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POSSIBILITIES OF USING SATELLITE TELETRANSMISSION FOR HYDROLOGICAL DATA COLLECTION IN GHANA

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SUMMARY

This paper gives a brief description of the socio-economic situation in Ghana and reviews the present hydrometeorological and hydrological data acquisition networks including problems being encountered in their operation. It then looks at the role of the networks in routine data collection and in project operations. This provides the background against which the paper examines the possibilities of using satellite teletransmission in the data acquisition system of the country.

Two conclusions are drawn. The first is that the use of satellite teletransmission of hydrological data cannot be justified for routine data collection. The second conclusion is that it can be applied to operate the Akosombo hydro-electric project on the Volta River. However, the introduction of the system will depend among other things on the level of development and water resources utilisation in the whole of the Volta Basin including those in Ivory Coast, Upper Volta, Mali, Benin and Togo.

RÉSUMÉ

Ce rapport fournit un bref exposé de la situation socio-économique au Ghana ; il passe en revue les systèmes hydrométéorologiques et hydrologiques ainsi que les problèmes que pose leur fonctionnement. Le rapport examine le rôle des réseaux dans la collecte des données de routine et de celles nécessaires à la réalisation de projets. Ces considérations servent de toile de fond dans l'examen des possibilités d'utilisation de la télétransmission par satellite dans le système d'acquisition des données au Ghana.

Deux déductions peuvent être formulées : premièrement, l'on ne peut pas justifier l'utilisation de la télétransmission par satellite pour acquérir des données hydrologiques de routine ; deuxièmement, l'on peut recourir à cette technologie pour la mise en œuvre du projet du fleuve Volta. Cependant, une telle décision dépendrait, entre autres, du niveau de développement et d'utilisation des ressources en eau dans le bassin entier du fleuve Volta y compris ses portions situées en Côte d'Ivoire, au Togo, et en Haute Volta.

BACKGROUND

01. Ghana lies approximately between latitudes 4°45' N and 11°1' N and longitudes 3°07' W and 1°14' E. It has a total surface area of 238,600 km^2. It shares boundaries with Ivory Coast in the west, Upper Volta in the north, and Togo in the east.

02. It is drained by two main river systems. These are the Volta River and the South-western and coastal river systems. The two systems are separated by the Kwahu Scarp which begins from Koforidua and runs in north-westerly direction to Wenchi near the border with the Ivory Coast. The south-western and coastal rivers take their sources from the Kwahu Scarp and flow generally in a south-westerly direction into the sea. They have a combined basin area of 65,000 km^2 and lie wholly in Ghana. The basin of the Volta River system, on the other hand, stretches into Ivory Coast, Mali, Upper Volta, Benin and Togo. The total basin area is 400,000 km^2 of which 168,000 km^2 lies in Ghana.

03. The population of the country was estimated at a little over 10 million people in 1977. Its current growth rate is 2.7 % per annum. The population is predominantly rural making up 71.1 % of the total (1970 census estimates). The population is distributed over 47,769 localities ; 47,634 of these localities, with 5.000 or less people are rural areas.

04. Water is utilized mainly for domestic and industrial purposes, for power generation and for agriculture in the areas of small scale irrigation and livestock watering. Water supplies in the urban areas depend mainly on surface water supplies, while the rural areas depend mainly on groundwater sources.
About 42 % of the total population was supplied with potable water in 1977. Of this, 94 % of the urban population was supplied with good drinking water, while only 20 % of the rural population had this facility.
The contribution of hydro-electric power is very significant in Ghana's electrical energy production. Of the total electrical energy produced in Ghana, hydro-electric energy forms 98 %. This is generated at the Akosombo hydro-electric power station on the Volta River, some 110 km. from Accra: The Akosombo plant has an installed capacity of 912 MW., and supplies power also to Togo and Benin. It is the biggest single water project in Ghana and also in the Volta River Basin. The use of water for agriculture viz. irrigation started only in the 1960s. At the moment, about 12,000 hectares are under irrigation. The areas under irrigation are small, ranging from 200 to 2,000 hectares.

05. Economically, Ghana is a primary producing country. It produces and exports cocoa, timber, gold, diamonds, and manganese. The foreign exchange earned is used in importing equipment, tools, machinery, food and other consumable items. The Gross National Product per person in 1974 was US.$418 at current prices.

A REVIEW OF HYDROMETEOROLOGICAL AND HYDROLOGICAL DATA COLLECTION NETWORKS

06. Data on the water resources of Ghana are collected by two main agencies. These are the Hydrological Division of the Architectural and Engineering Services Corporation, and the Meteorological Services Department of the Ministry of Transport and Communication. The Ghana Water and Sewerage Corporation and the Water Resources Research Unit of the Council for Scientific and Industrial Research, generate hydrogeological data in their drilling operations and research activities respectively. The Volta River Authority, which is responsible for the Akosombo project operation, also collects data on lake levels, plant flows and inflows into the lake.

07. The Meteorological Services Department is the older of the two main data collection bodies. It collects data on rainfall, evaporation, wind, humidity, temperature, etc. It has at present 590 stations of all kinds. Of these, rainfall is measured at 437 stations. Evaporation is measured at 16 of their stations. There are 70 self-recording rain gauges within the system, including those at the synoptic stations. The stations are manned by observers of the meteorological services, and also observers who work for other government agencies like the Ministries of Agriculture, and Health. Schools and Colleges. Quite a number of the observers at the rainfall stations are voluntary observers who are paid a small allowance at the end of each month. Data collected are first sent to regional offices of the Meteorological Services Department, before being sent to the head office in Accra for processing, storage and dissemination.

08. The hydrological data network is made up of a total of 193 stations. Of these 66 are equipped with automatic water level recorders. Discharges are measured at 98 of these stations, to establish rating curves for the rivers at the particular stations. These curves are checked normally once in three years to ensure their validity. The stations are manned by observers of the hydrological services, and also by voluntary observers. The voluntary observers are used almost exclusively to observe water levels at stations with staff gauges. The recording water level gauges are operated and maintained by the trained staff of the hydrological services who visit the stations, once a week or once a month as the case, may be to change charts and check on the proper functioning of the recorders. The data collected from the staff gauges and the recorders are sent to regional offices, which check them for any serious discrepancies, before sending them to the head office in Accra where they are processed, published, and stored.

PROBLEMS WITH OPERATING THE EXISTING NETWORKS

09. The reliability and efficiency of the data collection networks depend on the manpower, material and financial resources placed at the disposal of the responsible agencies by government.

10. The main problem with manpower is that there is an inadequate number of subprofessional and technicians/observers who are sufficiently trained and motivated. A number of reasons are responsible for this, but the net effect is that reliability of data so collected is undermined from the point of view of accuracy and continuity.

11. The second problem lies with equipment and logistic support for operating the networks. All the equipment used in the networks are foreign and have to be imported. The same is with the logistic support like vehicles and communication equipment to ease operations in difficult and remote areas. As these imports depend upon foreign exchange which is normally a major constraint on development in the country, operation of the networks has to be carried within this constraint. In the past two years the country has experienced a serious shortage of foreign exchange, and, consequently, the development and operation of the data collection networks have been correspondingly affected.

12. It is evident from the foregoing that considerable improvements can be effected to improve the reliability and efficiency of the present system if the manpower and foreign exchange constraints are minimised.

ROLE OF NETWORKS IN ROUTINE DATA COLLECTION AND FOR PROJECT OPERATIONS

13. The hydrometeorological and hydrological networks described above have been developed mainly in response to water projects. They were installed to collect data for feasibility studies and design, and later incorporated into the national data collection network. Hence it can be seen that they have a role to play in providing data, both for water resources assessment on a continuous and routine basis and for project operations.

14. It is to be noted however, that all the water projects in the country except one are comparatively small scale projects, and as such no elaborate and sophisticated system, for data collection and transmission to forecast runoff into the respective reservoirs, have been necessary.

15. The one project whose size requires extensive data collection for operation is the Akosombo Hydro-electric project on the Volta River sited some 110 km from the sea (see Fig. 1). The catchment area of the river at Akosombo is just under 400,000 km^2. The reservoir has a surface area of 8,500 km^2, and a length of 402 km. The gross storage volume of the reservoir is 148,000 millions m^3. The mean annual inflow into the reservoir is 1,270 m^3/sec. For the operation of the project, data is gathered on rainfall, water levels and discharges by field observers, and the information is sent by an elaborate network of road, telegraph and radio communication system to the operations room at Akosombo, using the facilities of the meteorological and hydrological services, the Posts and Telecommunications, the police and the army.

POSSIBILITIES OF USING SATELLITE TELETRANSMISSION TECHNOLOGY IN THE DATA COLLECTION NETWORKS

16. The above brief information on the socio-economic situation in Ghana, review of the present data collection networks, together with problems being encountered with their operation, assessment of the role of the networks in routine data acquisition and for project operations, have now set the background against which the use of satellite teletransmission technology in the data acquisition system can be considered.

17. It must first be accepted that satellite teletransmission technology in hydrological data acquisition is a feasible one as has been proved in the developed countries. However, it is necessary to bear in mind the factors that have influenced the development and adoption of such a technology.
The demand for more and more water in the developed countries to meet domestic, municipal, industrial, energy and agricultural needs, the control of pollution and the protection or enhancement of the environment, in the face of limited water supplies, have brought about an intensive utilisation of the available water supplies. Thus many river systems in the developed countries are highly regulated and conserved to increase the amount of water available for use.

18. It is usual to have the river water regulated both on the tributaries and on the main river, to achieve different combinations of single purpose and multipurpose uses. Within single river basin system it is possible to have water used for power generation, domestic, municipal, industrial purposes, irrigation, fishing development, navigation, flood control, pollution control and recreation. An example is the Tennessee Valley Scheme in the United States of America. The operation of such a system with the runoff resulting from rainfall imputs in such a way as to maximise economic, social and environmental benefits have become very complex. This has created the need to build system models for such basins. The calculations involved in running such models are many and also complex. Computers of large capacities have become a necessary tool. The data needs of such models are considerable and are collected over wide areas, some of which are difficult of access, and transmitted to the computer centre as quickly as possible. These are used in running the model to get outputs which will show how each facility within the basin system has to be operated to maximise benefits. In these circumstances the use of satellite teletransmission of hydrometeorological and hydrological data becomes an asset and justifiable.

19. Now a look at the situation in Ghana. It is evident that the problems created by remoteness and difficulty of access to such stations can be eliminated by using a satellite teletransmission system. However, the suitability of such a system, for data acquisition for routine purposes or for projet operation, or for both, need to be examined.
With regard to data acquisition for routine purposes, it does appear that the cost involved in changing from the present system can hardly be justified considering the investment needs of other sectors of the economy, and also the scale and intensity of water utilisation in the country. On the other hand, the possibility is worth considering in the area of project operations. But even here, as already pointed out, it is only the Akosombo hydro-electric project whose scale and size lends itself to the use of the system. Beyond its scale and size, consideration must also be given to the present level of development and water utilization in the basin. The Akosombo project was designed as multi-purpose one for hydro-power generation, irrigation, river transportation and fishing. At the moment it is being used almost exclusively for power generation. There is some utilization for river transportation and fishing, but these are on a limited scale and are yet to reach their full potential.

20. Presently, a second hydro-electric power project is under construction at Kpong, about 24 km downstream of Akosombo. It is to have an installed capacity of 160 MW. Facilities are being provided in this project to make it possible to irrigate about 7,000 hecta-

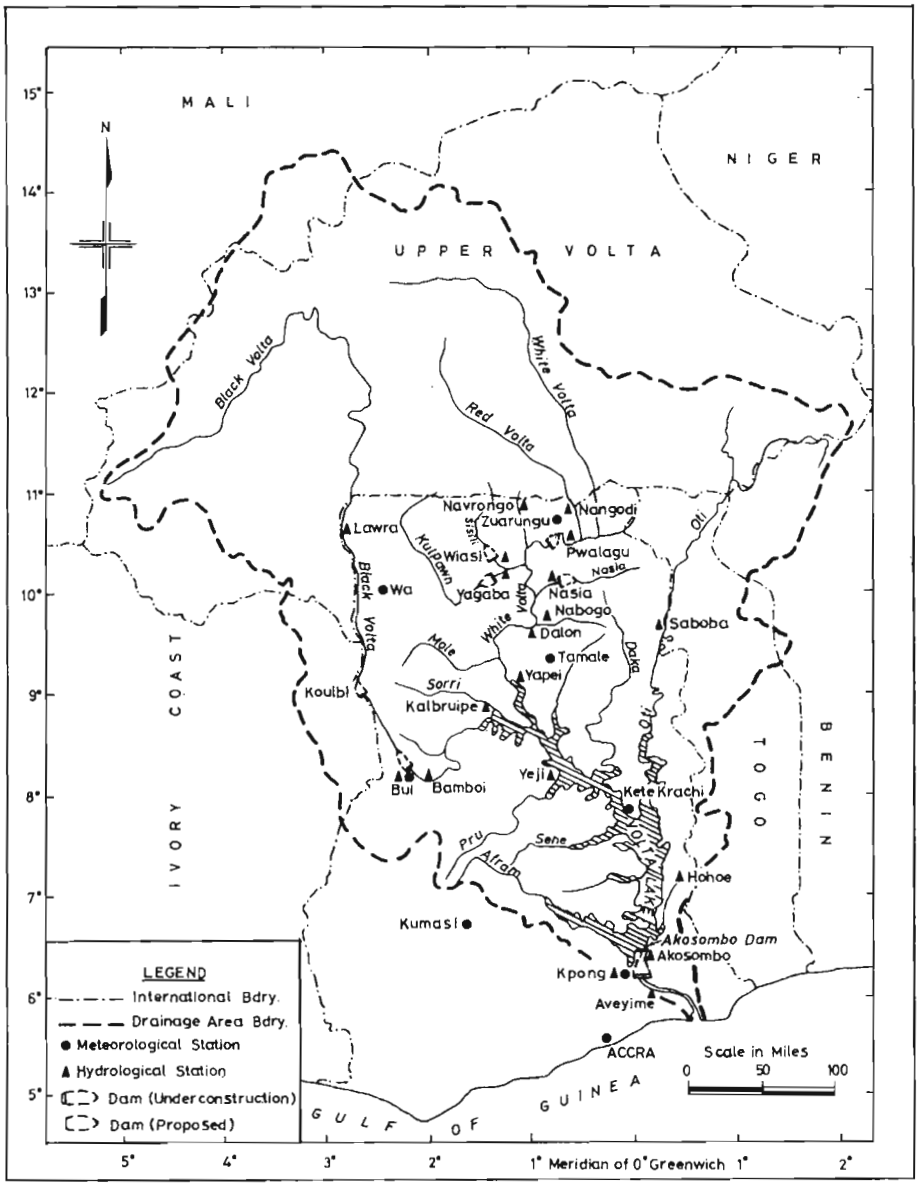

Fig. 1 – Volta Basin-Hydrometeorological and Hydrological Stations within Ghana

res of land in the Accra Plains. Between the new project and Akosombo, it would be possible to irrigate a total area of 176,000 hectares in the Accra Plains.

21. After the Kpong project, it is planned to construct another multi-purpose project on the Black Volta at Bui, upstream of Akosombo (see Fig. 1). This is intended to have an installed capacity of 300 MW to generate hydro-electric power and irrigate some 32,000 hectares of land. The next major project is planned to be constructed at Pwalagu on the White Volta, another tributary of the Volta. This is to be a multi-purpose project to control floods, to have an installed capacity of 36 MW to generate electricity and irrigate some 96,000 hectares of land.
Some six other smaller projects on the tributaries of the White Volta will bring another total of 42,000 hectares under irrigation. There are plans also to develop a site at Koulbi on the Black Volta, upstream of Bui, for hydropower with an installed capacity of 60 MW. These proposed projects do not take into account the water supply for domestic, municipal and industrial uses.

22. It is important to note that the proposed projects mentioned above are all planned to be developed within Ghana. If projects planned for implementation in the neighbouring countries which share the Volta Basin with Ghana, especially in Upper Volta, are added, it becomes evident that the Volta River Basin, at substantial or full development, would become a complex system to operate. At that stage the present simple system of hydro-meteorological and hydrological data, being gathered in the field by field technicians/ observers and transmitted by road, telegraph and radio, with the assistance of army and police facilities, would no longer be adequate to handle the complex operation problems to be encountered. At that stage, satellite teletransmission of observed data will become a very attractive alternative. The following points will then have to be taken into consideration.

23. First, there would be the need to change the data collection networks so that they become compatible with satellite teletransmission technology. This will require investment in new equipment for rainfall, evaporation, soil moisture, water level and water quality parameter measurements. These should have the ability to collect, store and later transmit their information to a suitable orbiting satellite when called by the satellite. The cost of using such an orbiting satellite will have to be considered. Secondly, consideration will have to be given to investment into building a receiving station or modification to an existing station to receive the data from the satellite.

24. Thirdly, it has to be borne in mind that data transmitted and received will have to be processed. At the stage where satellite teletransmission technology is adopted, it would be necessary to develop a system model for the Volta River Basin. The cost of computer acquisition and operation will have to be taken into account. Finally, there will be need to have engineers and technicians to manage the system. They will require training and this will be a cost item that should also be borne in mind. After these investments, the recurrent annual cost of operation and maintenance of the system should be worked out and made available.

CONCLUSION

25. It can be concluded that, in the light of the above considerations, the possibility for using satellite teletransmission in the routine hydrological data collection system in Ghana is rather low and does not appear justifiable.

26. However, there appears to be justification for its use in project operations, only with reference to the Volta River Basin system in which the Akosombo hydro-electric power plant is located. The justification should consider the investment cost and the operation and maintenance costs. It should also consider the timing of introduction of such a system, especially with respect to the level of utilisation of the water resources of the whole Volta Basin, in which developments in the riparian countries of Ivory Coast, Upper Volta, Mali, Benin and Togo are included.