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The Conservation and Utilization of Water [and Discussion]

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The conservation and utilization of water

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There is a need for a quantitative assessment of the factors that determine the water balance of each part of an area, cultivated or under natural vegetation, and of their variability in time and space. These factors are rainfall, soil physical characteristics, potential evaporation and topography, the latter acting on surface and/or subsurface inflow and outflow.

Knowledge needs to be assembled as to how to handle the rainfall received in an area. This aspect covers infiltration rates, methods to temporarily impound water on the field, knowledge about rates of water use and water recovery in small-scale storage reservoirs.

The next step is to ensure a careful use of water through a judicious choice of the cropping and farming systems and by methods of land preparation and of the timing and choice of farming operations.

It is important to increase the efficiency of water use through the choice of crops and varieties, by elimination of non-water factors limiting optimal growth and development of crops, by adequate crop protection and by adopting suitable harvest procedures. Energy inputs into the farming system are to be adjusted to the desired level of production.

Among the socio-economic factors that affect the economic use of water, are matters of land ownership and availability of credit for low volume investment.

The definition of the correct level of water conservation during a given cropping season is dependent on the requirements of other components of the cropping system, notably of the production of crops on adjacent low lying lands, usually cultivated from the end of the rainy season onwards.

Out of season (November–February) irrigated crops on relatively small areas may contribute very significantly to agricultural production during a period when water requirements are relatively low.

Introduction

As in most other dry regions, the agricultural production systems in the semi-arid zone of Africa south of the Sahara, the Sahel zone, have always been characterized by an unstable equilibrium between the human and animal populations and the natural resources. In the Sudanian zone, where average rainfall varies from 400 to 800 mm per year, the equilibrium has fluctuated between abundant food supply and harsh conditions of life, but widespread starvation has not been a threat so long as only the 'resident' population was concerned. In the northern Sahelian zone, where average annual rainfall is less than 400 mm, the variation has been between reasonable food supply and near starvation, except perhaps for small groups of people living close to the three great river basins – the Niger, the Senegal river and the Lake Chad system. Conditions in this northern zone have given rise to widespread movement of people and animals in very dry years, which have often had difficult consequences in the 400–1000 mm rainfall areas to the south.

Although several series of drought years occurred earlier in this century (particularly around

1910–14 and in the early forties), only the drought sequence of 1968–74 aroused worldwide concern. This was partly perhaps because communication was better than before, and partly because population pressure was greater than before, so that after the humid period preceding 1968, marginal land, that would in earlier times have been left as a buffer for use in sequences of dry years, had already been taken into regular use. Thus the opportunities for movement within the northern Sahelian zone were more restricted.

The question of whether or not the climate is changing in the Sahel zone has been amply discussed. This is certainly of academic interest, but it is not a major immediate concern for the population living in the area. For those who depend for their living on the agricultural production of the semi-arid zone, the problem is to formulate a new technology of farming, adapted to the present demands of the population and the year-to-year and decade-to-decade fluctuations in meteorological and hydrological conditions that affect agricultural production.

A technology that aims at a more effective use of water, which is correctly recognized as one of the limiting resources, will necessarily have to take account of limitations in other resources, notably the availability of human labour, alternative forms of energy, and plant nutrients. A new technology is of necessity a package deal. It may be an instrument in the government's policies on integrated rural development, lessening the flow of people to cities that are insufficiently equipped to accept them. In areas away from the main river basins, it may have to be a technology requiring investment, which, though widespread, is small enough to be provided by farmers, groups of farmers or villages. Nearer to the main rivers technology requiring larger investments on relatively small areas may prove beneficial, if all other factors in the technological package can be made available in commensurate amounts.

Solar energy is abundantly available in the area. Other forms of energy are either not so readily available or have not been developed. Since vegetation is a major agent which converts solar energy into a utilizable form, it seems logical to promote the growing of plants that make effective use of the limited amounts of available water.

Water resources

Studies of the conservation and use of water resources should define the amounts of water that can be expected to be available, the demand for water, and the manner in which the available water should be managed so as to be most effectively used: in certain cases demand may be decreased or adapted to the supply, or the supply at any one point in time and space may be effectively increased.

The studies must embrace agricultural production in the widest sense, from occasional grazing in the 50–100 mm area to intensive irrigated agriculture producing several crops per year. Apart from grazing, the most widespread crop production systems are: raingrown crops, grown during the rainy season on the higher ground; flood plain crops, often planted towards the end of the rainy season on lower areas; and irrigated crops, using either loosely-controlled flood irrigation or more strictly controlled irrigation techniques using advanced technology.

As the first two methods are practised on many millions of hectares in the Sahel, even a small increase in yield per hectare from the present average grain yield of 300–500 kg/ha will significantly increase total agricultural output.

Hitherto, hydrological and meteorological information about these two systems of cropping has not been available until after the end of the growing season. It has occasionally been used for statistical analyses, which have sometimes indicated ways of improving the agricultural practices. Because the information is not transmitted or made available in real time, it cannot be used to guide government policy decisions or farmers' actions during the course of the season, for example in allocating resources for growing and harvesting crops and in decisions about crop protection measures.

The supply of water

All water in the semi-arid area south of the Sahara, whether it falls directly as rain or is derived from rivers, is brought there by the masses of humid southerly air which have their origin over the Atlantic ocean. The extent of northward movement of this southerly air is indicated by the position of the Intertropical Convergence Zone, which moves, with a time lapse of four to six weeks, behind the 'movement' of the Sun, between about 5° N in January and about 25° N in July–August.

Rain

For precipitation to occur, the vertical distribution of water vapour in the atmosphere must satisfy certain conditions. The underlying, relatively cool, moist layer must extend to sufficient altitude and the vertical temperature distribution above this layer must be such as to permit large scale vertical turbulence.

Early in the season, rain usually comes in isolated thunderstorms; later on, the rain-bringing mechanism is the 'squall line', extending over several hundreds of kilometres in a north–south direction and moving from east to west at an average speed of 40–80 km/h. The mechanisms by which these 'squall lines' acquire energy and water vapour are still far from completely understood.

In the semi-arid area south of the Sahara, rainfall is measured at about 60 synoptic stations, some agrometeorological and climatological stations and several hundreds of rainfall stations. The main preoccupation of the meteorological services is to maintain the quality rather than the quantity of observations. Records of daily and monthly totals are collected and published as tables and as maps by the Agence pour la sécurité de la navigation aerienne en Afrique et en Republique Malgache (A.S.E.C.N.A.) and the Office de Recherche Scientifique et Technique Outremer, Paris (O.R.S.T.O.M.). Frequency distributions of 10-day and monthly totals have been calculated and published by O.R.S.T.O.M. Few analyses of intensity and duration of rainfall have been published.

Rainfall totals and frequency distributions with time can provide a reasonable assessment of the rain régime in an area, but, if the landscape is not flat (especially in the drier areas), agriculturally very important differences may be associated with variations in microtopography. As a result of runoff, small slightly lower-lying areas may effectively receive water equivalent to double the average rain. Farmers in these areas make full use of these local conditions. Isohyets by themselves are not necessarily an exclusive means of assessing effective supplies of water.

Equally important is the duration of the rainy season. There is, of course, a certain relation between the length of the season and the monthly and seasonal totals, as demonstrated by a frequency distribution diagram. Moreover, it is often observed that smaller seasonal totals are associated with larger year-to-year variability. This is the main reason why the risks of agriculture are greater in the drier areas.

Traditional farming systems have tended to move southward and northward in sequences of drier and wetter years. On the one hand, this has led some population groups to move in accordance with this pattern, and on the other, it has led some sedentary population groups to

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master several technologies and apply them as required in different years. Such sedentary groups are found in the northerly zones of the great river basins, roughly between 15 and 17° N.

Local runoff

Local surface inflow and outflow is sometimes exploited in subsistence agriculture to grow crops outside the principal growing season. This technique allows farmers to produce additional crops, adapted to the seasonal changes in the temperature and atmospheric humidity régimes, and it spreads the work load of rural families and communities. It also diversifies their diets. It may be possible to gain locally important increases in agricultural production by a better selection of suitable soils for this type of agriculture.

Surface water

An important amount of water can be made available in the semi-arid zone south of the Sahara by using surface water more effectively. More attention should be given to surface water hydrology so that plans can be made to take advantage of these resources. Most existing systems of irrigated agriculture have been based on flood agriculture. Little secondary or tertiary irrigation has been practiced.

Surface water supply in minor tributaries is often abundant from the beginning of the main rainy season until December. The main streams generally have a plentiful supply of water in their lower valleys up to March. The times when water is available are evidently associated with distance downstream. At the end of the dry season all watercourses are almost completely dry.

Plans are being formulated to control and regulate flow on the Senegal and Niger Rivers, to supply water all the year round for irrigated agriculture. This leads to a definition of three future phases in the water economy of irrigated crops grown either in the cool period from November to February or in the hot period from March to June. In the first phase, before the rivers are regulated, water will be scarce during the latter season, for which crops which produce a large quantity of dry matter per unit of water evaporated will have to be selected. In the second phase, when river flow has been regulated but before all land suited to irrigated agriculture has been brought into cultivation, water will not be scarce in any of the three possible growing seasons in any one year. In the third phase, when the total area of land suitable for irrigated agriculture has been taken into use, a large ratio of dry matter production to water used again becomes imperative.

The water balance

In all studies of the conservation and use of water for agriculture, the essential factor is not the total amount of water used but the length of time during which water is effectively and adequately available for crop growth. The real need is therefore for knowledge of the water balance in a given area, on a given soil type and under a given crop. The calculation of a water balance not only shows the periods of shortages but also the periods of excess, knowledge which is essential in the study of the possibilities of conserving and using water. The correct calculation of water balances requires not only detailed meteorological observations, but also data on soil physical characteristics and knowledge of the physiology of the types of vegetation to be grown.

Ideally, water balance calculations should be made from actual observations of rainfall and evaporation over a series of years, rather than on means or calculated statistical distributions. The assumptions about crop and soil characteristics which are used in such calculations can be

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tested against observations of the quantities and distributions of water in the soil at different times, measured with a neutron probe, Bouyoucos blocks, tensiometers or gravimetric sampling.

Water balance data may lead to the formulation of agricultural practices that aim to store in the soil as much water as is useful (not necessarily the maximum that can be stored) and that will permit the excess to be discharged as controlled runoff, to be recovered and stored in lower lying areas for later use. This method, which is under study at the International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, India (I.C.R.I.S.A.T.), among other places, can increase, and spread, the effective supply of water in semi-arid areas with a short wet season and a pronounced peak of rainfall.

Methods to increase water supply in this (and other) ways cannot be used efficiently without real-time knowledge of meteorological data. In many semi-arid areas of the world, the infrastructure to assemble this real-time knowledge has not yet been established. Such an infrastructure consists of a well-distributed network of weather observing posts (including weather radar where necessary) manned by qualified observers, equipped with a properly functioning telecommunications system, and feeding into a regional data analysis centre, that can transmit its conclusions rapidly and effectively to government services and farmers who need the information. The data analysis centre should also have rapid access to observations from weather and 'Landsat' satellites.

The data accumulated at such a centre can subsequently be analysed statistically, notably to determine the length of the growing season and the probability of early season or mid-season droughts. Such information will guide medium-term decisions on proposed modifications to, or inputs into, agricultural systems and practices, particularly when it becomes possible to forecast droughts.

The demand for water

In the driest areas, where the dominant agricultural exploitation is grazing, all water that falls as rain can normally be used.

In areas where arable agriculture is possible but the wet season is short, the demand for water is that of the main crops grown; millet, sorghum, maize, different varieties of *Vigna* (cowpea), vegetables and groundnuts. In areas where the wet season is slightly longer, farmers sometimes practise a form of intercropping, often with different sowing dates for the different crops, and the demands for water is more difficult to calculate.

The two most commonly used ways of estimating potential rates of water use for the calculation of crop water requirements are Penman's formula and observations from a class A pan. The empirical coefficients used in Penman's formula have to be determined at selected main agrometeorological stations in any one semi-arid area. 'Crop factors' for all major crops grown have been determined at many different locations and it seems that a working consensus has been reached.

While Penman estimates of crop water use can be applied to both rain-grown and irrigated crops, if the necessary precautions are taken, class A pan rates are more commonly used for irrigated crops only. A vast amount of well-tested work is available on 'crop factors' to be applied with evaporation rates from the class A pan. Both Penman and class A pan estimates of evaporation can be used to estimate evaporation from open water, lakes and reservoirs.

The use of Piche evaporation data has led to some very misleading conclusions, especially in regions where the vapour pressure deficit and temperature regime vary markedly with season.

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The correction formulae which have been proposed to allow for this variation do not seem to have been widely accepted.

When interpreting the calculations of crop water requirements, attention should also be paid to the amount and the type of dry matter that is produced per unit of water used. Irrigated rice would seem to be inappropriate in semi-arid areas, except on land that would be flooded anyway. Wheat and sorghum appear to be better adapted. When crops are being selected, especially for cultivation under irrigation in the dry season, other agrometeorological factors, such as day-length, radiation and temperature régime must be taken into account, as well as, of course, non-meteorological factors affecting the farming system as a whole.

A special aspect of crop selection in semi-arid areas is the difference between the effects on determinate and indeterminate crops of an inadequate water supply. For the former, of which sorghum is an example, inadequate supply can lead to total failure, while for the latter it usually affects only the degree of success. In traditional agriculture, farmers have sometimes met this sort of difficulty by using genetically mixed material or multiline varieties. It should be possible to adjust water supply to indeterminate crops so as to obtain the largest possible ratio of economically useful dry matter per unit of water used.

Crop water demand is, to a considerable degree, also a function of other agricultural practices, such as date of sowing, spacing, weeding, intercropping and fertilizer régime. While intercropping is certainly being practised by farmers in semi-arid areas, little scientific work has been done on the assessment of the water balance under such crops.

The handling and effective use of water

A number of measures can be taken to make water more useful. In the case of rain, most of these are agricultural measures. In the case of surface runoff and flood water, these measures may also be in the field of rural engineering.

For rain, a first requirement is to maximize the rate of infiltration of the early rains, which fall when the soil profile contains little or no available water. Measures to facilitate infiltration vary from region to region and according to many factors, such as soil characteristics, stocking rates, movements of livestock, and previous crops. Such measures may include the preparation of the soil at the end of the previous season, stubble conservation, and careful control of burning. Early season runoff can be decreased by agricultural methods which individual farmers can undertake.

On the other hand, there are cases when controlled runoff during the peak of the rains is beneficial, both to avoid the leaching of plant nutrients and to collect water in lower areas for later use. On soils in which water infiltrates or percolates slowly, methods of land preparation that hold water temporarily on the surfaces of the fields may be beneficial in the early part of the season, before the soil profile has become saturated with water. Dates of planting, and spacing and weeding practices all affect the effectiveness of the water supply, especially early in the season.

To handle surface flow and flood water efficiently, the downstream area that is to receive the water must be fully prepared. Apart from basic agricultural measures, a system for forecasting flow and flooding, based on a river-flow model in which real-time hydrological observations are used, will permit human energy and agricultural resources to be allocated efficiently in handling the water – an operation which requires much labour in a short time and can easily fail if actions are not properly timed and coordinated.

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There are several ways in which water can be more efficiently used than is the case at present.

(*a*) Choice of crops and varieties which will give large yields in a *life cycle of appropriate length*. Based on agrometeorological or hydrological data, crops and varieties can be chosen that can make full use of the length of the growing season that can be expected, at a particular location, say in 9 years out of 10 for food crops or 3 years out of 4 for cash crops. These possibilities should be examined jointly by agrometeorological services and national and international agricultural research institutions. Once the season's probable length has been determined and suitable varieties have been chosen, the cropping system, sowing dates, layout and preparation of land have to be designed or determined accordingly.

(*b*) Choice of crops and varieties with a large *ratio of dry matter production* (or *saleable product*) per unit of water used, and with a large growth rate at the stage of development when water is likely to be liberally available.

(*c*) Choice of crops or varieties whose *canopy architecture permits intercropping*, so that the combined water requirement of the two crops is adapted to the water supply that can be expected. It is important, in cases (*b*) and (*c*), to ensure *an optimum supply of plant nutrients*, especially *nitrogen, at the time when water is adequately available*. This may be done by intercropping or by applying fertilizer. The beneficial effect of intercropping may be increased if leguminous crops are chosen with root depths and crop architecture different from and adapted to those of the associated cereal crop, so that maximum use of incident radiation for photosynthesis can be assured.

(*d*) The choice of crops or varieties in which most, or even all, parts of the plants can be sold or used – *all-economic or multipurpose crops*. Examples of such crops are sorghum with a large sugar content in the stem, grain crops with a large ratio of grain to straw, or grain crops with straw that is palatable for cattle, such as wheat rather than rice.

(*e*) To increase the effective use of water, it is important to *protect crops* effectively. Seed treatment is a simple measure, readily accepted by farmers if properly organized. Protection of young seedlings against grasshoppers can also easily be organized (and moreover grasshopper outbreaks can be forecast if agrometeorological data are available in good time). Protection of crops in the latter part of the cycle is equally important. Agricultural measures and choice of genetic material may be important to lessen damage by birds and rodents as well as by insects and disease. In areas where meteorological conditions in the later parts of the season favour the outbreak of diseases or the increase of insect populations, the choice of shorter term varieties, even if their potential yields are rather smaller, may be advisable.

(*f*) *Harvesting procedures*, and the *infrastructure* for marketing and distribution, even over relatively short distances, should be improved in order to even out the differences in output due to variations in water supply from place to place and from year to year.

(*g*) When water is scarce, it can be more efficiently used if the *energy input into the agricultural system* is properly matched to the needs of the agricultural system. There are several periods when the demand for labour is large, notably when the land has to be prepared and rain-fed crops have to be sown and weeded, when the harvest of rain-grown crops coincides with the sowing of flood plain crops, and in the interval between the harvest of one irrigated crop and the sowing of the next one. This interval has to be as short as possible in semi-arid zones, where intensive irrigated agriculture may be based on a rotation of two or three crops per year (5 crops in two years).

Timeliness of sowing operations is often even more important for yield in tropical than in temperate zone agriculture. One reason is that changes in temperature are both rapid and large; another is that potential evaporation often changes in the same ways, which results in rapid changes in the amount of water available for establishing crops, particularly on soils which cannot store much water.

The exact method of matching energy requirements to needs will require detailed study in semi-arid regions. Animal traction may not be possible in those areas where the greatest demand for energy is at the end of the dry season, when animals are usually hungry and relatively weak. Individual farmers often lack the resources to invest in mechanical equipment. It may be possible to encourage the use of hired tractors, or of small farm implements like those which the International Rice Research Institute has promoted for small-scale rice farmers.

In some rain-fed areas, end of season land preparation, in readiness for the next season, may decrease the peak demand for energy and help the early rains of the next season to enter the profile.

(*h*) In areas where the topography is suitable, *impounded water* collected from the surface runoff *in months of excess rain* can be more intensively used. This requires cheaply constructed storage reservoirs, which could be built cooperatively by small groups of farmers or by villages. Studies intended to make this technique easily and reliably available to farmers are being conducted at I.C.R.I.S.A.T. It is probable that such techniques will be more easily accepted by farmers if the water collected can be used on their own land. Solar or wind energy might be used to return it at an appropriate time, to the land on which it was originally received. Applied at the end of the season, this water could permit crops or varieties with a longer growth cycle to mature, or allow the cultivation of a short-cyle catch crops, such as chick pea or pigeon pea.

The common emphasis on preventing runoff can be exaggerated. In some cases a certain amount of runoff may permit lower lying areas, perhaps in drier zones, to be taken into production. Sometimes alluvial soils lower down in a catchment may yield greater economic benefit per unit of water, than soils upstream. An extreme case is represented by the water-spreading systems of the Negev and parts of north and northeast Africa. In other cases the combined benefits from two crops, each grown with a slightly deficient water supply, may be greater than that of a single crop grown with a fully adequate supply of water. The difference in the phasing of the harvests of two such crops may also be important. An example might be an early upstream pasture crop combined with a later downstream small grain or grain legume crop, which would also provide palatable straw.

(*i*) Few exact studies have been made on the possible beneficial effects of *windbreaks* on the efficiency of water use of crops in the semi-arid zone south of the Sahara. Many side effects concerning, for example, the protection of crops against insects and birds, or the occurrence of excessively warm temperatures during periods when air movement is restricted, are associated with windbreaks. Detailed knowledge is needed before specific recommendations can be made.

(*j*) Although most nomads, whose animals graze range pasture, use very effective traditional *warning systems* to manage their pasture resources, real-time meteorological information and satellite observations may help to formulate information that could be disseminated in order to regulate pressure on natural grazing areas.

(*k*) Irrigated forage crops, grown during the dry season near the main rivers, and in the close neighbourhood of centres of population could help to maintain or even increase the live weight

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of animals raised on range pasture, in the period before they are sold, and so increase the effective return, to the producers, of the rain-fall range.

(*l*) Range can in some circumstances be improved by sowing leguminous species from the air, and resulting improvements in yield and quality could increase live mass gain. Where there are risks of overgrazing, aerial resowing may even include seed of unpalatable grasses, that would assure the continued presence of a vegetative cover, improve infiltration into the soil and reduce excessive erosion, for example around recently installed wells.

Conclusion

A number of agricultural techniques that can make the use of water more efficient are known and have been tested, but they are not yet widely practised. With appropriate investments and support services, a major extension effort might lead to rapid increases in agricultural output. Farmers generally judge innovations on their intrinsic profitability, but they will usually reject them if they increase their risks – for example (particularly in subsistence agriculture) by threatening the output of their food crops. Acceptable innovations may include relatively simple operations in seed treatment and crop protection. Information about such innovations should be more fully exchanged between anglophone and francophone countries in the drier parts of West Africa.

The collection, analysis, interpretation and dissemination of agrometeorological and hydrological information has received too little attention in many semi-arid areas in the past. Such information could facilitate both the detail and the timing of existing techniques of agricultural production in ways which could make the use of limited amounts of water more efficient. Weather forecasts, and particularly forecasts of the onset of rain and of mid-season droughts, are still far from perfect, mainly because we do not sufficiently understand many aspects of the dynamics of tropical climate and weather. However it may be that the analysis of weather at the 700 mbar level could help to improve forecasts.

On the other hand, we already possess the essential basic knowledge to forecast flows in streams and rivers, and are held back mainly because the necessary networks of meteorological and hydrological observations are neither complete nor efficient, and because we do not have fully satisfactory mathematical models for particular catchments and streams. Artificial rain-making remains a dream rather than a reality; the successes claimed so far seem to be induced accidents, rather than reproducible events. Some general weather lore exists in semi-arid zones, but little has been recorded, and still less tested or explained.

We know too little about the size and nature of the underground water resources in the semi-arid areas of Africa, to use them widely or intensively. Even under areas with little vegetation, water levels have dropped considerably during the droughts of the past decade. The present equilibrium of soil water is both unstable and precarious. Ill-considered and hasty use of ground-water resources on a substantial scale could have disastrous effects, which might be permanent by the time they became manifest. A comparison of water equilibria with grazing equilibria in the area might be instructive.

The rate of potential photosynthesis in the area is large. Given the required inputs of plant nutrients (notably nigrogen and phosphate), and of energy, it might be possible to make more efficient use of that part of the water resources that at present goes unused. This could lead to important increases in agricultural and notably in cereal production.

Discussion

R. A. S. Ratclifee (*Meteorological Office, Bracknell, Berks.*). The Meteorological Office has carried out some research aimed at forecasting whether summer rainfall in the Sahel zone will be above or below average. These methods use data from April and May and can give a forecast of summer rainfall category at the end of May. Would these be of value to Dr Rijks's organization?

D. Rijks. Yes.

R. E. Sowden (*The British Council*, 10 *Spring Gardens*, *London SW*1). We have heard today and yesterday that many of the technical problems of resource development can now be solved through the application of known scientific principles and techniques. We have also heard that effective implementation of known solutions is frequently difficult owing to associated socio-economic factors; in other words technological and financial inputs alone are not enough. I would therefore ask what further inputs in the broader field of education and training the industrialized countries can, and should, offer the third world in this respect.

Should the industrialized countries offer, for example, to provide more training of the MSc type for deskbound administrators so that they can better understand the full implications of their plans, or 'on the job' training for professional practitioners or even, dare I say, practical training for the planners? Alternatively one might, perhaps, concentrate instead on the provision of training for instructors and so utilize the multiplier effect, or devote more of the available but limited resources to the training of the local practitioner, the technician on the job.

D. Rijks. There are two bottlenecks in the data collection interpretation and dissemination programme that necessarily need to be solved on a national level. The first is the training and the employment of observers and technicians that assure the flow of basic data towards the data interpretation centres. The second is the training and the employment of technicians and field staff that ensure that the information, formulated by national hydrological and meteorological services, arrives in an understandable form at the farmer's level and can be implemented by him. There is thus a need for training of this field staff and the technicians, and for governments to make the necessary funds available for them to execute their work.

C. J. Bevan (*U.L.G. Consultants* (*Warwick*) *Limited*, 2 *Church Street*, *Warwick*, *Warwickshire*). We have heard that Dr Rijks and his colleagues intend determining crop water requirements using the Penman method. While using this method in an arid zone may lead to some controversy, it will undoubtedly be of great value to agronomists and others to have information of this kind available for the crops of the Sahel.

I would like to know what system of nomenclature, and which symbols, Dr Rijks will use for evaporation and evapotranspiration measurements. Travelling throughout the world a multiplicity of expressions and symbols are found, and much time is wasted in converting such expressions back to more familiar notation. It is high time, surely, that an international terminology for this subject was agreed upon.

D. Rijks: Our group will, understandably, use the terminology recommended by the World Metereological Office.