions taken by the VRA on Dam Affected Communities **F.K. Yeboah**

Director of Real Estate and Environment
Volta River Authority
Accra

Introduction

The construction of the two dams on the Volta River at Akosombo and Akuse has brought great benefits to the country. These dams have led to the production of electricity for both industrial and domestic use. The present production of electricity from the two dams is estimated to be about 1,072 megawatts¹. Not only does it supply the domestic market but there is also export especially to Togo and Benin. The benefits from the production of electricity on the Ghanaian economy cannot be over emphasised.

The creation of the Volta Lake behind the dam has also brought many other beneficial effects on the economy of the country. Fish production on the Lake has led to an increase in protein intake of many Ghanaians especially those living around the lake. Fish output from the lake reached a maximum of 60,000 tons per year in 1968, but it is currently estimated that fish production from the lake is now 40,000 tons per year². The fishery industry on the lake is estimated to employ over 100,000 people. The total estimated contribution to the economy annually from the fishing industry on the lake is currently put over 40 billion cedis annually.

The lake has also enhanced transportation between the north and the south. Imports into the country meant for the north can now be cheaply transported by the Lake to the north. The Volta Lake Transport Company established by the Volta River authority has helped in this area. Currently not only is that company transporting dry cargo from north to south and south to north but wet cargo made up essentially of petroleum products is now being transported cost effectively from south to north. There is also established on the Lake an indigenous transportation system that is enhancing the transportation of fish and other local agricultural products from producing areas to marketing centres dotted around the Lake.

It must be also mentioned that this great expanse of water has brought about possibilities for the irrigation of large tracts of land especially in the Afram plains and in the Accra plains. Experiments carried out by agents of the Volta River Authority in Ampem in the Afram plains and at Akuse has shown a great potential in this area.

Other benefits that can be derived from the creation of the Lake but which as yet have not been explored

are in the area of tourism. The tourist potential of the Lake has been examined and tourist activities including natural reserves, water sports, spot fishing boating and yachting are yet to be realised.

There is therefore no doubt that the construction of the dams and the creation of the impoundments have created great national assets. Enormous benefits are being enjoyed by the nation because of the construction of the dams but these national assets can further be exploited to benefit the national economy even more in the future.

Adverse Effects of the Impoundments

Lake Area

It is true that the construction of the dams and the impoundment brought major benefits to the economy of the whole country. However, it can nonetheless also be said that the creation of the impoundments brought some detrimental effects on many communities, which lived in the immediate vicinity of the Volta River. The construction of the first dam at Akosombo led to the creation of a lake whose surface area at maximum height of 276 feet above sea level is estimated to be 8,500 square kilometres³ (3,275 sq. miles).

The flooding of this large area affected about 80,000 people who used to live in this area and these people had to be resettled. Not only were their villages inundated but also their farmlands, their ancestral homes, their traditional groves and religious grounds were all covered by the newly impounded waters⁴. It is esti-

mated for instance that 6,000 acres of cultivated cocoa land was inundated. Crop lands, cultivated with the traditional crops of cassava, guinea corn, rice and yam, inundated by the impoundment was estimated to be at least 50,000 acres⁵. Apart from land under cultivation, large tracts of forest lands were also inundated. Most of the forest trees were mahogany and wawa, which have important economic value, but it should also be mentioned that some rare forest trees including ebony were also lost through the impoundments. The creation of the lake also led to some disruption in the economy of the country. Many roads were completely inundated and it was necessary to construct new roads. Many other infrastructure services including health centres, telephones markets and schools were all flooded out.

In the area of health the two major hazards in the Volta Basin was Onchocerciasis (river blindness) and Schistosomiasis (bilharzia). The vector of river blindness lived in the fast flowing original Volta River. The formation of the Lake wiped out the disease from the whole of the Lake area. However, the creation of the Lake led to an increase in Schistosomiasis (bilharzia). The arrival of fishermen from the Lower Volta on to the Lake further extended the boundaries of this disease and infection rates of the disease rose sometimes to as high as 90%. The presence of weeds on the Lake provided an ideal habitat for the vector (snails) worsened the situation.

The above adverse effects were anticipated by the Preparatory Commission, which was set up, to assess the

Volta River Project and some measures were suggested to deal with the problems. But one important adverse effect that was not anticipated is the deforestation that had gone on around the Lake. It is estimated that about 60,000 fishermen have moved on to the Volta Lake since its formation. These are fishing along the whole lake periphery of 4,800 kilometres and are using wood from the forest around the Lake for smoking of fish and for domestic purposes. This has led gradually to the denudation of the forest around the Lake. The result is increased erosion especially on the steep slopes in the eastern banks of the Lake. It is even on record that denudation of forest has led to landslides in many areas on the eastern banks of the Lake⁶. A combination of soil erosion and landslides is leading to siltation and sedimentation in the lake and it is realised that if the deforestation is not checked, siltation and sedimentation would lead to a shortened life span of the Lake.

Another hazard on the Lake is constituted by the many trees and stumps still standing in the Lake. As mentioned above, the Lake was allowed to inundate forests and trees crops under the erroneous notion that the trees would in time disintegrate. On the contrary the trees permanently under water have remained hardened. These have proved hazardous to transportation. Many fatal accidents have occurred on the Lake with transport boats due to trees and tree stumps in the lake.

Lower Volta

Before the dams were constructed, the Volta River had its annual cycle

of low water during the dry season and high water during the rainy season. From the records during the dry season, the flow rate at times came down as low as 1,000 cubic feet per second (cusecs) but during the rainy season, the flow rate rose to at least 125,000 cusecs, but in exceptionally rainy years the flow rate rose above 390,000 cusecs⁷. Thus whereas during the dry season one could walk across the Volta River in its lower reaches, during the rainy season the floods were so high that the water level rose by an average of 20 feet and in certain years up to 30 feet. During high floods, destruction of crops, farmlands, and property was common.

However, the Lower Volta experienced a phenomenon from the floods which boosted the local economy. The high water did not only enrich the lands for cultivation of annual crops but also all the creeks, ponds and lagoons in these areas were filled with water for the breeding of fish which was exploited as the flood waters receded. The construction of the dams completely cut out the annual floods of the Lower Volta. The floods for agriculture and especially for creek and pond fisheries were completely terminated. The Volta River at the Lower Volta now moves at a constant flow rate of about 28,000 cusecs which is far below what is needed to enhance the waters in the creeks and ponds. Thus one important asset in the Lower Volta was lost forever.

It has also been found that the water coming out of the dams is clear with very little sediments. This clear water allows penetration of sunlight to

the riverbed and this has resulted in the development of submerged aquatic weeds in the Lower Volta. The growth of submerged aquatic weeds has also affected another lucrative fisheries, the clam industry. The clam (*Egaria radiata*) an oyster-like shell fish lives at the bottom of the river. It is presumed that the weeds are adversely affecting the growth of these clams and even more so the harvesting of the clam. Thus, that industry is also gradually dying out.

The incidence of bilharzia in the lower Volta has also risen. Recent studies show that in many of the villages in the Bator area, bilharzia infection of school going children is 100%.

Another detrimental effect of the dams was the gradual development of a sand bar at the estuary of the Volta River. Before the impoundment of the river, the force of the annual floods quickly cleared out any formation of a sand bar at the estuary. With the cessation of annual floods due to the construction of the dams, the sand bar gradually started to grow. Within a period of 20 years, the sand bar had grown to such a proportion that the estuary was partially blocked and the saline water from the sea could no more penetrate the channel of the river during high tide. Therefore even at Ada, situated at the estuary, fresh water aquatic weeds started to grow along the channel of the river. These aquatic weeds are the habitat for the schistosome snail. The result was that bilharzia started to occur in the Ada area. The tourist industry at Ada had grown on the trust that the area was

free of bilharzia. The emergence of bilharzia at Ada virtually wiped out the tourist industry. Efforts to cut through the sand bar was the only way to re-introduce saline water into the channel which would lead to the eradication of bilharzia in Ada and its environs⁸.

Mitigative Measures by VRA

Compensation and Resettlement

As has been mentioned earlier, the construction of the Akosombo dam and the formation of the Lake displaced about 80,000 people. These had to be resettled in 52 new resettlement townships. On the whole 1,300 houses were constructed with 82 school blocks, 46 markets, 146 public latrines. In addition, 52 boreholes 6 wells and 34 mechanical and 23 hand pumps were installed, about 500 miles of roads were constructed and over 100,000 hectares of farmlands established⁹.

Compensation was paid for all properties destroyed by the formation of the lake but it was initially limited to farmlands, crops and economic trees. Because of time constraints, the resettlement under Akosombo project adopted the core house concept. This provided a single room together with foundation for three additional rooms provided for each settler family. Material for developing these rooms and experts to assist in completing the houses were provided. This method was adopted in order to beat the fast rising waters. The basic philosophy was for the re-settlers to use self help in finishing these houses¹⁰. It is a sad commentary that even up to today, some of the resettlement houses in the resettlement townships still re-

main in its core form. In addition to the provision of houses, other social amenities were provided. Schools, health facilities, water in the form of bore holes or wells, latrines and market centres were provided depending on the size of the resettlement town.

One of the criticisms of the Akosombo resettlement was that the core house was provided indiscriminately. In other words, despite the size of one's original house, which had been flooded out, the same core house was allocated. Those with large houses in the original villages therefore rightly felt cheated. With these lessons learnt from the Akosombo project, the Kpong project adopted a different strategy in its approach to resettlement¹¹.

Under the Kpong project, 7,000 people were displaced by the impoundment and these were resettled in six new resettlement townships. Here the core house system was abandoned. A complete house was constructed for each settler family but the size of house given to each individual family was based on the size of house originally owned by the family before impoundment. Thus, houses ranged between three rooms and six rooms, allocated according to their destroyed houses. There was also considerable improvement in the amenities provided for these townships. Apart from schools and other communal facilities, electricity, pipe borne water and improved communal latrines were provided. The resettlers were also provided with farmlands with extension officers located in each resettlement townships to assist the re-settlers in improving their agricultural production.

In the resettlement townships, where a considerable number of re-settlers were found to be fishermen, fish landing ramps were provided to enhance landing of fish produce. The Kpong resettlement programme was therefore seen as an improvement on the Akosombo programme¹².

Work of Volta Lake Research & Development Project¹³

The Volta River Authority realised that the lake formed by the Akosombo dam had enormous potential that could be channelled into useful economic ventures for the dam affected population. Thus, as early as 1968, the Authority with the assistance of UNDP and Ghana Government initiated research project known as the Volta Lake Research and Development Project which conducted various investigation into the fishery potential of the Lake. Studies were also carried out into drawdown agriculture, health, and sanitation especially into the control of Schistosomiasis. Improved fishing and transport boats were also developed. Finally, a fishery development plan was evolved to assist in the improvement of fish production and marketing around the Lake.

Under this project, the first fishery complex at Kpando Torkor was constructed where not only was fish marketed but also all the inputs that go into the fishing industry could be obtained. The Kpando Torkor project has served as a model, which could be used for the construction of other fishing complexes, earmarked for Yeji, Buipe, Kwamikrom, Dam-bai, and Ampem. It is heartening to note that Yeji Fishery complex mod-

elled on Kpando Torkor is now under construction.

In agriculture, experiments in the use of the drawdown for the production of short maturing crops, such as tomatoes were carried out in stations dotted around the Lake. The most successful experiment was carried out at Ampem where supplementary irrigation was used for the increased production of various crops. The use of irrigation especially for the production of vegetables mainly tomatoes caught on very well in the lower Afram plains centred on Ampem. This industry still produces most of the tomatoes sold in markets in Koforidua and Accra areas from December to about April.

In the area of health, the focus of attention was on bilharzia control. With the formation of the Lake, the incidence of bilharzia had increased and prevalence rates had gone up to between 80% and 90%. The studies carried out were to find a simple way of breaking the bilharzia cycle. The results achieved are now being widely applied in all the bilharzia infested areas both on the Lake and down stream of the dams.

The Volta Lake Research also carried out experiments in the construction of improved fishing and transport boats. In view of the tree stumps, which still stand in the lake, canoe fishing, and transportation of fish and agricultural commodities on the Lake, is hazardous. The projects came out with improved fishing boats and heavier transport boats, which were safe for the Lake environment. Unfortunately, these have still not been popularised. Especially

the transport boats when adopted would go a long way to curtail the often-heard accidents that occur on the Lake with loss of lives.

Transportation on the Lake

As has been mentioned above, because there was no clearing of forests before the inundation of the Lake area, tree stumps are found everywhere within the Lake area. In order to improve transportation on the Lake, therefore, the Volta River Authority charted the routes for all boats moving from the southern port of Akosombo to the northern port of Buipe. The route was buoyed so that the navigable channel could easily be recognised. The Authority as early as 1973 passed the Lake traffic Regulation (LI 862) which sought to regulate the transportation of goods and persons on the Volta Lake. The instrument has measures for the registration and licensing of boats, as well as regulating/controlling the type and mode of transportation on the lake. The enforcement of these regulations is yet to be achieved.

It must also be mentioned here that the Volta River Authority has taken measures to develop the Lake transport system by completing ports and installing navigational facilities to enhance safe navigation on the Lake. a subsidiary company Volta Lake Transport Company, was set up by the Volta River Authority in 1970 to operate as a public carrier on the Lake to assist the transportation of goods and passengers especially on the north-south route. The company has now 13 river crafts with a carrying capacity of 4,000 tons for both dry and wet cargo including industrial and constructional materials and

petroleum products for transportation especially to the northern sector. Agricultural produce and livestock are brought from the north. Thus produce from around the Lake including yams, beans, smoked fish and cattle are brought down to the south for marketing.

Recently clearing of trees in fairway to major marketing centres has been undertaken to cut down accidents on the Lake. This will continue in the future.

Disease Control Programme

The Authority has now set up on the Lake permanent machinery for dealing with health hazards on the Lake, especially for the control of Schistosomiasis.

It will be recalled that before the formation of the Volta Lake, Onchocerciasis (river blindness) was prevalent in the valleys of the Volta River. The fast flowing rivers provided the desirable habitat for the larvae of the *Simulium* (blackflies). With the formation of the Volta Lake and the creation of calmer and deeper water, the *Simulium* fly was eliminated from the Volta Lake area. The Senchi rapids still harboured these flies until the construction of the Kpong dam, which flooded the Kpong rapids and thus eliminated the fly from the Kpong area. The construction of the two dams therefore eliminated the *Simulium* fly in the flooded areas.

However, the Lake provided a perfect habitat for the spread of Schistosomiasis. Not only did the Lake provide the required haven for the bilharzia vector, but the slow moving

waters of the Lower Volta also provided a similar condition for the spread of bilharzia. The control measures devised under the Volta Lake Research Project, are now being applied to control or eliminate them both on the Lake and in the Lower Volta. The control measures being adopted currently are a combination of:

- chemotherapy by the use of biltricide
- control of weeds and snail vector by manual and mechanical clearing of weeds.
- health education to reduce individual's to water contact and change their sanitary habits and
- environmental sanitation where sanitary facilities like urinals and latrines are provided for the communities.

On top of all these the Volta River authority has placed on the Volta Lake a Medical boat (*Onipa Nua*) which is carrying out normal curative health service as well as health education against bilharzia. This boat moves from village to village along the Lake bringing medical service to the door of the fisher folk whose villages are accessible only by boat. It is estimated that the annual cost of running the medical boat is about 1 billion cedis.

Afforestation

Many fishermen especially from the Lower Volta and the coastal areas around the estuary, moved into the Lake area with the formation of the Volta Lake to take advantage of the boom in fish on the Lake,. Their settlements spontaneously established around the Lake were un-controlled;

fishermen could establish a settlement on the Lake wherever they chose to do so. The result is that fishing settlements are dotted around the whole periphery of the Lake. It is estimated that there are about 1,500 fishing villages around the Lake, in many cases located in very remote areas accessible only by water transport. Thus, fish caught by these fishermen can not be sold fresh. Smoking of fish is locally the most acceptable and profitable way of processing the Lake fish. The fishermen therefore gradually cut down the trees along the shores of the Lake for smoking of their fish and for household use. This has resulted over the years in the depletion of forest along the shores of the Lake. It can be anticipated that if this trend went on, there would come a time when the fisherman would be unable to smoke his fish catch because of unavailability of trees.

However, the situation is even more serious since the depletion of forests is also leading to erosion around the Lake and siltation and sedimentation in the Lake that could result in a shortened life span of the Lake. In order to arrest this situation, the Authority invited Conterra, a Ghanaian company to study the causes and make recommendations for remedial measures for landslides and erosion along the shorelines of the Volta Lake. The Conterra report presented in January, 1995 has recommended large scale afforestation especially along the steep slopes of the Lake¹⁴. The Authority is also currently funding a project based at Yeji, which aims at minimising the depletion of forests in the fishing areas around the Lake¹⁵. It is the intention of the Au-

thority that these projects which have already started will be extended to cover the areas around the whole of the Volta Lake.

Dredging at Volta Estuary

As earlier mentioned, the cessation of annual floods as a result of the construction of the two dams, has caused a sand bar to develop which has blocked the river mouth. This in turn prevented the normal flow of seawater into the river channel during high tide. The result of this is that bilharzia which was not known in Ada where the tourist industry was expanding suddenly found the presence of bilharzia. Freshwater weeds had started growing along the shores of the river and the vector snail had inhabited these areas. The Volta River Authority brought in a dredger at considerable cost and since 1991, the dredger has been clearing a channel through the sand bar. With the clearing of the channel, there is now a free flow of seawater into the river channel leading to the eradication of bilharzia in the Ada area. The tourist industry in Ada had now picked up again.

VRA Resettlement Trust Fund

The Volta River Authority has recognised the enormous difficulties encountered by the resettlement towns especially those established under the Akosombo project. In order to assist these resettlement towns and other communities adversely affected by the operations of the Authority around the Volta Lake, a trust Fund known as VRA Resettlement Trust Fund has been set up. The purpose is mainly to assist these communities in their socio economic development. The authority's con-

tribution to the Fund is half a million dollars per year. Monies had already been paid into the fund and its disbursement will follow as soon as the Trust Fund Deed is executed.

Electrification Programme

In addition to the above, the Volta river Authority has started a special programme to assist the 52 resettlement townships under Akosombo Project to get electric power into these townships. The Authority has undertaken to provide the community components under the Governments Self Help Electrification Programme (SHEP) for electricity to be provided to these settlements.

Lower Volta Programme

Finally, the Volta River authority has accepted to assist the communities in the Lower Volta. As a start, the authority is negotiating with the Volta Basin Research Project to do a study, which hopefully will lead to:

- some revival of the fishery industry in the creeks and ponds of the Lower Volta
- revival of the clam industry in the Lower Volta
- an improvement in agriculture along the shores of the Lower Volta and
- improvement in health especially in the control of Schistosomiasis.

It must be appreciated that by law, the Authority is charged with certain primary functions, especially for the production of electricity for industrial and domestic use in the country. The Authority is however trying hard to take upon itself civic responsibilities

arising as a result of problems created by its operations.

Future Trends

General Assessment of mitigative programs

Various assessments have been made of the mitigative actions taken by the Volta River Authority especially concerning resettlement¹⁶. There is some outright condemnation of the Akosombo resettlement programme. There are others who still fault the Authority for not paying adequate attention not only to compensation payment but also to the needs and the welfare of the resettled population under the Akosombo project. Many commentators of modern times have used the present day approach in resettlement of dam affected population to assess the Akosombo dam project but it must be remembered that in the early 1960's when the Akosombo construction took place, the modern concept of environment and the treatment of resettlement population were not so advanced. By the standards of those days and with the speed by which the waters of the Volta Lake rose and the great number that had to be resettled, one could conclude that a fair job was done.

It may again be a commendation to the Volta River Authority that having learnt her lessons from the mistakes and shortcomings of the Akosombo project, there was considerable improvement in the resettlement programme under the Kpong project. For instance the core house concept under Akosombo project was totally abandoned under the Kpong project and a fairer allocation of houses based on the actual number of rooms

lost was used under the Kpong project.

There is one area, which has been found to have been over-looked under both projects. That is the question of legal title. It is found that under both projects houses that were allocated and the plots of agricultural land that were given to the re-settlers were never properly and legally transferred to the re-settlers. Thus, no re-settler has legal title either to his housing plot or to his agricultural land. Whereas there has not been much litigation on housing plots, there has been considerable litigation on agricultural plots. The Authority is currently acting to give proper legal title to all housing plots under the 58 re-settlement townships. Although it will be more difficult to extend this to farmlands, it is hoped this will still be tackled in the future.

Another area of constant criticism is the plight of the inhabitants of the Lower Volta. It is true that the preparatory commission advised that an amount of about half a million pounds sterling should be paid in compensation to those who were adversely affected by the construction of the Akosombo dam. However, it is on record that none of these people received any compensation. It may be necessary to look at the act of Incorporation of the Volta River Authority - the Volta River Development Act 1961 (Act 46). Section 30 of the Act lays down clearly that in the matter of compensation and resettlement the VRA was required to spend 3 1/2 million pounds sterling and the law laid it down specifically that any extra expense should be borne by the central Government.

With the speed with which flood affected persons were moved into new resettlement towns, the authority spent initially available monies on compensation for crops lost and resettlement. It is on record that even though the law laid down that the Authority should not spend more than 3 1/2 million pounds sterling the authority eventually spent over 12 million pounds sterling¹⁷. It can be argued therefore from the legal point of view that anybody who has further claim for compensation should make the claim against the central government. However, the thinking in VRA has gradually changed for her to accept civic responsibility for matters, which it had hitherto legally rejected. The present thinking of the Authority is in line with the present day thinking in the world, concerning environmental issues and population affected by hydro Projects.

Present environmental thinking in the world

In the 1980's, planners and development experts considered that in the development of hydro electric power projects, apart from taking into consideration the environmental effects of such projects, the human population that would be affected in any way should not only be compensated and resettled adequately, but should be made to share in the profits arising out of such projects¹⁸. This line of thinking became accentuated in the proceedings of the Rio de Janeiro Conference on Environment held in 1992. After this conference, hydroelectric projects have been critically analysed and in many cases where it was found that there would be no adequate protection even for flora

and fauna, such projects have been stopped.

Even more so have projects been stopped where it was found that indigenous populations affected by the projects would not have adequate compensation from resettlement programmes designed for the projects.

In Canada, the Great Whale project which formed part of the James Bay development, a project belonging to Hydro Quebec, was forced to be stopped by the Quebec government, because of world-wide adverse comments, native Indian demonstration and volumes of scientific and ethnic studies which showed a projected adverse environmental impact on the ecosystem and the native Indian population¹⁹.

Pangué Dam in Chile

It has now become apparent that in view of changes in present day thinking concerning hydro electric power projects in respect of the ecosystem and populations affected by these projects, it is likely that past ambitious projects particularly those involving extensive flooding and diversions would not have been possible today at least in their present form. It is therefore pertinent that the Volta River Authority has adopted a fresh approach towards the effects of future dams on flora, fauna, and populations. In line with this thinking and in connection with the Bui dam which is currently being seriously considered for implementation, the Volta River Authority sent a team of experts to Chile to study the construction of the Pangué dam and especially the environmental measures being taken for the benefit of flora

fauna and populations to be adversely affected by the project. An ecological station had been established to co-ordinate and develop a strategy to mitigate the negative impact on the environment and to increase positive impact associated with the construction of the dam. This ecological station has set up a nursery of local plant species, which will be used to replant areas that would be adversely affected by the construction of the dam. It was also found that for those whose homes were to be flooded by the impoundment after the construction of the dam, resettlement of their choice and adequate compensation has been provided. For the Indian population who were not affected directly but whose livelihood were to be indirectly affected, a Foundation had been set up to assist them²⁰.

The objectives of the Foundation are to:

- promote and develop programmes for improving socio-economic conditions of the native communities in the areas of health, education, housing and level of economic growth.
- develop training programmes to improve job opportunities and access to higher qualified jobs.
- provide extension in productive techniques in farming and
- promote their Indian culture.

However, one cardinal principle was that the local community should reap some of the benefits that will come with the construction of the project. These are lessons that the Volta River Authority is taking seriously in connection with the Bui dam.

Arrangements for the Bui Dam

The Bui dam is providing an opportunity for the Volta River Authority to cut a new future path in respect of resettlement and the general environmental impact. The Bui Dam will involve the resettlement of less than 3,000 people but more importantly the eastern shores of the lake formed, would affect an existing nature reserve. Apart from the arrangements being made to resettle the population involved and the provision of compensation for land and property lost, a Fund is under consideration to be set up not only for the continued wel-

fare of the resettled population but also to support the nature reserve and to protect flora and fauna in this nature reserve.

One can conclude that the Volta River Authority is now moving abreast with present trends where environmental considerations are paramount and where populations adversely affected by the construction of a dam will have to be adequately compensated and made to share in the profits arising out of the project.

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Discussion on Socio-Economics Issues

Suggestion: Hunnuor T.K. Bobobee (Farmer/Fisherman): It would be highly beneficial if a forum of this nature is held in parts of the affected areas e.g. Sogakope or Adidome.

Contribution: Kofi Lawer: It would be prudent to investigate incidence of skin-itch with swimming and causes of bloated stomach. In addition, dredging should be extended to islands between Big Ada and Ada-Foah. These islands are infested with Schistosomiasis. Siltation is gradually recurring due to slow nature of dredging. VRA should provide tow dredgers, at Amedeka and Ada. V.R.A. can sell dredged material (sand) to supplement funding for the exercise.

Contribution: Togbe Avoroattor II/Togbe Anipati : Appealed to V.R.A. to provide the Lower Volta with the following:

- General Improvement of infrastructure especially schools.
- Improve on the operation of two ferries operating between Amedeka and Ada.
- Pipe-borne water to supplement bore holes being dug by DANIDA.
- help in the form of poles to enable central government extend electricity to areas like Dorfor and Mepe.

Response: Mr. Kalitsi: Law establishing VRA is the present setback preventing it from performing some of these functions.

Response: Napoleon Asumah, North Tongu District Assembly: Either the VRA Act is amended or the Lower Volta Basin is declared a disaster Area.

Question: Dr. K. A. Oduro (Legon): After Rio de Janeiro summit on environment is it only dam construction that requires compensation and settlement or a general environmental impact assessment? Also, any project, which does not aim at profit sharing with, deprived areas around it, and causing irreparable damage must be stopped.

Response: Mr. F. Yeboah (VRA): No, projects like Mining also need E. I.A. reports.

Contribution: Dr. Odei (C.S.I.R.): Discussions would help to enable the formulation of some policy issues. A need for Environmental Impact Assessment for all development projects. This will ensure a follow up mitigative activities and useful post-audit discussion as being done here. It would be useful to do Visual recording (Video) of all processes and activities in the development of the Bui dam for initial surveys, clearing, blasting, construction (of dam and settlements) and meeting with communities affected. Ensure that affected communities be among the first beneficiaries of the projects undertaken. We should be mindful of not only recordings of plants and animals

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inundated but endeavour to rescue them and if possible ex situ planting is done elsewhere. Plants of medicinal importance must be of greater concern here, also, archaeological materials and sites.

Response: Mr. F. Yeboah (V.R.A.): The intended plans for the Bui project would take care of biodiversity as well as archaeological sites and artefacts.

Contribution: Prof. J.A. Dadson :Delighted and grateful to VRA at the renewed interest in providing funds for research in the Lower Volta.

Closing Statement on the Sustainable Integrated Development of the Volta Basin Nii Boi Ayibotele

Director
Water Resources Research Institute
CSIR
Accra

Introduction

In these closing remarks, I will like to highlight what I consider to be some of the key issues that came up during the presentations and discussions, make comments on some of them and suggest what I consider to be the way forward.

I have been in many fora at which the environmental problems created by water resources development projects have been discussed. Invariably, developers have come under sharp criticism for the problems created with hardly any mention of the benefits that the projects have brought.

It was therefore appropriate that Mr. Yeboah reminded us of the benefits that have been derived from the Akosombo and Kpong projects. These benefits include, hydro-electric power navigation, irrigation, fisheries, tourism and recreation. It must be noted that electrical power, has contributed tremendously to the industrialisation of this country. Also we have a comparative advantage on electricity tariffs over our neighbours in Togo, La Cote d'Ivoire, Burkina Faso, and Benin because of cheaper generating costs. Attempts to push up electricity tariffs to levels obtain-

ing in the neighbouring countries would therefore deprive Ghanaians of this advantage.

The problems created by the dam construction have been very much highlighted in the papers. They include social problems arising from resettlement, loss of agricultural production, erosion and sedimentation, formation of sand bar at Ada and change in the regime of salt water intrusion etc.

Future problems which can be foreseen, but which were not mentioned, include the competition between energy production on one hand, and drinking, industrial and irrigation water supply on the other. This can be expected at Kpong where the headpond is used for the above purposes. We should be preparing to resolve such conflicts. The VRA as an interested party cannot be expected to do so impartially. A regulator like the proposed Water Resources Commission will have to be assigned such a task.

The mitigative measures which were mentioned include payment of compensation to displaced persons, provision of good drinking water, education to dissuade people from entering the lake; promotion of fisheries,

dredging of the sand bar at Ada etc. We should note that it will take time to deal with all the problems.

Development Approach

It was mentioned that one of the reasons that these problems have persisted is that even though the project was conceived as an integrated one it has not been implemented in that manner. Sectoral and disciplinary approaches have been more applied.

In the presentations, terms like sustainable and holistic approaches were suggested. These terms are often used but it is important that we agree on their meaning and hence the strategies for bringing them about.

In this regard the presentation made by Prof. Okigbo as to what sustainable development is, is worth bearing in mind. The global circulation of water, minerals, gases etc. provide the life support system of the Earth and to sustain it, we should make sure that no development interferes, adversely with it.

Instruments to Ensure Sustainable and Holistic Development

To achieve integrated and holistic development it is imperative that some cross-sectoral instruments or mechanisms are applied in the development process. The following instruments were mentioned during the presentations and discussions. These should be noted for future development of the Volta basin, and for research.

Institutions

The institutional structures (agriculture, health, infrastructure etc.) should provide adequate support

from national levels right to the peasant farmers and artisanal fishermen to improve the standard of living and quality of life. VRA should not be made entirely responsible for the administration of the Volta Basin. This seems to be expectation from the long shopping list (assistance to health, agriculture, roads, research etc.) as was put up by Dr. J. Geker. This would mean that the authority would be responsible for about 70% of the land area of Ghana. If this should be accepted then electricity tariffs will have to go up to generate the funds to meet the expected expenditures. This will certainly not be politically acceptable.

The need for appropriate institutional set up was demonstrated when it became necessary for VRA to retail and distribute power to individual consumers in the northern region. Before then, the authority was used to making only bulk sales to Valco, ECG, the Mines, Togo, Benin, and La Cote d' Ivoire. The establishment of the Northern Electrification Development (NED) met the challenge that the authority faced. In the initial stages NED was subsidized from the authority's bulk sales. However, in recent years it has started to break even and make a profit. It is important that other institutions be organised with the capacity to meet needs of beneficiaries and stakeholders in a cost effective manner.

Regulation

Another instrument that is required for integrated development is that of Regulation. We need to regulate land use, water use, and the exploitation of natural resources like soils, forests, animals, minerals etc. for

sustainable development. It is certainly not every land that is suitable for farming or for the development of human settlements. Information about the resources and what they can be used for are needed to guide and regulate development.

It must not be forgotten that regulation is not a new thing. There are laws on the statute books (however imperfect) to regulate for example land use and pollution of water resources. These are hardly enforced. The reasons for this lack of capacity must be found and measures taken to improve them if we are to achieve sustainable development. The introduction of Environmental Impact assessment under the new Environmental Protection Agency (EPA) law prior to development offers a good opportunity to put regulation in place.

Economics and Finance

While accepting that water is a social good, its economic importance as a factor of production or as an amenity to be enjoyed should not be kept in mind. As such the development and management of the water resources of the Volta basin must make economic sense. The benefits must outweigh costs. VRA has survived so far, because the economic basis of its development has been sound. This is not so in other areas like irrigation. There has been considerable advocacy at this seminar to introduce irrigation in the downstream area of the Akosombo/Kpong dams. While this is welcome care must be taken not to introduce schemes which will become economic and financial liabilities.

This is worth keeping in mind, having regard to the situation in Ghana where non of the existing irrigation projects is able to recover costs.

Transboundary Co-operation

This is necessary within the country as between regions or districts; and also between countries as with Burkina Faso and other countries with whom we share the Volta Basin. This is to avoid upstream/downstream conflicts, and also for the reconciliation of conflicting uses of water. From the beginning, Ghana developed the Akosombo and Kpong projects without obtaining the consent of her riparian neighbours. However, by sharing the benefits of hydropower with La Cote d'Ivoire, Togo and Benin conflicts have so far been avoided. It is being planned to use the Volta Lake transport system to move petroleum and other products to land-locked Burkina Faso, so that the latter can also share in the benefits of the Akosombo project..

It must be pointed out that recent World Bank policy to ensure that riparian countries consult each other and get each others approval before the Bank grants loans to finance water development projects in shared river basins has been helpful in promoting co-operation. In this regard, it should be recalled that Ghana had to be consulted by Burkina Faso obtain the former's approval, before the World Bank provided funds to build the Bagre dam on the White Volta in Burkina Faso for irrigation and hydropower. Presently, Burkina Faso is

again seeking Ghana's approval to build another dam on the White Volta upstream of the Bagre dam to meet the drinking water supply needs of Ouagadougou. For the future integrated development of the basin we should move from such ad hoc approaches and institutionalize the process of consultation, co-operation collaboration and co-ordination in the use of the water resources of the Volta basin among the riparian countries. Similar arrangements need to be made within the borders of Ghana for developments at the regional and district levels.

Research and Information

This is one of the most critical cross sectoral instruments for ensuring sustainability, for it deals with the knowledge base which is required for policy and decision making at all levels. The point made by one of the participants that more seminars should be organised for researchers to interact with operatives at the grass root levels should be taken seriously and implemented. Research and information dissemination is the reason for setting up the Volta Basin Research Project (VBRP). It is therefore important that this seminar has been convened to review what has been achieved in the past 33 years and to identify where gaps still exist. Let us look at where we stand in the following fields where we need to go.

Water Cycle Information

This includes:

- Climate (rainfall, evaporation, wind etc.)

- Surface water (riverflow, reservoir levels, sediment etc.)
- Groundwater (yields, levels, drawdowns etc.)
- Water Quality (physical, chemical, biological including microbiological etc.)

The presentation by Mrs. Amoah on the Microbiological Overview of the lake shows information has been gathered on downstream section of the lake. It is important to complete our knowledge by carrying the study upstream of the lake. Not only that we need to synthesize the present knowledge about the physical and chemical quality of the lake and also of the upstream and downstream sections.

Presently, the information vitally needed by the VRA is the amount of inflow that can be expected in any rainy season within the Volta catchment area. The VRA will like to have this information if not a year in advance at least at the beginning of the rainy season, to plan its reservoir operations so as to maximize energy production for sale. Research into forecasting rainfall in the catchment and inflow into the reservoir is very much needed, and should seriously engage our attention.

Physiographic Land cover/Land use Information

The paper by Dr. Amatekpor on Soils and Land use in the Volta Basin, shows that present soil maps on 1:1 million scale is far too small for any detailed information to be provided. While the detailed information may be available for particular projects covering a few hectares, this is not so

for the greater part of the country. The field work that needs to be done to provide information on larger scale is expensive. Information is needed for land use planning so that, land not suitable for human settlements or for agricultural purposes are not used as such. The experience of upland farming in the Jasikan district which led to the landslide in 1994 with its consequential impact on sedimentation of the Volta Lake should remind us of the need for proper use of land.

It is suggested that modern techniques like remote sensing be used to speed up the work of soil survey and the production of soil maps on scales that can be used for planning purposes at various levels. It is important to note in this regard that the Soil Research Institute of the CSIR is currently producing regional soil maps on 1:250,000 scale.

Socio-Economic Information

Prof. Dadson's paper indicated the need for information on the social and economic conditions of the people in the basin. While there may be estimates of indicators of infant mortality rates, GDP per capita, literacy rates etc. at national levels, we do not have these desegregated to the sub basin, regional or district levels. There is considerable gap in our knowledge in this particular area and future research must address it if planning is to be more meaningfully carried out.

Technical Information

There is no doubt that we have to develop our own technologies as in

the case of finding means of combating the incidence of bilharzia which has increased in some areas since the creation of the dams. Presently, the strategy of providing potable water, using drugs, preventing people from entering the lake, coupled with education is our best technology. Other technologies are needed to combat the growth of weeds especially the water hyacinth which Mr. de Graft Johnson indicated in his paper, could become a serious threat from within and outside the country. Similarly, we need to put in place technologies to master rainfall agriculture under the vagaries of the weather to which our region is exposed.

It is important, to bear in mind Dr. West's contribution about being open to knowledge and technologies from outside Ghana so as to take advantage of them and not reinvent the wheel.

Ecosystem Information

The ecosystem changes in the area flooded by the Akosombo and Kpong reservoirs, and also downstream the dams to the sea have been highlighted in the papers by Asafo, de Graft Johnson, Titriku, Geker and Yeboah. The impact on the lives of the people have been severe to the extent that some have lost their livelihood as in the case of the clam fisherman downstream of the reservoirs. there was no doubt that some of these changes were not foreseen. The efforts being made by the VRA to mitigate the impacts and adapt to the new ecological situation should be noted and supported. Again their promise to ensure that future projects like the proposed Bui dam would be

preceded by comprehensive environmental impact assessment which will include detailed identification of the flora and fauna and their social, cultural and economic value, together with actions proposed to be taken to mitigate or eliminate any adverse effects should be the way we need to go in the future

In addition, we need to undertake studies to fill in gaps in our knowledge about the flora and fauna in the terrestrial and aquatic ecosystems in the country.

Conclusion

Finally, I think it is important to learn from our mistakes and those of others. The problems that arose during the resettlement of some 80,000 people during the construction of the Akosombo dam led to useful lessons being learnt. These were applied in handling the displacement of people during the construction of the Kpong and Weija dams. The social and economic impacts were less severe as compared with the Akosombo project.

Again it has become good practice to carry out an Environmental Impact Assessment for any development project, and obtain clearance before the project is implemented. This is a good practice that should be adhered to in order to avoid some of the problems that occurred in the past.

RECOMMENDATIONS FOR VOLTA BASIN RESEARCH

A. General recommendations:

- that an intensive environmental education exercise be mounted to sensitise local communities on issues linking their life patterns to their health needs, and arouse the interest of the local communities in the quest to find integrated means of solving their problems, instead of blaming the Volta River Authority (VRA) for all of such problems.

- that all decentralised departments should closely collaborate with the local communities and have regular meetings with leaders and communities to determine how best resources could be utilised to the advantage of the communities as well as formulating integrated approaches for collective adoption

- that there should be a multidisciplinary approach to problem resolution within the communities. In addition to the use of established staff, student research work (post- and undergraduate) could be utilised in identifying solutions to problems at reduced cost.

- that the VRA should help provide amenities like potable water, electricity extension and schools in the deprived areas within the Lower Volta Basin. Where some of such facilities already exist their delivery should be improved, e.g. ferry services between Amedeka and Ada. The environmental impacts of VRA projects should be noted to ensure mitigative activities and useful post-audit discussion, in times of crisis.

- that whenever possible, future meetings of this nature must be held in parts of the affected areas. This would afford a better means of collective identification of problems and their resolution.

B. Specific Recommendations

In addition to the general recommendations given above, specific recommendations relevant to the socio-economic status of the people were given in the areas of health, fisheries and weeds, soils and land use as well as future research approaches that the VBRP should employ.

Health

- that potable water (stand pipes/bore holes) should be provided within the communities. This would reduce the level of contact with the river, to possibly check the prevalence of certain diseases.

- that the harmful impacts of certain unavoidable health problems should be reduced through education on effective management's practices and attitudes.

- that proper sanitary facilities should be provided and sited considerably away from the river and its tributaries.

Fisheries and Weeds

- that fishermen in the local communities be organised to benefit from the supply of inputs and other extension services, including training in good fishing methods and practices.

- that fish ponds must be constructed in suitable places and that steps be taken to salvage the clam industry.

- that there should be concerted effort, backed with adequate funds, to control the weed problems. Physical methods should be considered as this will help provide jobs

- that the presence of Water hyacinth, within the basin should be reported immediately for identification and removal and that the river Korlor should be dredged, to improve water exchange.

Soils and Land-use

- that the VRA should help initiate an irrigation project especially between Dafor and Adidome to provide enough farmlands, to halt migration. This could be done by re-directing the Korlor and Alabo streams. Catchment planning schemes should be initiated so as to harvest water at higher elevations and channel it through canals to lower levels to supplement rainfall.

- that soil surveys reports be made affordable and easily accessible to local farmers.

- that farmers should be encouraged not to cultivate hill slopes, so as to reduce erosion, and that everyone,

including farmers, must be involved in soil-conservation efforts.

- that farmers should improve soil fertility with organic manure, and not to over-rely on synthetic fertilisers so as to maintain soil condition.

Future research approaches

that an inter disciplinary approach to research must always be used and emphasised.

- that emphasis must be placed on the benefits of research work to the communities within the research area. Such benefits should be as regards to socio-economic activities, health needs and biodiversity conservation especially plants and animals of traditional importance within the basin.

- that information management must be stressed. This must aim at providing information, to benefit everyone; farmers, fishermen and policy makers. The dissemination of such information may be in the form of training courses and workshops

- that research must be geared towards income generation to supplement funds. This could be done through possible initiation of relevant income generating activities like consultancies and the publication and sale of audio-visual materials.

APPENDIX

Research Activities of Organisations working within the Volta Basin

by Dr. Chris Gordon

The Volta River Authority

Limnological Studies

Physico-chemical and bacteriological studies have been regularly undertaken on the Volta Lake, Kpong Headpond and in the Lower Volta river in collaboration with other national institutions such as the IAB and the VBRP of the University of Ghana. The main objective of these studies has been to assemble data that will enable us detect changes in the status of the water environment and to address any problems that may arise with respect to water quality, pollution, fishery development, and human hazards.

Aquatic Weeds Surveys and Control

Pre-impoundment studies were carried out in the Volta Basin before closure of the Akosombo dam in 1964. Similar studies on the Volta Lake in the post-impoundment era indicated that as at 1969, only about 1% of the lake area had been covered by aquatic weeds and the situation has not changed much since then. Aquatic weeds monitoring is still being undertaken regularly on the Lake and we have been extra vigilant at this time because we have been informed that some areas of the White, Red and Black Volta in neighbouring Burkina Faso have been colonized by the dreadful weed, water hyacinth (*Eichornia crassipes*).

The virtually weed-free situation observed on the Volta Lake has been entirely different on the Kpong Headpond and in the Lower Volta River.

In spite of the application of mechanical and manual control, about 35% of the headpond is still infested with aquatic weeds. Areas cleared are re-infested at a fast rate (6-8 weeks after clearing).

The podiferation of weeds on the headpond has been facilitated by a number of factors including:

- the presence of seeding material in the ponds and creeks originally in the area earmarked for inundation in the form of seeds, shoots, offsets, turions, rhizomes etc.
- the shallowness of the headpond (max. depth 18m) allowing for sunlight penetration and good aeration which promote plant growth.
- import of nutrients from the sewage system at nearby Akosombo, cattle dung on the East Bank, fertilizer import from nearby rice farms and also nutrients from the inundated area itself (1/6th of this area was under intensive commercial agriculture) and
- the presence of a relatively large number of sheltered coves and physical barriers which provided undisturbed conditions required

for weed growth and development.

This weed development at the Headpond has interrupted/impeded some economic activities in the area. For example, there have been instances where some power generating units have had to be shut down in order to remove weeds that have drifted into them.

A five-year weed control programme has also been drawn up under which an estimated area of 150 acres of weed infestation is expected to be cleared manually at the shores alone, while a weed harvester shall be used in clearing the off-shore weeds. By this arrangement we hope to reduce weed coverage to 1-5% of the total headpond area.

The construction of the two dams on the Volta River, at Akosombo has created ecological changes in the Volta Basin. In the riverine portion of the Volta between Amedeka and Azizanya at the estuary, these ecological changes are manifested in such noticeable features as the proliferation of aquatic weeds and snail vectors of Schistosomiasis, and the creation of a sand-bar at Azizanya. The ecological changes have affected the riparian communities adversely as follows:

- reduction in fishery and fishing grounds
- reduction in crop farming on the flood plains due to cessation of natural irrigation and supply of alluvial soil that used to be brought in during the annual floods of the pre-impoundment era

- proferation of aquatic weeds and shall vectors of Schistosomiasis in the bed of the Volta river and
- increased prevalence of Schistosomiasis especially the intestinal type which was originally not in the area.

As at now about 30% of the surface area of the Lower Volta river is infested with aquatic weeds. The infestations are extensive and dense with a square metre of harvested weeds weighing as much as 160kg. It has been observed that among others, the following factors have contributed to this development.

- The regulated water flow from the 2 dams to the estuary has caused a reduction in the volume of water flowing downstream making the river shallow and sluggish and hence suitable for weed growth.
- The retention of water in the 2 reservoirs results in desliting which makes the water discharged downstream very transparent which has encouraged weed growth.
- The reduction in tidal sea-water influx, which used to flush the freshwater system up to about 30km upstream, has increased the habitat for freshwater biota including weeds and snail vectors in the area.

With the on-going dredging of the sand-bar, tidal sea-water influx is now recorded as far as 20km up-

stream of the estuary and this has resulted in the elimination of both aquatic weeds and snail vectors of Schistosomiasis previously inhabiting the area between the estuary and Ada Foah.

The VRA has drawn up a 10-year programme for environmental and health management in the Lower Volta. The programme, which has already taken off at Adidome, Ada, Bator and Mepe areas, is community based and involves dredging, weed control, environmental monitoring/water analysis and Schistosomiasis control (which includes sanitation, potable water supply health education and screening and treatment).

Onchocerciasis (River-Blindness) In the Lower Volta River Basin

Onchocerciasis or River blindness is transmitted by *Simulium damnosum s.l.*; black flies that breed in very fast flowing sections of rivers and streams. In the Volta River proper, these flies used to be found at about 20 miles up-stream of Akosombo at the Dodi Island areas. The breeding sites were covered when the dam was completed in 1966 and the flies migrated into the rapids created downstream in the Atimpoku to Kpong areas. These breeding sites again were eliminated after the second dam at Akuse. Currently therefore, there is no proper breeding of black flies in the main Volta from the North to Ada in the south.

Breeding however, continues in almost all rivers and streams within the Volta Basin.

Like all other vector-borne diseases, Onchocerciasis is controlled by both treating the host (human) and attacking the vector. The human is subjected to skin-snips, which are examined under the compound microscope. When found positive, then he-she is treated with microfilaricide - Barnocide or Suramin, which is both microfilaricide and macrofilaricide. With respect to the vector, the larval stage is attacked by putting Emulsifiable concentrates in the water, just above the breeding site. The chemical used currently is an Organophosphate called "ABATE" and treatment is at weekly intervals owing to the larval life-span. Biting population is reduced drastically after 5 weeks of treatment, if the breeding river is isolated but chemical control should be continued for 12 weeks. River blindness can thus be controlled by using the above 2 methods, particularly when detected early in the hosts.

Schistosomiasis Control

The main intermediate hosts of Schistosomiasis in the Volta basin are *Bulinus truncatus rohfsi* (for *S. haematobium*) and *Biomphalaria pfeifferi* (for *S. mansoni*). The construction of the two dams on the Volta River at Akosombo created ecological changes favouring the proliferation of these snails in the lake area, on the headpond and in the Lower Volta. Prevalence rates of urinary bilharzia have ranged between 70 and 75% in some lakeside communities and in some cases rates of almost 100% have been recorded among school children. The situation has not been very different in the Lower Volta where disease preva-

lence has been on the increase especially the intestinal type. In some riparian communities for example, within a short period of 4 years (1989-1993) prevalence rate of intestinal Schistosomiasis has risen from 6% to 53.3%.

The VRA is making every effort to control the disease both in the reservoir areas and among the riparian communities.

In its simplest form, the control of Schistosomiasis is avoidance or reduction of water contact, avoiding defecating and urinating into the water body, but this involves change of human behaviour which makes the control more complex. The VRA therefore has adopted an integrated approach to control of the disease, which includes all major players in the transmission of the disease.

Chemotherapy

This is to reduce the worm load and consequently the egg load in the infected members of the community. On individual basis it reduces the pathology in the infected organs, especially the liver in mansoni and the bladder in haematobium. Our experience in the lower Volta indicates that reasonably advanced cases of mansoni infection with hepatosplenomegaly are reversible with the treatment of Praziquantel tablets (Biltricide).

Control of Weeds and snail Vectors

Manual and mechanical clearing have been used. Since most of the snails are attached to the weeds, clearing the weeds automatically reduces the number of snail vectors. This method is a quick way to reduce

the transmission of the disease. Molluscicides have been considered but their effect on the ecology of the lake prevented their use.

Health Education

The riparian and lakeside communities are constantly being educated on the transmission and the pathology of the disease. They are also educated on the control measures. Health education is to help the communities change the habits, which encourage transmission of the disease. This method is a very slow process but very effective if it gets going.

Environmental Sanitation

Mere education without providing the facilities does not work. The VRA is providing places of convenience to these communities. Together with DANIDA, the VRA is also helping to provide potable water to some of these communities.

The Medical Boat (Onipanua)

The creation of the Volta lake resulted in an initial fish boom. This attracted fishermen from the lower Volta area to the lake where they settled in small communities along the shores. Some of these communities are not accessible by road.

The VRA therefore acquired a Medical Boat to reach these communities with the basic health care needs.

Conclusion and Recommendations

From our experience it is apparent that for effective Management of environmental, socio-economic and health problems arising out of the creation of reservoirs, thorough pre-impoundment studies in these areas

are very important. The aim of these studies shall be to gather the base-line data on the basis of which control/management policies can be formulated for adoption.

With respect to water quality, weeds and health it is recommended that monitoring and control should continue after the impoundment since most of the problems arise several years after reservoir creation. Control/management of the environment and disease should employ the integrated multidisciplinary approach including water quality/pollution monitoring and control, weed and disease vector control, screening of affected communities for water-borne diseases and treatment of infected people, education on personal and environmental hygiene and disease transmission and control, provision of potable water, places of convenience and refuse disposal among others.

Such integrated approach shall ensure a sustainable environmental and health management programme that will help to improve the lives of the communities living both at the shores of the lake and below the dam.

***Department of Soil Science
University of Ghana, Legon.***

The Department of Soil Science is one of the University of Ghana's participating departments of the Volta Basin Research Project. The department has been carrying out research on various soil series in the Volta basin. This forms part of the normal staff, undergraduate and post-graduate research in the department.

The department's research activities within the basin increased when the Volta Basin Research Project was set up in the University in 1963 and especially when multidisciplinary ecological investigations in the draw-down area of the Volta Lake commenced in 1968. Some of the department's staff and students participated in the Reconnaissance Soil and Landuse survey of the drawdown area upstream from the Akosombo dam. This enabled sample strips to be demarcated in the three ecological zones into which the whole basin upstream from the Akosombo dam was divided. These sample strips have formed the focus sites where sampling is done for assessing changes in the drawdown area soil properties.

Recently the department has turned its attention to research in the Lower Volta Basin downstream from Akosombo. As part of the ODA funded IBSRAM Vertisols network project, the department has been researching into appropriate management techniques of the Vertisols (Akuse series) at Kpong

Investigations into the management of other difficult-to-manage soils in the Lower Volta basin is now proposed and, when adequate funds are acquired, will take off in full swing.

All the department's research findings have been published as Technical Reports or dissertations and some as articles in various scientific journals. The department has also been providing pedological data and advice to individuals and companies who approached the department for information on soils in the basin.

Department of Geography and Resource Development University of Ghana

The main resource allocation, planning and methodological issues and other related issues that have been addressed by the Department of Geography and Resource Development in the Volta River Basin over the past 30 years (1965 - 1995) may be categorized as follows:

- M.A/M.Phil. and Ph. D. theses
- dissertations
- Planned collaborative research of the Department.

These activities cover several aspects notably Population and Settlement, Health, and Resource Use and the Environment. The spatial coverage of the activities extend to both the lower and upper reaches of the basin. A recent development in the activities of the Department is the Densu Basin Integrated Research Project which has been formulated along the lines of the VBRP and which will utilize equipment of the Ecological Laboratory (ECOLAB) and the Remote Sensing Laboratory (RSAL) all located in the Department of Geography and Resource Development.

The following listing is to provide a summary of completed and on-going activities of the Department. These and others are available in the Department for consultation.

A. Population And Settlement

- Amatekpor (BA, 1965) Population and Settlement in the Anlo District.
- Azu (BA, 1971) Ada: Growth and decline of a port
- Ntumi (BA, 1971) Recent changes in the Human Geography of Kpandu area.
- Kumi (BA, 1969) The Volta River Resettlement Scheme with special reference to the Nkonya Wurupong.
- Ofori (BA, 1987) The Kpong Resettlement Programme.
- Sewor (BA, 1976) Migration and population change in Ada-Foah.
- Ocloo (BA, 1973) Problems of Resettling Keta.

B. Health

- Dewortor (BA, 1977) The Guinea worm problem at Vakpo: A Medical Geographic analysis.
- Disu (MA, 1986) Spread of Schistosomiasis Haematobium along the Afram and Pawon-pawnya arms of the Volta Lake.
- Osei-Karikari (BA, 1994) Problems of rural water supply and sanitation of households in selected communities within the Afram Plains.

C. Socio-Economic/Agriculture

- Taylor (BA, 1979) The prevalence and incidence of Onchocerciasis (River Blindness) among the rural inhabitants in the Volta Basin area - four Frafra villages.

- Agbenyega (BA, 1975) The Lower Volta Plain: Its morphology and changing land use.
- Afenyo (BA, 1979) An appraisal of the Kpandu-Torkor Fishing Complex on Volta Lake as a fishing harbour and market centre.
- Adonu (BA, 1973) The rise and decline of the fishing industry around Mepe-Vume- Agave area of the Lower Volta.
- Ahedor (BA, 1986) The Amelorkope Cattle Project and its impact on the Tongu District.
- Amoako-Ansah (BA, 1980) Impact of the Volta Lake on traditional system of land tenure and farming practices in Nkonya Traditional Area.
- Dunya (BA, 1988) A study of the Oyster fishing industry in the Tongu District.
- Fosu (BA, 1990) An evaluation of the Resource potential of Aquatic weeds in the Mepe area.
- Hansen (BA, 1989) Kpong Farms Ltd: An appraisal of agricultural innovation.
- Kofigah (BA, 1979) Development of Tourism in the Lower Volta estuary.
- Koranteng (BA, 1990) Agricultural activity and environmental degradation at Donkorkrom.
- Korletey (BA, 1972) The emergence of fishing as an industry in the Krobo District along the Volta River.
- Kowu-Tsiri (BA, 1968) The effect of the Volta River Project on the Tongus of the Lower Volta Plains.
- Kufogbe (Ph.D, on-going) Land use and Environmental change in the Afram Plains.
- Kumedzro (BA, 1974) An appraisal of the economy of Aveyime and its service area.
- Kwakye (BA, 1992) The changing rural economy of the Afram Plains.
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Densu Basin Integrated Research Project

The proposed Densu Basin Integrated Research Project is being formulated along the lines of the VBRP. It will be funded by DANIDA through the University of Copenhagen, Denmark. It will utilize equipment in the Ecological Laboratory (ECOLAB) and the Remote Sensing Laboratory (RSAL) all located in the Department of Geography and Resource Development. The project will train a number of graduate students.

Collaborating Departments from the University of Ghana include Geogra-

phy and Resource Development, Soil Science, Crop Science, Animal Science, Botany, Zoology, Geology, Oceanography and Fisheries, Chemistry, Physics and the VBRP.

Department of Oceanography and Fisheries

The Department of Oceanography & Fisheries of the University of Ghana has concerned itself mainly with the fishery and faunal diversity of the Volta Lake. These have formed part of staff and/or postgraduate research.

There have been extensive publications on the biology and ecology of the clupeids and other fishes in the Volta Lake. These works comprise, among others, the environmental characteristics of the lake, changes in the species, families/groups and ecogroups of fish stocks, reproductive biology and food and feeding habits of key species.

Chrysichthyes spp. which rank second to the tilapias, is popularly fished in the Volta Lake. Its biology and ecology has been of interest to the Department. Studies on its taxonomy, biology and assessment of the stock are on-going. The FAO, through the Integrated Development of Artisanal Fisheries (IDAF) project in the Volta Lake, has concluded a Contractual Services Agreement (CSA) with the Department, and a student is carrying out studies on the exploitation of the *Chrysichthyes* for his M Phil thesis.

Studies on the benthic and zooplankton diversity as well as fish community ecology of the Volta estuary by members of staff are in the pipeline.

Institute Of Aquatic Biology

- 20 years of monitoring potential effects of larviciding to control *Simulium* populations in the Volta basin as part of the Onchocerciasis Control Programme (OCP).
- Biological studies of fisheries of fresh water lagoons of the Volta Basin.
- Biological studies on major commercial fishes in Stratum VII of Volta Lake to provide information for strategic management of fisheries resources.
- Ecology and Fisheries of the Volta Estuary.
- Ecology of prawn species in the lower Volta system.
- Evaluation of *Oreochromis niloticus* stocks in the Volta basin towards sustainable utilization of the species in aquaculture.
- Genetic characterization of tilapias in inland waters of Ghana including the Volta System.
- Periodic limnological and water quality studies of the Volta Basin - OCP Rivers; Volta Lake; Kpong Headpond; Lower Volta River and Volta Estuary; covering water and sediment chemistry, algae, invertebrates, occurrence of nuisance aquatic weeds and potential for water-borne diseases.
- Preimpoundment fisheries survey of the lower Volta prior to the construction of the Kpong dam.
- Survey for the aquatic manual *Trichechus senegalensis* in the Volta basin and other inland waters of Ghana.

- Survey of changes in fish community structure in the Kpong Headpond after impoundment.

Irrigation Development Authority

The Ghana Irrigation Development Authority (GIDA) was established in 1977 for the systematic planning and development of irrigation in the country.

At the moment the Authority has developed 22 projects out of which 20 are directly managed by it. Tono and Veve projects are managed by Irrigation Company of Upper Region (ICOUR). Presently the area under irrigation countrywide is about 8,000 ha out of which 1902 or 24% are in the Volta Basin and directly irrigated from the Volta river or the lake.

Presently the Kpong Irrigation project comprising the old Asutsuare project area and a new section between Akuse and Asutsuare totalling 3,073 ha is under development and irrigation would be done directly from the Volta dam at Kpong.

Crops grown on these projects are mainly rice on the loamy and clayey soils and vegetables on lighter soils.

Department of Crop Science University of Ghana

Work done by researchers from the Department of Crop Science in the Volta Basin has been in the Lower Basin area. This included (1) Cropping Systems and Cropping activities in the Adidome - Sogakope - Akatsi area. Through this work information has been collected on varietal selection and indigenous

seed technology knowledge. A calendar of cropping activities has also been put together which is applicable to localities in this area subject to seasonal flooding. (2) Study of bambara-based Cropping practices/systems in the Ada area.

Work has also just started in a Land-Water Interface Project in which issues of resource use and management and environmental quality are being studied within the context of the livelihood aspirations of coastal communities in the Lower Volta Basin. The pilot study in Phase I of this project is located in Anloga.

Lessons learned in this project are expected to guide planning for coastal resource in similar areas in Ghana.

Ministry of Health

With a few rivers in the south such as Densu, Pra, Ankobra and Tano, which open directly into the sea, all the other rivers, in the rest of the country, drain into Volta system. The catchment area of the Volta Lake occupies more than 2/3 of the total land area of Ghana.

Many of the diseases that afflict the people especially the rural populations are water borne or water related diseases. Before the creation of the Volta Lake, in 1964, through the length of the Volta River, now inundated by the man-made lake, there were numerous important black fly (*Simulium damnosum*) breeding sites, foci of transmission of the dreaded disease of river blindness. Dr. Waddy was the first to draw the attention of the Colonial Government

to the havoc the disease was causing in the north of Ghana. Dr. Noamesi did much work on the biology of the black flies and demonstrated the feasibility of the control of the disease by judicious application of chemical at the breeding sites thereby killing off the flies. This is in fact the strategy later adopted by the successful, WHO sponsored West African Onchocerciasis Programme, utilizing aerial spraying with a number of insecticides.

The Health Department in response to an epidemic of Trypanosomiasis in the 40s hastily set up a specially organised Tsetse Control Unit. The health personnel of the Unit, operating from Gambaga, worked with such dedication and success that the disease was soon brought under control. The original Tsetse Control Unit, through its good work, metamorphosed into the famous MFU (Medical Field Unit), and in the process, taking on the treatment of many other diseases, earning well deserved respect and gratitude of the rural communities.

In the 50s and early 60s mainly through the effort of the MFU of the Ministry of Health the distributions of many of the important diseases in Ghana were mapped. For instance, the most comprehensive map of the distribution of Schistosomiasis in Ghana is still one prepared by the MFU in the 60s. They are much outdated, especially after the creation of the Volta Lake, but they have remained the foundation on which all subsequent work on Schistosomiasis has grown.

With the erection of Akosombo Dam and, later, the Kpong Dam, the creation of the huge Volta Lake, the Kpong Lake, new ecological conditions have been created on a large scale, bringing in their wake the dreaded but expected increases in many of the water-borne or related endemic diseases in Ghana. One of the first to be tackled on a large scale was the WHO Programme, supported by the Ministry of Health, on research into the control of urinary Schistosomiasis on the Volta Lake. The prevalence of this disease within a period of 10 years after the formation of the dam had already reached, from an initial low level of 5% or less, anything from 30 to even more than 90% in some Lakeside communities. The research work brought out a host of interesting facts about the ways the disease was transmitted and provided solutions, which, however, were too costly for the country to adopt.

In the late 80s and early 90s, a number of attempts were made by the parasitic Diseases Unit, MOH, to put under control the spread of intestinal Schistosomiasis in the lower Volta at Ada, and the estuary. This work, based on chemotherapy, proved effective in conjunction with the dredging of river-bed by the VRA. However, the successful control of the situation in the Ada area, which the Government is eager to turn into a tourist centre, will require serious commitment and sustained effort to make it work.

Department of Botany University of Ghana

Department of Botany has been actively participating in research programmes on the lake and involved in the management of the project.

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Below is a list of some of the publication and students thesis

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