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REPORT ON THE TRAINING SEMINAR ON HYDROMETEOROLOGICAL INSTRUMENTS, METHODS OF OBSERVATION AND ESTABLISHMENT OF HYDROMETEOROLOGICAL NETWORKS IN AFRICA

Addis Ababa, 2-20 October 1967

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EXECUTIVE SECRETARY OF THE ECONOMIC COMMISSION FOR
AFRICA

M68-1724

Origin and Purpose

1. In pursuance of the recommendations contained in the 1965-1967 Programme of Work and Priorities^{1/} and taking cognizance of the conclusions of the 1966 joint ECA/WMO hydrological survey, a training seminar on Hydrometeorological Instruments, Methods of observation and Establishment of Hydrometeorological Network in Africa was convened at Africa Hall, Addis Ababa, from 2-20 October 1967. The Seminar was designed to provide series of lectures on technical subjects and discuss measures for providing facilities for training of engineers in the use of hydrometeorological instruments, methods of observation and design of networks.

Organization and Attendance

2. The Seminar was organized by the United Nations Economic Commission for Africa with funds provided by the United Nations Development Programme and with WMO, providing assistance on technical aspects as a further contribution to joint efforts for developing hydrometeorology in Africa.
3. Mr. J. Otnes, Chief of the Hydrological Department of the Norwegian Water Resources and Electricity Board, Oslo, Norway, was appointed by the two sponsoring organizations, as Director of the course. Mr. A. Forsman, Chief, Hydrometeorology Section of WMO was Co-director and representative of WMO, and Dr. K. Riad, ECA Hydraulic Engineer was appointed as Co-director and representative of ECA.
4. A Steering Committee was formed comprising the Director, the two Co-directors, the lecturers and two representatives of the participants, elected by the latter (see Annex II).
5. The Seminar was attended by thirty-six participants from twenty African countries, nominated by their Governments: Burundi, Cameroon, Congo (Brazzaville), Dahomey, Ethiopia, Ghana, Kenya, Liberia, Lesotho, Madagascar, Mauritius, Morocco, Nigeria, Rwanda, Senegal, Somalia, Sudan, Tunisia, United Arab Republic and Upper Volta. The list of participants with their official titles and addresses appears in Annex II of the report.

^{1/} E/CN.14/393 - Project No. 38.

Opening Ceremony

6. The Seminar was formally opened on Monday, 2 October 1967, at 3 p.m. by Mr. R.K.A. Gardiner, the Executive Secretary of ECA, who in his opening statement stressed the importance of developing hydrometeorology in Africa and commended the sponsors of the Seminar. Brief remarks were also given by the Director and the two Co-directors.

Evaluation of the Seminar

7. Participants were requested to submit their views on the course so as to take them into consideration when arranging similar courses in the future. The following is an excerpt from their report.

"We are all gratified at the holding of this seminar which has familiarized some of us with measuring instruments, has given others the opportunity to improve their knowledge of the subject and has allowed all to benefit from the experience of the lecturers. It has given the participants the chance to become acquainted with one another, to explain their problems and to try and solve some difficulties peculiar to their countries.

This course has focussed our awareness on the need to establish a dense and efficient network as well as to disseminate the data that can and must be drawn from the operation of such a network.

To sum up, the seminar has been of great value to all of us. The subjects chosen were excellent, the surroundings pleasant.

May we be allowed, however, to present some suggestions that might help in the organization of such future seminars.

In future, before the beginning of seminars, Governments and relevant services should be provided with the syllabus proposed for the course to allow them to send the most appropriate delegations and to allow participants to prepare themselves and to present the problems that arise in their respective countries.

The seminar was rather short in view of the amount of information that the experts had to pass on to us, so much as, that certain essential practical exercises had to be cancelled. In view of the considerable sums of money spent on transport and organization, ample time should be allocated to such future courses. The purpose would be better served in this way, even if the expenditure were slightly higher.

It is desirable that such seminars be held periodically, every two years, in different countries capable of receiving all the participants and of helping in practical exercises."

Closing of the Seminar

8. The seminar ended on Friday, 20 October 1967, at 1 p.m.
9. The Director, Mr. J. Otnes, thanked the lecturers as well as ECA and WMO for their contribution to the success of the Seminar. He also paid a tribute to the keen and active interest shown by the participants in all topics of the Seminar.
10. Mr. Forsman expressed on behalf of the Secretary-General of WMO his high appreciation of all local facilities and arrangements provided for the Seminar by ECA, which had contributed so much to its success.
11. On behalf of the participants, Mr. J. Babalola expressed gratitude to ECA and WMO for organizing the Seminar and to the Imperial Government of Ethiopia for the facilities made available to the participants. He was sure they had all benefited from the Seminar and suggested that such courses should be held regularly.
12. Dr. K. Riad on behalf of ECA thanked the lecturers and the participants for their remarkable interest and their co-operation spirit which has greatly facilitated the task of organizing the Seminar. He stressed that without the active and enthusiastic participation of WMO, it would not have been possible to attain such excellent results.

ANNEX I

PROGRAMME OF THE SEMINAR

The Seminar was divided into the following four parts:

Part 1 - Instruments, Methods of Observation and Processing of Basic Data on precipitation and Evaporation;

Part 2 - Instruments, Methods of Measurements and Processing of Basic Data on Water Levels and Streamflow;

Part 3 - The Measurement of Sediment Load Transport;

Part 4 - Design and Establishment of Hydrometeorological Networks.

Series of lectures were given on each of the four parts by the following experts who served as consultants:

- | | |
|---------------------------------------|--------|
| - Professor J. Nemec (Czechoslovakia) | Part 1 |
| - Mr. J. Otnes (Norway) | Part 2 |
| - Mr. F. Fournier (France) | Part 3 |
| (sponsored by UNESCO) | |
| - Mr. J. Rodier (France) | Part 4 |

A discussion period followed each lecture. Practical exercises were organized on Parts 1, 2 and 4, the participants being divided into two groups (see Annex II).

Demonstrations of hydrometric and meteorological instruments were arranged. In addition, there was a field trip to a number of hydrometric stations and a study visit to the Meteorological Service.

The working languages of the Seminar were English and French, and simultaneous interpretation was provided in both languages.

SYLLABUS OF LECTURES AND PRACTICAL EXERCISES, STUDY TRIPS, ETC.

Introductory Lecture

The introductory lecture given by Mr. J. Otnes included a discussion of the elements of the hydrological cycle, the need for basic hydro-meteorological data and their required quantity, quality, accuracy and recommendations for units of measurements conforming to the WMO Guide to Hydrometeorological Practices.

PART 1. INSTRUMENTS, METHODS OF OBSERVATION AND PROCESSING OF BASIC DATA ON PRECIPITATION AND EVAPORATION

Professor Nemec gave a series of lectures on Part 1.

The lectures on precipitations included definitions, origin, formation and process of precipitation, installation of non-recording and recording rain gauges and basic requirements for gauges construction. Results of a number of experiments were also discussed and examples of gauges given. Errors in observation were analysed and corrective methods reviewed. In the basic treatment of precipitation data methods of time and space averages were given as well as elementary notions on studies: intensity - duration - frequency - area relationship of storm rainfall. A short review of snow measurement and its interpretation was given. The importance of radar in measurement of rainfall was stressed and methods as well as multiple utilization of radar precipitation measurement listed.

The lectures on evaporation included methods of measurement of evaporation by instruments of various types and comparison and installation of instruments. Factors influencing evaporation were discussed and a description of pans and tank evaporimeters was given. Computation of lake evaporation on the basis of pan data was demonstrated.

In estimating evaporation from meteorological and other data the energy budget, the mass transfer as well as Penmans and other formula were described. The lectures on measurement and estimating evapotranspiration included description of evapotranspirometers and lysimeters and a discussion of different formulae used for this purpose. The different instruments were presented either in situ or on slides.

Practical exercises included computation of double-mass curves, methods of graphical and mathematical evaluation of time and space averages of precipitation, analysis of precipitation recording gauges charts and frequency analysis of annual precipitations as well as of storm rainfall using different types of statistical distribution curves. (Person and Gumbel)

PART 2. INSTRUMENTS, METHODS OF MEASUREMENTS AND PROCESSING OF BASIC DATA ON WATER LEVELS AND STREAMFLOW

Mr. J. Otnes gave a series of lectures on this part covering the following subjects:

Observations of waterlevel. Description of sites, methods of manual and automatic observations as well as flood measurements.

Measurements of discharges by current meter using the vertical velocity-method and point methods. Measurements of discharge by dilution methods with emphasis on the relative dilution method, measurements by transportable weirs and the less accurate surfaces float methods.

Establishment of discharge rating curves, unique curves, complex rating and rating at stations with shifting control. The fitting of a curve to available measurements by using series of differences and logarithmic fitting. Methods for extrapolation of the curve.

Slides were projected during one of the lectures.

The lectures were followed by practical exercises on the following subjects:

- (a) Computation of cross-section curve, wetted perimeter and computation of discharge using the Manning formula;
- (b) Computation of discharge and average velocity by the vertical velocity method and computation of monthly discharge at a station with shifting control.

PART 3. THE MEASUREMENT OF SEDIMENT LOAD TRANSPORT

Mr. F. Fournier gave a series of lectures on solid load transport in streams, the establishment of networks of measuring stations, instruments and the interpretation of data obtained.

His lectures could be summarized as follows:

Solid load transport in streams is most closely linked with water erosion, which takes place on the surface of drainage basins. The second phenomenon must therefore be studied, as being the origin of the first. The mechanisms, factors and forms of water erosion were reviewed. Such study gives a clearer idea of how the measurement network must be organized.

A measurement network must include the study of splash, measurement in experimental plots, experimental fields, small basins, and finally large basins. In each case, the installation of conventional measurement systems was reviewed, and the instruments used were described. The second part concluded with an account of new methods (the use of isotopes), as well as the effect of their use on the organization of networks.

Finally, the problem of the interpretation of data was broached. To be explicit, once they have been obtained, it is necessary to ascertain their significance for water shed management.

The lectures on this subject concluded with an outline of the present state of knowledge with regard to the forecasting of

solid load transport, in the light of the various factors involved.

PART 4. DESIGN AND ESTABLISHMENT OF HYDROMETEOROLOGICAL NETWORKS

Mr. Rodier lectured on the establishment of hydrometeorological networks and their correct operation which are essential for the development of African countries. He stressed that dividing stations into three categories: primary stations operated permanently, secondary stations and special stations, it is possible to obtain the maximum of information at minimum expense. The instruments used in the networks must be accurate and reliable in operation, robust and simple to use, and their price must not be too high. As far as possible, all instruments used in any one country should be of the same type. The study of extreme values should not be neglected: precipitation, discharges readings and exceptional floods.

The density of the stations varies mainly according to the irregularities of local topography. In plains and tropical regions, there should be one rain-gauge for every 3,000 km² and one stream-gauging station for every 10,000 km² (norms tolerated in difficult areas). In arid zones, the tolerated standards are one rain-gauge for every 10,000 km² and one stream-gauging station for every 20,000 km². In many cases, it is necessary to replace staff gauges by recording devices, but this is difficult in Africa, and exceptional care should be taken when recording charts and in maintenance. Stream-gauging stations must be visited frequently and gauging carried out with maximum precision. Every precaution must be taken to avoid errors in data processing. In the future, the trend will be towards automation of networks, and African countries should bear this in mind. However, this must be introduced gradually. The first step is to enter the daily precipitation and then water level figures on punch cards, which will necessitate qualified staff for error control before punching. A suitable type of punch card must be selected.

Modern equipment should be fully tested beforehand. However, it will be many years before the operation of African networks becomes an everyday affair.

Mr. Rodier also conducted practical exercises, which dealt with the problems of network design in Chad and in Senegal, Mali, Upper Volta and Niger, and examined some problems arising out of data processing using punch cards.

Study Tours

With the kind co-operation of the Awash Valley Authority, a field trip was organized on Saturday, 14 October to Modjo (demonstration of bridge measurement), Melka Gorge (demonstration of cableway measurement and bubble gauge) and Koka Dam.

On Sunday, 15 October, a study trip was organized with the kind co-operation of the Civil Aviation Board to the Meteorological Forecasting Centre at the Addis Ababa airport.

ANNEX II

LIST OF PARTICIPANTS / LISTE DES PARTICIPANTS

<u>Country / Pays</u>	<u>Participant</u> (Name and profession / Nom et profession)	<u>Mailing Address /</u> <u>Adresse postale</u>
Burundi	<u>Mbugubugu Méience</u> , Coordonnateur du Réseau climatologique national (R.C.N.)	Ministère de l'Agriculture et de l'Elevage, B.P. 1850, Bujumbura
Cameroon / Cameroun	<u>Bounda Samuel</u> , Météorologiste	Direction de la Météorologie, B.P. 186, Douala
Congo (Brazzaville)	<u>Bandzouzi Esad</u> , Adjoint technique Météo (spécialiste hydrologie)	Direction Aviation Civile, B.P. 128, Brazzaville
Dahomey	<u>Vodji Louis</u> , Chef Section Hydrologique	B.P. 385, Cotonou
East Africa / Afrique de l'Est	<u>F.A. byarugata</u> , Meteorologist	P.O. Box 30259, Nairobi
Ethiopia / Ethiopie	<u>Akalu Meshesha</u> , Hydrologist	Awash Valley Authority, P.O. Box 591, Addis Ababa
	<u>Ali Mohammed</u> , Agro-Meteorologist	National Climatological Service, P.O. Box 1090, Addis Ababa
	<u>Amare Retta</u> , Assistant Irrigation Agronomist	Institute of Agricultural Research, Addis Ababa
	<u>Assefa Teferra</u> , Agricultural Engineer, Field Hydrology Operation-Chief	Water Resources Department, P.O. Box 1008, Addis Ababa
	<u>Borga Sabera</u> , Meteorologist	Civil Aviation Administration, P.O. Box 978, Addis Ababa

<u>Country / Pays</u>	<u>Participant</u> (Name & profession / Nom et profession)	<u>Mailing Address /</u> <u>Adresse postale</u>
Ethiopia / Ethiopie	<u>Eshetu H. Mariam</u> , Weather Forecaster	Civil Aviation Adminis- tration, P.O. Box 978, Addis Ababa
	<u>Godana Tuni</u> , Climatologist	National Climatological Service, P.O. Box 1090, Addis Ababa
	<u>Hailu Hapte</u> , Office and Field Engineer	Water Resources Depart- ment, P.O. Box 1008, Addis Ababa
	<u>Samuel Mehari</u> , Hydrologist	Awash Valley Authority, P.O. Box 591, Addis Ababa
	<u>Shemelis Ageze</u> , Hydrologist	Water Resources Depart- ment, Blue Nile Basin, P.O. Box 1008, Addis Ababa
	<u>Stephanos Ogbasellasié</u> , Civil Engineer, Hydrologist	Water Resources Depart- ment, P.O. Box 1008, Addis Ababa
	<u>Teshome Workie</u> , Civil Engineer, Hydrologist	Water Resources Depart- ment, P.O. Box 1008, Addis Ababa
	<u>Wolde Gabriel W. Michael</u> , Meteorologist	Water Resources Depart- ment, P.O. Box 1008, Addis Ababa
	<u>Workineh Degefu</u> , Meteorologist	Civil Aviation Adminis- tration, P.O. Box 978, Addis Ababa
	<u>Yilma Wolde Emanuel</u> , Hydrologist, Civil Engineer	Water Resources Depart- ment, P.O. Box 1008, Addis Ababa
Ghana	<u>Emmanuel Nyame Kumi</u> , Engineer	Volta River Authority, Box M77, Accra
	<u>George Gogo Naih</u> , Engineer (Hydrology)	P.W.D., P.O. Box 2099, Accra
	<u>A.K.E. Ussher</u> , Meteorologist	Meteorological Depart- ment Headquarters, P.O. Box 87, Legon, Accra
Lesotho	<u>J.R. Tuoane</u> , Hydrologist Assistant	P.O. Box 426, Maseru
Liberia	<u>Richard D.A. Hill</u> , Engineer (Hydrology)	Department of Public Works, Monrovia

<u>Country / Pays</u>	<u>Participant</u> (Name & profession / Nom et profession)	<u>Mailing Address /</u> <u>Adresse postale</u>
Madagascar	<u>J.P. Andrianifahanana</u> , Ingénieur de la météorologie	Service météorologique, Tananarive
Mauritius / Ile Maurice	<u>Venkataswamy Kumaraswamy</u> , Hydrometeorologist	Meteorological Head- quarters, Vacoas
Morocco / Maroc	<u>Mbirkou Mohamed Naji</u> , Météorologiste	Service météorologie nationale, 7 rue Docteur Veyre, Casablanca
Nigeria	<u>Joshua Babalola</u> , Meteorologist	Meteorological services Headquarters, Lagos
Rwanda	<u>Munyaruyoga Venusto</u> , Fonctionnaire hydrologue	B.p. 621, Kigali
Sénégal	<u>Tall Doudou</u> , Service agrométéorologie	Ministère des travaux publics, B.p. 549, Dakar
Somalia / Somalie	<u>Ali Abdi Odawa</u> , Meteorological Officer	Meteorological Service, Department of Civil Aviation, Mogadiscio
Sudan / Soudan	<u>Kamal Ali Mohamed</u> , Chief Hydrologist	P.O. Box 878, Khartoum
Tunisia / Tunisie	<u>Nasrallah Salem</u> , Hydrologue	5, rue Ibn Kaldoun, Le Bardo, Tunis
UAR / RAU	<u>Abdel Sabour A. Khalil</u> , Instrument Expert (MIRT)	6, Abul Sorrow St. Manshiat Elbakry, Cairo
Upper Volta / Haute Volta	<u>J.G. Yameogo</u> , Ingénieur, Chef de l'Hydraulique urbaine et industrielle	B.p. 330, Ouagadougou
<u>Secretariat</u>		
Mr. A. Forsman (Co-director)	Chief of the Hydrometeorology Section, World Meteorological Organization, Geneva, Switzerland	
Dr. K. Riad (Co-director)	Hydraulic Engineer, Economic Commission for Africa	
Mr. J. Otnes (Director- Lecturer)	Chief of the hydrological Department of the Norwegian Water Resources and Electricity Board, Oslo, Norway	
Professor J. Nemec (Lecturer)	Head of the Department of Water Resources at the Prague Agricultural University, Prague, Czechoslovakia	
Mr. J. Rodier (Lecturer)	Chief of the Hydrological Department ORSTOM, Paris, France	
Mr. J. Fournier (Lecturer)	Inspector General of Research ORSTOM, Paris, France	
Miss M.C. Aeschbacher	Natural Resources and Transport Division, ECA	

Steering Committee

In addition to the Director, the two Co-Directors and the lecturers, the following two representatives were elected by the participants as members of the Steering Committee:

Mr. J. M. Babalola	(Nigeria)
Mr. J.G. Yameogo	(Upper Volta)

ANNEX III
LIST OF DOCUMENTS

No.	Title	Author	Language	
			English	French
1.	Methods of measurement of water levels and stream discharges	J. Otnes	X	X
2.	Outline of lectures	J. Nemec	X	X
3.	Introduction and lectures	J. Nemec	X	X
4.	Aménagement et exploitation des réseaux hydrométéorologiques	J. Rodier	X	X
5.	Etudes sur l'évaporation à l'Ile Maurice	H.W. Underhill and Venkatasawng	X	X
6.	Aperçu de la situation actuelle du réseau hydrométéorologique malgache et traité de son développement au cours de la prochaine décennie	J.P. Andrianifahanana		X
7, 8.	Exercices	J. Otnes	X	X
9.	Exercices	J. Rodier	X	X
10.	Exercices	J. Nemec	X	X
-	Ghana Hydrological Networks and Stream Gauging Methods	G.G. Naih	X	
-	Hydrological Facts about Liberia,	Richard D.H. Hill	X	
-	Considérations générales sur le but et l'organisation du réseau hydro-agro-climatologique au Burundi	Mbugubugu Mélenca		X

In addition, Mr. J.M. Babalola (Nigeria) orally presented a paper entitled "Variability of Annual Rainfall in Nigeria" and Mr. A.A. Khalil (UAR) orally presented a paper entitled "An Outline of the Scientific Instruments in the Meteorological Department in the UAR".

ANNEX IV

OPENING ADDRESS BY Mr. R.K.A. GARDINER, EXECUTIVE SECRETARY
OF THE ECONOMIC COMMISSION FOR AFRICA

History records the rise and fall of civilizations which thrived when they had water and perished because their sources of water dried up or because they were unable to cope with an excess of it.

In Africa, more than 30 per cent of the land area is desert or arid land receiving little or no rain. Rainfall varies from region to region and within regions and even within individual countries. The continent experiences extreme scarcity of rain, highest evaporation rates, and an extreme abundance and a great outflow of water into the oceans.

It is not necessary to point out that with the increase of population the daily consumption of water - eating, drinking, washing, cooking - is rising steadily. The development of agriculture to feed the population is also dependent on the wise use of water. The harnessing of rivers and their possible damming and diversion to areas which receive little or no water and the collection and storage of water are services which we must learn to provide.

Hydrometeorology has not received much attention in Africa, but its significance should not be underestimated; because its findings can help farmers to determine a rhythm of activities which will affect not only crop yields but also the type of crops to be grown. In the Far East, a WMO programme is helping to establish stations which will map out the cause of typhoons, cyclones and hurricanes, and provide flood warnings. These are only a few of the advantages a network of meteorological stations can confer. And, as you all know, meteorological observations and forecasts are basic to aerial navigation.

In Africa, we are lagging behind other regions in the understanding and practice of hydrometeorology and what we are attempting to do in this seminar is to take the first step in looking at the tools of the trade and to ascertain whether we too can make use of them efficiently

for our development. Africa has over 40 international rivers and many of these are being harnessed for hydro-electric power and in addition controlled extensively for irrigation. As this process continues, there is likely to be conflicting claims from countries through which these rivers flow. We must know how to measure both in absolute and seasonal terms the amount of water likely to be available in order to have equitable distribution of this valuable resources among contending countries.

This Seminar is intended for practitioners of hydrometeorology in Africa and experts and consultants from the United Nations. Its objective is to provide a forum for the exchange of experience about techniques and procedures. It may seem unnecessary to bring people together just to be introduced to the instruments used by hydrometeorologists, but this is not really so. Sometimes, some governments, in their zeal to improve conditions make the mistake of acquiring and installing unnecessarily expensive equipment. If we can avoid this mistake, as a result of this Seminar, that will be a help. We also hope that this Seminar will enable us to know more about existing personnel, observation stations, and facilities for training. As a result of this, we may be able to establish training programmes and institutions to meet the needs of Africa.

ECA is very grateful to the World Meteorological Organization for the support which it has given to this Seminar. As you all are aware, ECA is not a technical body and it is my hope that after this Seminar the work of the Commission will be confined to encouraging governments and doing whatever it can to promote a programme which can be carried out with the technical advisory services available in and through the World Meteorological Organization.