EDUCATION AND TRAINING
IN AGROMETEOROLOGY

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CAGM Rapporteurs on Training and Education Matters

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EXECUTIVE SUMMARY

Following the description of the scope and aims of Agrometeorology and the historical review of the development of this scientific discipline, the current status of the contribution of the academic and in-service education and training programmes are reviewed.

The self-assessment analysis of a large, internationally representative sample of ex-trainees is presented and an assumed outlook into the 21st century is attempted.

The developed countries of the world are expected to show greater interest in sustainable rural development and environmentally friendly agriculture. The developing countries are expected to continue to strive for increased agricultural production and the application of sustainable technologies, all of which are climatically related. Pressure on the scarcity of economic resources may cause a reduction of the funds available for education and training in Agrometeorology. Therefore, non-traditional methods of education and training should be investigated. The effectiveness of education and training on the individual and on institutional capacity-building urgently needs to be measured scientifically and monitored, so as to plan the education and training of Agrometeorology of the 21st century more confidently.
# TABLE OF CONTENTS

1. INTRODUCTION ............................................................................................................. 1
   1.1 The concept of education ....................................................................................... 1
   1.1 The concept of training ........................................................................................... 2

2. AGRICULTURAL METEOROLOGY - ITS SCOPE AND AIMS ........................................ 3

3. HISTORICAL DEVELOPMENTS IN AGRICULTURAL METEOROLOGY ...................... 5

4. CURRENT STATUS ....................................................................................................... 5
   4.1 Academic Institutions ............................................................................................. 5
   4.2 Inter-University cooperation - The Picnic Model .................................................... 7
   4.3 In-service training centres ....................................................................................... 7
   4.4 Summary of the current status ............................................................................... 10
   4.5 Constraints in human resource development in Agrometeorology ....................... 10

5. RESPONSE TO THE QUESTIONNAIRE ON EDUCATION AND TRAINING ............... 11
   5.1 Education and training: the objectives ..................................................................... 11
   5.2 The impact of education and training for institutional capacity building ............... 12
   5.3 Seeking professional qualifications for personal scientific growth ....................... 13

6. AGROMETEOROLOGY - FUTURE NEEDS .................................................................. 14
   6.1 Future needs - Academic Institutions .................................................................... 14
   6.2 Future needs - Service Institutions ....................................................................... 15

7. FUTURE OUTLOOK ..................................................................................................... 16
   7.1 Lack of knowledge of Agrometeorology by the agricultural industry .................... 16
   7.2 Preparation of material for basic instruction ......................................................... 16
   7.3 The urgent need for inter-institutional coordination ................................................. 16
   7.4 Utilization of human resources and long term planning of capacity building .......... 17
   7.5 Commercialization of meteorological services ....................................................... 17
   7.6 Urgent programme for evaluation of training ........................................................ 17

8. REFERENCES ............................................................................................................... 19

9. APPENDICES .............................................................................................................. 21
   Appendix 1. WMO Personnel Standard Classification ................................................. 21
   Appendix 2. Analysis of Questionnaire ........................................................................ 23
   Appendix 3. Activities of the RMTC, Bet Dagan, Israel - 1997 .................................... 24
1. INTRODUCTION

Agricultural Meteorology, which is an interdisciplinary science, has a major role to play in the efforts to promote sustainable development of agriculture in both developing and developed countries. It also has a major role to play in the protection of the environment and the management of our natural resources. To do so, it is essential to have human resources duly skilled and capable to provide both the necessary research and operational services on a scientific basis.

The Commission for Agricultural Meteorology (CAgM) at its eleventh session (Havana, February 1995) appointed Joint Rapporteurs on Impact of Training in Agrometeorology to survey methodologies to assess and study the impact of training in agricultural meteorology imparted through various training programmes (Res. 16 CAgM-XI refers). Mr J. Lomas (Israel) was invited to act as coordinator of the joint rapporteurs.

To accomplish the task assigned to them, the coordinator, in consultation with the President of CAgM and the other rapporteurs, prepared a questionnaire which was circulated to Members of the WMO to be distributed to persons who received training in Agrometeorology through various training programmes, both within and outside WMO.

In addition, an attempt was made to review some of the educational efforts of the academic institutions, especially the progress made in the developing countries. The analysis of the present situation and the possible future outlook is presented in this report.

In doing so, one has to keep in mind major factors which will clearly cause significant changes in the way meteorology is taught in the next century. Mottram (1995) suggests the following five major factors as significant causes of curriculum change in the area of general meteorology:

1. Technological developments and scientific advances.
2. Concerns for the environment.
3. Changing identities of National Meteorological and Hydrological Services (NMHSs).
4. International agreements and the global community.
5. Educational and vocational training initiative.

This list might not be exhaustive and some overlap between its items could exist. However, it contains identifiable forces for change and the future of education and training in Agrometeorology has to be approached taking in mind the scenarios above.

1.1. The concept of education

The Oxford English Dictionary defines education as: systematic instruction, schooling or training given to the young and adults in preparation for the work of life including scholastic instruction, which a person has received. Education is the development of sound-reasoning processes to enhance one’s ability to understand and interpret knowledge. The concept of education, by and large, includes activities directed at providing knowledge, skills, moral values and understatig required in the normal course of life. The provision of knowledge and skills is not for a limited scope or activity but focuses on a wide range of activities. The main aim of education is to create circumstances and opportunities for young and adult people to learn, among other things, cultures and natural laws and acquiring skills, including languages, that form the basis for learning, personal development, creativity and communications. Therefore, it may be concluded that education is basically theoretical in nature, broadens the scientific base and is usually of long duration.
1.2. The Concept of Training

The Oxford English Dictionary defines training as: the training of a person for some particular profession. Training, is therefore, a learning experience that seeks a relatively permanent change in an individual that will improve his or her ability to perform a job. Training is regarded as a systematic and planned process to improve the existing knowledge, skills and behavior of personnel to achieve the objectives of the organization they work for. In contrast to education, training is task-oriented and it focuses on the work performed by a person. Job description or task requirements of a particular job are used to determine the nature of a training programme. Training is, therefore, directed at improving the personnel’s work performance in an organization. Training is conducted as a result of technological innovation and in other instances when current work standards are not being maintained and when such situations are ascribed to lack of knowledge and or skills among individual personnel in an organization. Therefore, it may be concluded that training is more specific, job oriented and usually of short term.

From the above description it may be concluded that:

<table>
<thead>
<tr>
<th>Education is:</th>
<th>Training is:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Understanding-oriented.</td>
<td>1. Application-oriented</td>
</tr>
<tr>
<td>2. Develops reasoning ability.</td>
<td>2. Develops task performance</td>
</tr>
<tr>
<td>3. Wide and of long duration.</td>
<td>3. Focused and of short duration.</td>
</tr>
</tbody>
</table>

Education and training can no longer be seen as a one-time effort. Knowledge and skills acquisition must be viewed as a continuous process throughout an employee career.

2. AGRICULTURAL METEOROLOGY - ITS SCOPE AND AIMS

The scope and aims of Agricultural Meteorology is stated in the Guide to Agricultural Meteorological Practices (WMO - No. 134) 1981 as follows.

Agricultural Meteorology is concerned with interaction between meteorological and hydrological factors, on the one hand, and agriculture in the widest sense, including horticulture, animal husbandry and forestry, on the other hand. Its object is to discover and define such effects, and thus to apply knowledge of the atmosphere to practical agricultural use. Its field of interest extends from the soil layer of deepest plant and tree roots, through the air layer near the ground in which crops and woods grow and animals live, to the highest levels of interest to aerobiology, the latter with particular reference to the effective transport of seeds, spores, pollen and insects.

In addition to natural climate, and its local variations, agricultural meteorology is also concerned with artificial modifications in environment (as brought about, for example, by windbreaks, soil management, irrigation, glass-houses, etc.); in climatic conditions of storage, whether indoors or in field heaps; in environmental conditions; in animal shelters and farm buildings; and in transport of agricultural produce by land, sea or air.

The primary aim of agricultural meteorology is to extend and fully utilize our knowledge of atmospheric and related processes to optimizing agricultural production with maximal use of weather resources and with minimal damage to the environment. Improving quantity and quality of crop and animal production are amongst its priorities.

A secondary aim concerns the conservation of natural resources and protection of the environment from detrimental usage. The climate may place constraints upon a particular form of land-use at a given place and time. Land-use planning and the application of technology are climate dependent. Sustainable human activity is therefore, dependent on climatic conditions and variability.
A third aim, of rather recent origin, is to predict the effect of climate change, including climate variability, on agricultural production.

Agricultural Meteorology, therefore, includes two basic subjects:

(a) The Earth (physical) sciences - specifically the physics of the atmosphere, i.e., Meteorology and Climatology, but also Soil Physics and Hydrology.

(b) Certain biological sciences - specifically Physiology, Ecology and Pathology of plants and animals, the biosphere and associated "technologies" of Agriculture.

3. HISTORICAL DEVELOPMENTS IN AGRICULTURAL METEOROLOGY

Decker (1994) reviewed the historical development of Agricultural Meteorology from the year 1800. Although the review is biased towards the experiences in the United States of America, the analysis and projections have application to events occurring in other regions of the world. The applications of Agrometeorology and the specific requirements of the farming community have been stated by Lomas (1996) to be based on three fundamental criteria:

(a) Availability of a suitable data base and infrastructure.

(b) Provision of accurate and timely information.

(c) Economically beneficial services to the customer (farmer, advisor, agriculture commodity, trader, etc.)

Although few dispute the statement that "farming is the most weather-sensitive occupation and that the agricultural industry is most responsive to variabilities in weather and climate", the attempts to establish special weather services for agriculture have not been completely successful. For example, the reason why the weather service programmes for agriculture, following the pilot programme in the lower Mississippi, has never been expanded in the U.S.A. is not obvious, according to Decker (1994) but lack of coordination and cooperation may be one reason. Lack of interministerial cooperation has been reported in Africa, Asia and Latin America by the Cooperative Institute for Applied Meteorology, even for countries where the Meteorological Service is part of the Ministry of Agriculture. A similar situation was also reported for the Soviet Union Meteorological Service by Kogan (1986).

On the other hand, the effect of a cooperative effort between the Meteorological Service and the Soil Conservation Service (Ministry of Agriculture) in providing a farmer specialized agrometeorological forecasting, information and advisory service has been reported from Israel. (Cohen, A. - Personal Communication). The farmers from the Central Coastal Plain showed considerable interest in the four day medium range general forecast explained to them as well as the advice provided by the soil conservation extensionist especially during the rainy season (October - May). The interest of the farmers can be measured by the number of calls seeking detailed information recorded at the local office of the Agrometeorological Information Service as shown in Fig. 1.

The service was introduced in 1985 and within the first three years changed from a frost advisory to a general agroclimate Warning and Advisory Service. Growing rapidly during the first ten years, request for advice seems to have reached some 100,000 per season (average 400-500 per day) and dropped to some 90,000 during the last few years. During rainy spells there is an increase in calls. Recent general forecasting by the various Television Channels may have contributed to the 10% drop in farmers' demand for agrometeorological advisories. A nominal telephone charge is paid by the farmer.
Fig. 1. Pattern of calls for agrometeorological advice to the Agricultural Meteorology Service in Israel.

Following this long-term experiment, the advisory service has expanded to most agricultural regions in the country. However, the quality of the Information Service depends on the professionals who operate the programmes. Special Training Courses in Agrometeorology have been provided for the Soil Conservation Service Extension personnel and its staff must be willing to work at unconventional hours.

In developed countries overproduction of some basic agricultural commodities and financial implications of storage costs may be other reasons for the lack of funding of a service which aims to increase agricultural production. This may, perhaps, be the case in the U.S.A. and some countries of Western Europe.

However, the lack of professional trained personnel at all levels, especially in the horticultural industry may be another major barrier for the application of Agrometeorology. For instance, Wieringa (1995) reports surprising results from the Netherlands, where some prognostic information and some data are available by data link. However, out of several hundred-farm counsellors hardly anyone has subscribed to the Service at a cost of 200 Euro/year. The agricultural industry needs educational programmes to improve the use of existing meteorological information even in the United States (Perry, 1994). Many agricultural producers, agro-business managers, extension officers lack a complete understanding of the data analysis and forecast products which are now available and they do not know how to apply them in their management systems. Several reasons can be postulated for this situation existing even in highly developed agricultural economies:

- Agricultural extension personnel and advisers consider weather unimportant.
- Management applications are not available or not known.
- Extension personnel and advisers know too little about meteorology to appreciate or apply such information.
Wieringa (1996) concludes that the lack of knowledge of meteorology is the most likely reason. Such is the also the situation for all the nineteen countries of Western Europe reviewed, as well as in the U.S.A. (Perry, 1994).

Economic justification for the application of weather information to agricultural practices maybe another aspect (Maunder, 1989). In Israel for example, as long as the cost of water was fairly low, there was no economic reason for using agrometeorological information for the management of irrigation. However, as the price of water increased an ever larger number of farmers turned to the irrigation management information service. (Lomas, 1996).

Thus, it appears to be a number of reasons for the lack of application of Agrometeorological Services by the weather sensitive agricultural community.

(a) The lack of cooperation between the institutions providing information and those responsible for the transfer of information and relevant advisory services.

(b) Education of the user community including the farm advisory services.

(c) Economic justification for the application of agrometeorological advisory services.

4. CURRENT STATUS

4.1 Academic Institutions

Agricultural Meteorology as such is not taught at the Universities at the undergraduate level. A number of Universities, however, provide Agrometeorology as a major course leading either to the M.Sc. degree or to the Ph.D. degree. Universities providing such courses in Agrometeorology are listed below:

- Argentina, Buenos Aires
  University of Buenos Aires

- Belgium, Arlon
  Foundation University Luxenbourgoise

- Canada, Guelph
  University of Guelph

- China, Nanjing
  Institute of the Academy of Meteorology

- England, Reading
  Universities of Reading and/or Nottingham

- France, Montpellier
  University of Montpellier

- Netherlands, Wageningen
  University and Research Centre

- India, Assam
  Agricultural University

- India, Gujrath
  Agricultural University

- India, C.C.S.
  Haryana Agricultural University

- India, Kerala
  Agricultural University

- India, Madhya Pradesh
  Indira Gandhi Agricultural University

- India, Maharashtra
  Center of Advanced Studies in Agrometeorology
  Mahatma Phule Krishi Vidyapith

- India, Ranichauri, U.P.
  G.B. Plant University of Agriculture & Technology
- India, Pune
  Centre of Advanced Studies in Agricultural Meteorology
  College of Agriculture, Mahatma Phule University
- India, Punjab
  Agricultural University
- India, Visakhapatnam
  Andhara University
- Israel, Rehovot
  University of Jerusalem
- Italy, Firenze
  University of Firenze
- Kazakhstan, Almata
  University of Kazakhstan
- South Africa, Pietermaritzburg
  University of Natal
- U.S.A., Davis
  University of California at Davis
- U.S.A., Columbus
  University of Missouri
- U.S.A., Ames
  Iowa State University
- U.S.A., Lincoln
  University of Nebraska
- U.S.A., Logan
  Utah State University
- Zimbabwe, Harare
  University of Zimbabwe

It is interesting to note that most of the Universities providing M.Sc. and Ph.D. degrees in Agrometeorology are within the Faculty of Meteorology or Department of Atmospheric Sciences. Therefore, it is natural that the graduates continue their professional activities in the field of agriculture and the biological sciences. This can be demonstrated by an analysis of the eighty references used in the review of 200 years of the development of agricultural meteorology in the U.S.A. (Decker, 1994). (See Fig. 2)

![Bar chart showing participation in scientific disciplines](chart)

**Fig. 2.** Scientific references used by Decker, 1994 in analysis of agrometeorological developments in the USA.
The dominant contribution to the development of Agrometeorology comes from the scientific agronomy community. If one considers that the scientific reports from the experimental stations (20%) come mainly from agricultural faculties of various universities, the agricultural scientific community furnished 57% of the research "effort" whereas the meteorological research community's contribution is only 16%. There are, of course, a number of exceptions when graduates of meteorology (Physics and Mathematics at the B.Sc. level) have continued their education in Agrometeorology (at the M.Sc. or Ph.D. level) mainly in the field of soil-plant-atmosphere continuum and environmental physics. A clear approach can be noted in India where Agrometeorology has been accepted as a subject under agricultural science by the Indian Council of Agricultural Research and Education (ICAR). The council has identified "Agrometeorology" as a priority subject and has encouraged the establishment of separate departments of Agrometeorology in State Agricultural Universities. 8-10 such departments have been established in India and the ICAR is also operating a National Coordinated Project on Agrometeorology in the different State Agricultural Universities.

4.2 Inter-University cooperation - The Picnic Model

An interesting new development in Agrometeorology has been the concept of cooperation between African Universities and Universities of the industrialized world. (Stigter, et al., 1995). The main aim of this so-called Picnic Model for Postgraduate Education and Training was to strengthen the sustainable capacity of African Universities in addition to the Ph.D. and M.Sc. research (Stigter, et al., 1995). The overall Agrometeorological field of research and application chosen was traditional techniques of micro-climatic improvement (TTMI).

The two stage project started in 1984 and was completed in 1992 with the partnership of the Agricultural University of Wageningen, The Netherlands, and four Universities in Africa - the University of Nairobi, Kenya; The University of Dar El Salam; Tanzania; The University of Gezira, Sudan; and the Amado Bello University, Nigeria. During this period Ph.D. and M.Sc. degrees have been obtained and an evaluation workshop was held in Nairobi in 1994 (Stigter et al., 1995).

The Picnic Model of Research and Training aimed at research in the candidate's home country but data analysis and the preparation of the thesis was done at Wageningen Agricultural University. This model was a cooperative effort in South-North Postgraduate Inter-University Research. Its strength is that problems and needs of the developing countries will determine the selection of research topics. Also, that such an approach strengthens the University Department where the research is carried out and, therefore, contributes to human capacity building, purchase of research equipment, acquisition of know-how and interdepartmental cooperation.

On the other hand, Stigter et al., (1998) suggested that some rules have to be followed for viable collaboration in research and education and its sustainability. A realistic assessment of the contribution of such an effort to the national research and training priorities, as well as of the infrastructural carrying capacity of the southern university is essential. Finally, the cooperative inter-university programme has from the outset to consider the phasing out process of the expatriate element and the institutionalization of the research within the framework of the southern university. The replacement of external material support, once the objective of strengthening local research capacity has been achieved, has to be given serious consideration.

4.3. In-service training centres

In-service training (training received from time to time during the course of employment) plays a significant role in updating National Meteorological and Hydrological Services personnel with recent technologies and methods of data analysis as well as in refreshing the knowledge and skills gained by Agrometeorology personnel many years ago. Numerous in-service training facilities exist at
Meteorological Services for different levels. Syllabi drawn up primarily for meteorology professionals and teaching material have also been published by WMO. WMO recognizes nineteen Regional Meteorological Training Centres (RMTC) which provide training facilities in various languages for Member countries in different fields of meteorology, including Agrometeorology. WMO - RMTC locations where Agrometeorology courses are offered are located in: Argentina, Algeria, Barbados, Brazil, China, Egypt, India, Iran, Iraq, Israel, Kenya, Niger, Nigeria, and Philippines.

In-service training courses provided by the different Member countries are heterogeneous not only in the syllabus but also in the objective of the training programme and its duration. For technical personnel, Agrometeorology is usually presented as an applied branch of climatology with a two - three hour overview. For graduate personnel, there are usually no in-service training facilities at the National Level, except in the larger Member countries but at regional level. (Ecole Nationale de la Meteorologic Toulouse, France, Hydrometeorological Institute, Odessa, Russia, Indian Meteorological Department, Pune, India; RMTC, Bet Dagan, Israel; Institute for Meteorological Training, Nairobi, Kenya). Uniform syllabi and the specialized curricula provided by WMO are usually followed in these programmes. Teaching material has now been updated and will shortly be published by WMO. (Wieringa and Lomas, 1998).

A specialized programme of Agrometeorology has been developed by the RMTC at Bet-Dagan, Israel. The training course is of relatively short duration (4-6 weeks) and is carried out at postgraduate level. Special attention is paid to the application of meteorology to the farming community and the demonstration of such practices under field conditions. The training programme provides four specialized courses:

- Basic Agrometeorology - for beginners.
- Data Base Management - for agroclimatologists.
- Modeling in Agrometeorology - for advanced professionals.
- Hydrometeorology - for water resource management experts.

The training programmes are operational since 1963 with fairly good results. For more details see Appendix 3.

Table 1 presents a summary of a recently published November 1997) WMO information report on the training programmes of eight RMTC's. In seven out of the eight RMTC's agrometeorological training is provided. However, the level of instruction and the target population is extremely variable.
<table>
<thead>
<tr>
<th>Organization</th>
<th>Duration (weeks)</th>
<th>For WMO Class</th>
<th>Entry Requirement</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALGERIA</td>
<td></td>
<td></td>
<td></td>
<td>Introductory</td>
</tr>
<tr>
<td>Inst. Hyd. de formation pour la recherche Course in Agrometeorology</td>
<td>3</td>
<td>II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EGYPT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMTC - Cairo</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic Course in Agrometeorology</td>
<td>26</td>
<td>I</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Course for Agrometeorological Technicians</td>
<td>26</td>
<td>III</td>
<td>III</td>
<td></td>
</tr>
<tr>
<td>ISRAEL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMTC - Bet Dagan</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agrometeorology - Data Base Management</td>
<td>5</td>
<td>I</td>
<td>BSc</td>
<td>No. of Trainees annually 31</td>
</tr>
<tr>
<td>Basic Agrometeorology</td>
<td>6</td>
<td>I</td>
<td>BSc</td>
<td>29</td>
</tr>
<tr>
<td>Crop Weather Modeling</td>
<td>5</td>
<td>I</td>
<td>MSc</td>
<td>30 (specialists)</td>
</tr>
<tr>
<td>KENYA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMTC - Nairobi</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meteorology with specialization in Agromet. Course in Basic Agrometeorogy</td>
<td>112</td>
<td>I (MSc)</td>
<td>BSc (Hon)</td>
<td>General Meteorology</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NIGER</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centre Regional Agrhymet. Course for Agrometeorological Technicians</td>
<td>112</td>
<td>III</td>
<td>Matriculation</td>
<td>Specialized observers</td>
</tr>
<tr>
<td>NIGERIA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMTC - Laos</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meteorology with specialization in Agromet.</td>
<td>164</td>
<td>I(PhD)</td>
<td>MSc</td>
<td>With Univ. of Akure Ondo State</td>
</tr>
<tr>
<td>RUSSIA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMTC - Kuchino, Moscow Use of aerospace information in Agrometeorology</td>
<td>2</td>
<td>I - II</td>
<td>BSc, MSc</td>
<td>Specialists</td>
</tr>
</tbody>
</table>


*No information is available as to the number of trainees that took part at the RMTC programme NMS.
Basically, there are four major types of agrometeorological training:

1. Academic instruction in Kenya and Nigeria, leading to a M.Sc. or Ph.D. degree in Meteorology, with specialization in Agrometeorology. (In cooperation with the Universities).

2. Courses in Agrometeorology in Egypt, Israel and Kenya, providing a basic background of the interrelationship between the climate and agricultural production.

3. Some specialized short duration courses in Algeria and Russia.

4. Training of Agrometeorological Technicians as it is the case in Egypt and Niger.

4.4. Summary of the current status

From an analysis of the training facilities of the academic institutions and the in-service facilities, the following conclusions can be drawn:

(a) Agricultural meteorology is a postgraduate subject at the M.Sc. as well as the Ph.D. levels at academic institutions. One university offers it at the undergraduate level (University of the Orange Free State).

(b) Where available the postgraduate studies are usually to be found in the Agronomy Department of Universities although some universities have it in other departments (Department of Meteorology - Reading University, Department of Atmospheric Sciences - University of Missouri).

(c) The low number of graduates studying Agrometeorology in comparison to other graduate subjects may be due to less demand of agrometeorological scientists when compared to other fields.

(d) In-service training facilities provided training of meteorological personnel in Agrometeorology, especially in the larger national services.

(e) The training is extremely heterogeneous and varies from one country center to another.

(f) At RMTC’s, training is provided for academic as well as technical personnel.

(f) Very little instruction in Agrometeorology is provided to the agronomy community thus the potential user groups of agrometeorological information lack sufficient understanding of Agrometeorology in order to make use of the information provided. This seems clear from a recent survey by the European Commission of nineteen countries of Western Europe (Wieringa, 1996) and from the United States (Perry, 1994).

4.5. Constraints in human resource development in Agrometeorology

The constraints of education and training programmes, especially in developing countries, may include the following:

(a) A rigid “two tier” curriculum at academic institutions at postgraduate level.

(b) Lack of systematic follow-up and evaluation of post-training performance, especially in in-service training.

(c) Poor selection of candidates for Agrometeorology training programmes (selection made on the basis of seniority of personal contacts) rather than relevance and objectivity, indicating an inadequate training policy at the organization level.

(d) Diminishing financial resources especially in less developed countries.

(e) Poor understanding of the contribution of Agrometeorology to economic and social development on the part of national decision-makers.
5. RESPONSE TO THE QUESTIONNAIRE ON EDUCATION AND TRAINING

The survey on the impact of Training in Agrometeorology is based on the replies of 243 questionnaires distributed by the WMO to Directors of Meteorological Services with the request to have the questionnaires handed to former participants in education and training events within and outside the National Meteorological Services. The information received is heterogeneous in view of the varied objectives of the training events, the expectations of the trainees and their different backgrounds (see Appendix 2).

Following some preliminary analysis, it was finally concluded that the most homogenous population groups will be obtained if the analysis is made on the basis of the academic level of the trainees, as such clustering also represents fairly well employment institutions.

Ph.D. participant - are mainly from the Universities (87%).
M.Sc. participants - are predominantly from Research Institutions and Extension Services (78%)
B.Sc. participants - come mainly from Government Service Institutions, (Meteorological and Hydrological Services) (61%)

The geographic distribution of response to the questionnaire is shown in Table 2. (Replies Received to Questionnaires.)

<table>
<thead>
<tr>
<th>WMO Region</th>
<th>No. of Countries</th>
<th>No. of Participants</th>
<th>Countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>26</td>
<td>76</td>
<td>Africa</td>
</tr>
<tr>
<td>II</td>
<td>15</td>
<td>39</td>
<td>Asia</td>
</tr>
<tr>
<td>III</td>
<td>14</td>
<td>67</td>
<td>South America</td>
</tr>
<tr>
<td>IV</td>
<td>7</td>
<td>11</td>
<td>North &amp; Central America</td>
</tr>
<tr>
<td>V</td>
<td>4</td>
<td>6</td>
<td>South-West Pacific</td>
</tr>
<tr>
<td>VI</td>
<td>11</td>
<td>44</td>
<td>Europe</td>
</tr>
<tr>
<td></td>
<td><strong>77</strong></td>
<td><strong>243</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Geographic distribution of response to the questionnaire on Impact of Training.

5.1 Education and training: the objectives

The objective of education and training may be seen from two distinct points of view: that of the Institution and that of the personnel (trainees).

The Institutional objective of education and training is to strengthen the capacity of the University, or institution to carry out research that addresses national priorities, and the needs to improve the relative standing of the department in relation to the other departments of the institution. Its aim is to be able to obtain a larger share of institutional resources in view of its relative contribution to the country's
agricultural economy and also to publish scientific and applied research in order to increase its national and international acclaim.

The objective of the individual trainee is basically to seek professional qualification for personal scientific growth and external social and material stimuli and to improve his/her future employment prospects.

The analysis of the questionnaires was, therefore, carried out for each group separately. (Ph.D., M.Sc. and B.Sc.)

5.2 The impact of education and training for institutional capacity building

University Departments monitor work of M.Sc. and Ph.D. students out of idealism and the wish to contribute to highly needed local manpower development. Also they may invest time and energy because they have the genuine desire to contribute to the personal scientific development of their students. They may also be interested, by virtue of the fact that the continuation of their own employment may be partly based on the number of postgraduate students connected to them. Furthermore, they may be interested because these students provide the possibility for them to be engaged in scientific research of some importance and, thus, in international networks. Postgraduate students who produce quality theses may further enhance the status and the raison d'etre of their academic departments and their scientific publications. Agricultural meteorology will, however, remain a small unit in comparison to other University Departments, i.e., Agronomy, and will consequently not be a priority for the allocation of resources, except in such cases where it can be a part of a national priority research item, i.e., water resources management, sustainability, and the impact of possible climatic variability and change on agriculture.

Service Departments, such as the National Meteorological Service are the major beneficiaries of education and training events. Most participants from those Institutions hold the B.Sc. degree (61%) and M.Sc. (31%) degree. Table 3 clearly shows the participants of training events reported that their training had only a marginal effect on their promotion, except at the academic institutions.

<table>
<thead>
<tr>
<th>Degree</th>
<th>No.</th>
<th>Self Rating on Training Impact on Promotion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Significantly</td>
</tr>
<tr>
<td>PhD</td>
<td>19</td>
<td>28%</td>
</tr>
<tr>
<td>MSc</td>
<td>126</td>
<td>6%</td>
</tr>
<tr>
<td>BSc</td>
<td>98</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3 - The effect of training on promotion 3-6 years following the training event.

A serious depletion (40%) of trained personnel occurred with the "leakage" out of the agrometeorological units and into other operational divisions. Some trainees left the Service altogether.
usually for better paid employment. This tendency is especially marked in Government Services (Table 4).

<table>
<thead>
<tr>
<th>Service Institutions</th>
<th>Scientific Staff Sustainability</th>
<th>No. of Years Following Training</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>+4</td>
</tr>
<tr>
<td></td>
<td>In Percent</td>
<td></td>
</tr>
<tr>
<td>Meteorological Services</td>
<td>109</td>
<td>100%</td>
</tr>
<tr>
<td>Agricultural Research</td>
<td>21</td>
<td>100%</td>
</tr>
<tr>
<td>Institutions</td>
<td>Commodity Research Centres</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 4 - Reduction of trained staff in service units following training events (in percent of number of trainees, all trainees = 100%)

5.3. Seeking professional qualifications for personal scientific growth

Personal scientific growth is difficult to measure quantitatively. The number of scientific publications as well as their scientific rating may be one possible way to do so - but the scientific output of a person will also depend on the institution where he/she works, the infrastructure, the availability of funds, and the sharing of administrative responsibilities. Keeping these limitations in mind, Table 5 presents the self-assessment of 243 participants of education and training events, as it affected their personal professional growth.

<table>
<thead>
<tr>
<th>Degree</th>
<th>No.</th>
<th>Self rating on personal professional growth (in percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Significantly</td>
</tr>
<tr>
<td>PhD</td>
<td>19</td>
<td>61%</td>
</tr>
<tr>
<td>MSc</td>
<td>126</td>
<td>55%</td>
</tr>
<tr>
<td>BSc</td>
<td>98</td>
<td>27%</td>
</tr>
</tbody>
</table>

Table 5 - The effect of training on personal professional growth, over a period of 6 years following the training event.
Education and training had a most beneficial effect on the scientific growth of the individual trainee especially at the higher academic levels. For further analysis, see Appendix 2 and 2.1.

6. AGROMETEOROLOGY - FUTURE NEEDS

6.1. Future needs - Academic Institutions

Agricultural Meteorology has advanced during the last 100 years from a descriptive to a quantitative science using physical, biological and mathematical principles. However, the application of Agrometeorology has considerably lagged behind due to a lack of cooperation between the Agricultural Advisory Service and an unaware farming community. Furthermore, in most of the developed world overproduction of some agricultural commodities and a growing interest in rural ecology dampened the interest and use of agrometeorological services that were designed to improve agricultural production. The opportunity for the development of effective agrometeorological education programmes remains a challenge for the 21st Century.

Models of agrometeorological programmes have been prepared in the past by Robertson (1980) and for pest management by Omar (1980) and the economic impact of such services was discussed by McQuigg (1975). Nevertheless, it seems that in the future the demand for such Services will come mainly from the developing countries. There is an urgent need to prepare a syllabus acceptable by the academic institutions for agricultural extension and farm advisory officers, for which new WMO Guidelines for Education (WMO No. 258, 3rd ed. in preparation) could be used as a reference. It is an indisputable fact that most agricultural extension personnel are more frequently in contact with the farming community than most agrometeorologists. The acceptance by the farming community of the agrometeorological products is therefore, dependent on an understanding and cooperative extension service (Perry, 1994). The needs of independent agricultural/environmental consultants should also be kept in mind.

Prior to designing Agrometeorology training programmes it is necessary to ascertain the needs of the target group. A need has been defined as 'a discrepancy or gap between the way things are and the way things ought to be' (Gagne and Briggs, 1979). Having identified, verified and placed in some form of priority the training needs, writing instructional objectives follows. The success of a training programme will depend on how well the objectives have been planned and documented.

Due to diminishing financial resources for Agrometeorology training purposes, there is an urgent need for institutions in developed countries to conduct training programmes in collaboration with developing nations' institutions as already demonstrated by the TTMI project. This may maximize the resources available because there are training programs in developed countries especially tailored for developing countries. This brings about the need to re-assess the capacity of the training institutions in developing nations to conduct such joint ventures and the TTMI evaluation reports could be used as a starting point.

Development of linkages between universities and service institutes in a region to share course offerings and graduate research opportunities should as well be explored. There are a number of ways in which such arrangements can be achieved. Firstly, a student could visit a co-operating institution and take courses not available at his/her home institution. Secondly, an institution could offer a series of short courses for credit and invite students for a few weeks to take these courses. In a similar manner, co-operative agreements could be established between institutions in various countries to work together in the education of students (Blad, 1994).

Blad (1994) inquired as to whether or not there should be an undergraduate major in Agrometeorology in the U.S.A. and went on to state probably not yet, but it is a question that should be given careful examination over the next decade or two. However, it was stated that agrometeorologists should be
actively involved in B.Sc. degree programmes and in related disciplines that help prepare students for graduate studies in Agrometeorology. Introductory undergraduate course(s) will stimulate interest in agrometeorology and will educate students in basic principles required for making rational decisions about agricultural, environmental and other important issues for today and future society. The University of Dar es Salaam, Tanzania, for example, offers environmental physics and instrumentation as such an introductory course. The University of the Orange Free State (South Africa) already offers undergraduate Agrometeorology major, although for reasons, already indicated, of job prospects, it registers extremely low numbers of students per academic year.

Evaluation of training is an extremely feature of any training programme. This should be performed for all agrometeorology training programmes to determine the extent to which training objectives have been achieved. Training evaluation is looked at as a systematic collection of descriptive and judgmental information necessary to make effective decisions related to the selection adoption, value and modification of various instructional activities. During evaluation, appropriate instruments should be used to collect information at the end of a training programme. This information plays a key role of quality control of the training system by providing feedback on the effectiveness of the training methods being used, the achievement of the objectives by both trainees and trainers and whether the needs originally identified, both at institutional and individual level, have been satisfied.

The scientific manpower requirements for Agrometeorology are small when compared with requirements for agronomists or other professionals. The small size makes the field of Agrometeorology particularly vulnerable to financial cuts by Governments. Consequently, it is most likely that this interdisciplinary science may be exposed to: reductions in financial allocations; attempts to combine training facilities with other related sciences (Environmental or Plant Physiology/Agronomy); reductions in the number of Institutions providing education and training in Agrometeorology. Should such a situation occur the pools of research and service personnel dedicated to Agrometeorology are bound to be reduced especially in the developed world.

In-service training programmes need to prepare its human resources to deal with the challenges. In addition an effective infrastructure will have to be developed to deliver the products to the farmer in the shortest time.

6.2. Future needs - Service Institutions

The future for Agrometeorology depends, to a large extent, on having scientifically concerned and informed citizens who recognize the critical role that agrometeorologists play in meeting critical challenges facing all nations (Blad, 1994). This calls for user education. Permanent Representatives with WMO should get involved in policy discussions at national level. This activity will not only make policy-makers aware of the value of Agrometeorology, but also it can help in the development of policy and legislation to use the expertise of agrometeorologists.

The Services required by agriculture for the 21st Century will basically consist of the following functions:

(a) Mesoscale forecasting for agriculture.
   Climate risk analysis for long term planning, including possible effects of climate change.
   Current production assessment and forecasting, including irrigation requirement and pest and disease control.
   Climate change variability impact.
   Drought preparedness.
   Environmental degradation assessment, impact and combating.
   Land use planning.
In addition in the field of the application of technology there will be different requirements for Agrometeorology in the developing and the developed world.

(b) Developing Countries - Technology applications.
Optimum time for planting and other farm operations.
Climate and weed management.
Climate and fertilizer applications.
Soil moisture conservation.
Micro and topoclimatic modifications.

(c) Developed Countries - Technology applications.
Effect of technology on environment.
Climate and production quality.
Ecosystem sustainability.
Climate and storage, Transport and shelf life of products.
Water, air and soil quality.

7. FUTURE OUTLOOK

7.1. Lack of knowledge of Agrometeorology by the agricultural industry

Assuming that the major aim of Agrometeorology is to assist the agricultural industry to produce goods economically (both quantity and quality) and that the system thus designed is sustainable in time, the first step must be to rectify the lack of knowledge of Agrometeorology at all levels in the agricultural horticultural industry. This may prove a difficult task as educationalists consider that teaching meteorology is for meteorologists only. The growing interest in sustainability and ecology may be an appropriate time to introduce some basic agrometeorology in the syllabus of agronomy facilities of Universities and Agricultural Colleges. With this objective in mind an international effort should be made by WMO/FAO/UNESCO to hold a number of regional workshops on the application of Agrometeorology to Agricultural planning and technology for educationalists (University Department Heads and Directors of Agricultural Colleges). The objective of such workshops should be to demonstrate that some 35% of the interannual variability in crop yields is due to climatic variations and another 10% - 15% to the interaction between climate and planting dates, fertilizer applications and pest/disease control. Such an opportunity should be used to discuss a minimum syllabus requirement for undergraduate and graduate students at both University and Agricultural College level (Blad, 1994). At the same time new teaching approaches may include satellite delivery of specialized courses to many academic institutions and inter-university cooperation to enable students to take agrometeorological courses in a visiting university.

7.2. Preparation of material for basic instruction

Basic instruction in elementary meteorology is almost absent in educational programmes of weather and climate sensitive professions such as agriculture. Consequently, it is necessary to develop suitable teaching material in agrometeorology for agronomists and farm advisors.

7.3. The urgent need for inter-institutional coordination

It is expected that in the developed countries, Agrometeorology will be placed in departments of Environmental sciences and not in the Crop sciences as in the past (i.e., Wageningen Agricultural University). This will lead to greater emphasis on natural and managed ecosystems and much less emphasis on crop production. While the need for agrometeorological graduates in the developing world
is expected to increase in view of the economic importance of the agricultural sector of the national economy, there is an urgent need for national efforts to improve the coordination between the meteorological services and the agricultural extension and research departments (usually located in different Ministries) in order to serve the agricultural/horticultural/forestry community.

7.4. Utilization of human resources and long term planning of capacity building

National Meteorological Services have also to ask themselves if they have developed an agrometeorological information and advisory service meaningful and applicable to the farming community, and if their human resources are suitably qualified and available to provide such a service. In many instances the services offered are a by-product of the weather and climate information available, irrespective of the specific needs and requirements of the crops and operations being carried out in agriculture. A good example of a meaningful agrometeorological database, farmer friendly and applicable is the Agroclimatic Atlas of Ireland (Collins and Cummins, 1996). Maps, for example, showing the mean distribution of accumulated potential water deficits for the most active growth period (May to August) and for the whole year, allow an estimate to be made of "windows of opportunity" for on-farm successful operations, such as late season harvesting autumn/winter sowing and fertilizer applications. Likewise maps showing the beginning, end and the duration of the active grass-growing season are a practical guide to pasture and herd management. The atlas is published by the Joint Working Group on Applied Agrometeorology which includes personnel from the Meteorological Service, Agricultural Advisory Service, Geological Survey Office of Public Works and Universities and Colleges. In 1992 the American Society of Agronomy reviewed the past, present and future of agrometeorology in the U.S.A. in view of the concern for education, research and services in Agricultural Meteorology. The summary of the papers presented at this meeting is reported by Hollinger (1994). Hollinger concludes that when the agricultural community becomes more aware that using climate and weather information will improve their profitability, there will be a greater demand for Agricultural Meteorological Services. These services will include the provision of high quality real time weather data, more descriptive and accurate agricultural - oriented weather forecasts, and agricultural meteorology consulting for the agricultural community.

Education and training can no longer be seen as a one-time effort. Knowledge and skills acquisitions must be viewed as an ongoing process throughout a person's career. It is in this light that Competency Based Training (CBT) should be considered especially in Applied Agrometeorology. In some countries it involves a shift from an "educational" model to a "market" model where training is based on the requirements of the customer (the farming community) and the demonstration of "skills". Educational and vocational training initiatives have recently been reviewed by Mottram (1995).

7.5 Commercialization of meteorological services

Commercialization and "contracting out" are new influences changing traditional modes of operation of NMHSs thereby affecting agrometeorological services. How to package and sell agrometeorological products required commercial proficiency by future agrometeorologists working in a competitive free market. Such changes were noted by Tennukes (1988) following developments in the United Kingdom and in Sweden. Additional educational and training efforts will therefore be necessary in business practices and marketing disciplines.

7.6. Urgent programme for evaluation of training

Finally, although an initial effort has been made to evaluate the effect of education and training in Agrometeorology on the individual trainee and on the institution where he works (Lomas, 1998), the evaluation programme needs further detailed consideration: first, immediately following an educational
or training event and second, four to five years later. The basis question of how can the effectiveness of training in Agrometeorology be scientifically measured depends on the specific course and site chosen and it is related to training objectives. It will also be dependent on the institutional administrative infrastructure and socio-economic conditions. Nevertheless, such an evaluation is urgently required in order to indicate the quantitative output of trainees in Agrometeorology as well as the educational objectives and if these objectives have been met. Consideration must also be given to the relative priority of subject areas, the methodology of instruction, the teaching capacity, etc. As we move into the 21st Century it is vital to analyze the results of the efforts during the last ten years or so in order to plan more confidently the future.
REFERENCES


Wieringa, J., 1996. Is Agrometeorology used well in European farm operations. COST 711 European Commission. Directorate General XII.


APPENDIX I.

A. WMO Personnel Standard Classification

Technical Personnel

Class 4 = Meteorological Observers
Class 3 = Meteorological Observers

Academic Personnel

Class 2 = Forecasters and other well-trained Meteorologists.
Class 1 = University level Meteorological experts.

B. Proposed new WMO classification for personnel in meteorology and operational hydrology.

I. PURPOSES

The purpose of the proposed new WMO system for classification of personnel in meteorology and operational hydrology is:

(a) to provide an international framework for common understanding of the basic qualifications required of persons performing the meteorological and hydrological functions prescribed in the WMO Convention;

(b) to facilitate the development of reference syllabi for the education and training of personnel in meteorology and operational hydrology performing these functions;

(c) to assist the NMHSs of individual countries, particularly developing countries, in developing their own:
   • personnel classification systems suited to their particular needs
   • training programmes applicable to their classification structures and needs.

II. CATEGORIES OF PERSONNEL

It is proposed that two broad categories of personnel be identified as follows:

♦ For meteorological personnel

   (a) Meteorologist - a person who holds a university degree or equivalent, has acquired an appropriate level of knowledge of mathematics, physics and chemistry, and has completed the Basic Instruction Package in Meteorology (BIP-M).

   (b) Meteorological Technician - a person who has successfully completed the Basic Instruction Package for Meteorological Technicians (BIP-MT)
♦ For hydrological personnel

(a) **Hydrologist** - a person who holds a university degree or equivalent and has completed the Basic Instruction Package in Hydrology (BIP-H).

(b) **Hydrological Technician** - a person who has successfully completed the Basic Instruction Package for Hydrological Technician (BIP-HT).

III. **CAREER PROGRESSION**

It is envisaged that within both categories, depending on national circumstances, individuals will progress through initial intern or assistant roles to more senior and subsequently leadership roles based on their increased experience and expertise.

IV. **RELATION TO THE PREVIOUS CLASSIFICATION**

♦ For meteorological personnel

The previous four-class system recognized the Meteorologist classification and essentially three sub-classes of the proposed new category of Meteorological Technician such that the former:

- Class I was broadly equivalent to the proposed new category of Meteorologists;
- Class II was equivalent to assistant meteorologists and highly experienced meteorological technicians;
- Class III was equivalent to expert and some assistant technicians;
- Class IV was equivalent to assistant technicians.

♦ For Hydrological personnel

The previous three-class system recognized the somewhat different situation compared to the meteorological classification. The proposed new categories are such that:

- The Professional Hydrologist is equivalent to the proposed new category of Hydrologist;
- The Hydrological Technician can be equivalent either to the new proposed category of Hydrologist or Hydrological Technician depending on the holding or not-holding of a university degree or equivalent degree;
- The Hydrological Observer is equivalent to the new category of the Hydrological Technician.
APPENDIX 2

ANALYSIS OF QUESTIONNAIRE

On average, trainees attended 1.42 courses.

1. Age distribution of trainees

<table>
<thead>
<tr>
<th>AGE GROUP</th>
<th>20-25</th>
<th>26-35</th>
<th>36-45</th>
<th>46-55</th>
<th>56-60&lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of trainees 243 = 100%</td>
<td>2.4%</td>
<td>32.7%</td>
<td>50.1%</td>
<td>12.3%</td>
<td>2.5%</td>
</tr>
</tbody>
</table>

2. Academic qualifications

<table>
<thead>
<tr>
<th>Academic degree</th>
<th>B.Sc.</th>
<th>M.Sc.</th>
<th>Ph.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of trainees</td>
<td>98</td>
<td>126</td>
<td>19</td>
</tr>
<tr>
<td>Percentage %</td>
<td>40</td>
<td>52</td>
<td>8</td>
</tr>
</tbody>
</table>

3. Activities of trainees before and following education and training (three to six years)

<table>
<thead>
<tr>
<th>Activities</th>
<th>Services</th>
<th>Scientific Activity</th>
<th>Research</th>
<th>Management</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before training</td>
<td>36</td>
<td>51</td>
<td>7</td>
<td>6</td>
<td>100</td>
</tr>
<tr>
<td>Following training</td>
<td>37</td>
<td>48</td>
<td>11</td>
<td>4</td>
<td>100</td>
</tr>
</tbody>
</table>

APPENDIX 2.1

Activity and promotion following training of 14 Kenyan participants - A case study: activity.

<table>
<thead>
<tr>
<th>Degree</th>
<th>Education</th>
<th>Research</th>
<th>Services</th>
<th>Administration</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ph.D.</td>
<td>40</td>
<td>30</td>
<td>0</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>M.Sc.</td>
<td>48</td>
<td>32</td>
<td>11</td>
<td>9</td>
<td>100</td>
</tr>
<tr>
<td>B.Sc.</td>
<td>21</td>
<td>17</td>
<td>38</td>
<td>24</td>
<td>100</td>
</tr>
</tbody>
</table>

Activity assessment on an annual basis.

Promotion three to six years following training.

<table>
<thead>
<tr>
<th>Degree</th>
<th>No. of Trainees</th>
<th>Significant</th>
<th>Marginal</th>
<th>Not at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ph.D.</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>M.Sc.</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>B.Sc.</td>
<td>9</td>
<td>0</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
APPENDIX 3

ACTIVITIES OF THE RMTC BET DAGAN, ISRAEL - 1997

The Regional Meteorological Training Centre (RMTC) for Postgraduate training in Applied Meteorology at Bet Dagan, Israel, is a WMO recognized Training Centre, funded by MASHAV, Centre for International Cooperation, Ministry of Foreign Affairs, Jerusalem, Israel.

During 1997, one hundred and twenty one (121) participants took part in four International Postgraduate Courses in Applied Meteorology, from three hundred and fifty two (352) potential applicants. The participants consisted of eight two (82) men and thirty-nine (39) women.

Participants had the following geographical distribution.

(a) **AFRICA**

Burkina Faso (1), Cameroon (3), Cote D'Ivoire (1), Egypt (1), Eritrea (2), Ethiopia (9), Ghana (2), Kenya (7), Madagascar (2), Nigeria (4), Senegal (2), South Africa (1), Tanzania (1), Uganda (1), Zimbabwe (2)

(b) **ASIA**

Cambodia (1), China (8), India (4), Kazakhstan (1), Mongolia (4), Myanmar (1), Nepal (4), Thailand (4), Turkmenistan (1), Uzbekistan (4), Viet Nam (4)

(c) **EUROPE**

Azerbaijan (2), Bulgaria (5), Cyprus (1), Czech Republic (1), Georgia (2), Hungary (1), Jordan (1), Moldova (1), Poland (2), Romania (4), Turkey (1), Ukraine (1)

(d) **SOUTH AND CENTRAL AMERICA**

Argentina (1), Bahamas (1), Barbados (1), Brazil (2), Chile (1), Costa Rica (2), El Salvador (3), Haiti (1), Jamaica (2), Mexico (2), Uruguay (1)

(e) **PACIFIC**

Cook Islands (1), Papua New Guinea (1), Philippines (4)

POSTGRADUATE COURSES

(a) **The 5th International Postgraduate Course in Data Base Management in Agrometeorology**

Thirty (30) participants were accepted to the 23rd Course in Basic Agrometeorology. The main objective of the Centre was to provide participants with the basic and updated knowledge on the principles of the collection, verification, quality control storage, availability and recovery of climatological and biological data. To provide a venue for discussion on new developments in data management and for the exchange of experiences among participants and professional personnel. Much attention was paid to the application of data in Agriculture and Water Management.
At the end of the Course, a round table discussion took place. The discussion highlighted the advantages of the Course, and the use of PCs for data management projects. A number of available Data Base Management programmes were demonstrated including Clicom and dBase4. Participants expressed satisfaction with the Course programme.

Some shortcomings were discussed. It was felt that a more homogeneous group of participants would have been of considerable advantage and that some practical experience in the use and operation of PCs is necessary. A special programme of visits was arranged to the Libraries and Computational facilities of the Israel Meteorological Institute. The Faculty of Agriculture at Rehovot and the Volcani Centre of Agricultural Research were also visited.

(b) The 9th International Postgraduate Course in Crop-Weather Modeling

Thirty (30) participants were accepted to the 9th International Postgraduate Course in Crop Modeling. The computational facilities provided for participants included professional guidance in Crop Weather Modeling. The P.C. Computational Centre was updated to the DESAT 3.0 version for the Crop-Weather Modeling programme which was obtained from the University of Hawaii. The participants were divided into nine working groups. They presented the results of their own practical exercises and, thereafter, useful discussions took place.

Dr Orlandini (IATA - CNR, Florence, Italy) was the Guest Lecturer and presented his work on Modeling Epidemiology of Crops. The mission of Dr S. Orlandini was financed by MASHAV.

The Course spent two days in the north of Israel. During the trip Dr M. Meron demonstrated the Crop-Weather cotton model and its application under field conditions.

(c) The 23rd International Postgraduate Course in Basic Agricultural Meteorology

Thirty (30) participants were accepted to the Course. In addition to classroom presentations, the participants toured Israel, visiting places of agrometeorological interest and observing the application of meteorological information and advisories to agricultural practices and the use of Meteorology and Climatology in Agricultural planning.

In order to demonstrate the practical application of Agrometeorology, the participants spent five days at Kibbutz Bror Chail. The objective of this extended field trip was to permit the observation of the application of agroclimatic data to agricultural planning and agrometeorological services to technology. The participants were "adopted" by members of the Kibbutz in order to provide a family atmosphere especially during the extended weekend.

The participants and teaching staff prepared a number of computer programmes for training purposes in their home countries using local climatic and agricultural data and information. During the Course, a number of "round table" discussions took place between the lecturers and the participants. The written material presented, as a compendium in Agrometeorology was much appreciated by the participants. The availability of computational facilities during the Course and their accessibility during the evening hours was praised.

Special visits of individual participants were arranged to the Libraries of the Meteorological Service, to the Volcani Institute of Agricultural Research and the National and University Library to Jerusalem.
(d) The 6th International Postgraduate Course in Hydrometeorology

Thirty-one (31) participants were accepted to the 6th International Postgraduate Course in Hydrometeorology. Hydrometeorological models were of particular interest to participants and led to lengthy discussions. Considerable time was devoted to exercises of data analysis using various P.C. programmes. Dr F. Merio presented a complete water balance based on daily and monthly meteorological data, which formed part of the major exercise of the participants. Diskettes with hydrometeorological analysis methods were distributed on request. Dr M. Collin presented a series of lectures on water quality.

The study tours were introduced in the classroom and demonstrations included visits to the National Water Carrier, the Sea of Galilee and the Coastal Aquifer. A special visit was arranged to the Dead Sea Works to demonstrate the hydrological balance of the Dead Sea. Water quality was reviewed. A long weekend at Kibbutz Bror Chail demonstrated water management systems in agriculture.

The academic qualifications of the participants are shown below:

<table>
<thead>
<tr>
<th>UNIVERSITY DEGREES</th>
<th>No. of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhD</td>
<td>MSc</td>
</tr>
<tr>
<td>(a)</td>
<td>4</td>
</tr>
<tr>
<td>(b)</td>
<td>9</td>
</tr>
<tr>
<td>(c)</td>
<td>2</td>
</tr>
<tr>
<td>(d)</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
</tr>
</tbody>
</table>

Fifty-six (56) of the participants came from Meteorological Services while sixty-five (65) came from Universities and Research Institutes.

"ON THE SPOT" COURSES AND TRAINING ACTIVITIES ABROAD

Four "on the spot" training courses took place during 1997, in the RMTC Oshodi, Nigeria; at the Agrohydrological Research and Training Centre, Izmir, Turkey; and at the National Agricultural Research Centre (INTA), Buenos Aires, Argentina. The Training programmes were jointly financed by MASHAV, Centre for International Cooperation, Ministry of Foreign Affairs, Jerusalem, Israel, and the WMO, Geneva, Switzerland.

(a) Efficient Utilization of Agrometeorological Information in Agricultural Production of Marginal Areas, in Oshodi, Nigeria

A three-week mobile course in Agrometeorological Applications took place at the RMTC in 1997, in Oshodi, Nigeria, for eighteen countries of West Africa (ECOWA) from 4th-24th May 1997.
(b) Regional Training Course in Agrometeorology Utilization of Agrometeorological Information in Agricultural Planning and Operations, in Nairobi, Kenya

A short-term Regional Training Course in Agrometeorology took place between 27th July and 15th August 1997 at the Institute of Training and Research of the Kenya Meteorological Department, Nairobi. Twenty-six participants from Kenya (13), Tanzania (6), Uganda (6) and Ethiopia (1) took part.

(c) Agrometeorological Aspects of Water Application Efficiency, Izmir, Turkey

A special programme was provided for an Advanced International Course in Agrometeorology in Izmir, Turkey, from 1st to 12th September 1997. Twenty-four (24) Turkish participants and six (6) International participants took part in this Course. The objective of this joint Course was the transfer of advanced agrometeorology to farming planning and technology applications.

(d) Israel-Argentina Joint Workshop. The Application of Agrometeorology to Agricultural Planning and Technology, 16th October - 3rd November 1997, Buenos Aires, Argentina

Thirty-one (31) participants representing the academic research and extension services of Argentina took part in the joint workshop dealing with the technology transfer process and its application. Considerable interest was expressed in agrometeorological modeling, water use efficiency, and epidemiology both research and applications.

Israel-China Joint Workshop on Agrometeorological Aspects of Sustainable Agriculture and Water Management, 17th - 29th November 1997, Yehud, Israel

Five (5) Chinese and fourteen (14) Israeli participants took part in the above workshop. The Chinese team consisted of the following:

Lue Yuanpei, Professor, Agrometeorological Institute, CAAS, Beijing; Zhang Guo, Ministry of Agriculture, Beijing; Mrs Yu Kongyan, Ministry of Agriculture, Beijing; Mrs Peng Shiqi, Extension Service, Ministry of Agriculture, Beijing; and Chen Zhenming, Director, Shouyang County, Government, Shanxi.

The workshop subject concentrated on modeling evapotranspiration, efficient use of water resources under semi-arid climatic conditions as well as agro-ecological impacts and agrometeorological aspects of efficient use of water resources in the management of sustainable agriculture.

The Chinese team toured Israel and visited places of administrative, experimental and extension interest.

Joint Israel-Poland Workshop on Meteorological Aspects of Water Management and Utilization, 17th November - 29th November 1997, Yehud, Israel

The Poland-Israel joint Workshop took place in Bed Dagan. Six (6) participants from Poland and seventeen (17) participants from Israel took part.
The Polish represented the Institute of Meteorology and Water Management and the Academy as follows (IMWM):

Prof. P. Kowalczyk, Director, IMWM; Prof. W. Grzebisz, Agr. University, Poznan; Mrs M. Kepinska-Kasprzak, IMWM; Mr J. Sadon, IMWM; Mr P. Mager, IMWM; and Dr P. Strusik, University of Cracow.

WORKSHOP ON DROUGHT AND DESERTIFICATION

The Workshop on Drought and Desertification was held in Israel from 26th to 30th May 1997. Forty-four (44) participants from Africa, Asia and Europe who took part in the Workshop were sponsored by WMO. In addition to the Israeli lecturers, three foreign experts, namely, Dr O. Brunini (Campinas, Brazil), Prof. S. Mei (CAAS, Beijing, China) and Dr D. Wilhite (University of Nebraska, U.S.A.) provided in depth analysis on drought, and drought preparedness.

Presentations by lecturers and discussions were conducted under the following four main headings:

1. DROUGHT AND DESERTIFICATION DEFINITIONS.
2. DROUGHT CAUSES AND MANAGEMENT RESPONSE
3. DROUGHT MONITORING AND MITIGATION
4. ASSESSING DROUGHT IMPACT AND THE DEVELOPMENT OF A RATIONAL POLICY

The methodologies of drought assessments, meteorological, hydrological and agricultural over a wide range of climatic conditions were presented and discussed, and recent lessons from the 1996 drought in the U.S.A. were presented as well. In addition, the possibility and economic consequences of alternative agricultural systems in semi-arid climates was presented and numerous case studies of drought prediction, monitoring, impact assessment and response efforts were discussed from Africa, Asia and the Middle East and Eastern Europe.

EVALUATION OF THE TRAINING PROGRAMME

Evaluation of the Training Programme and its execution is carried out during and following the completion of the course in the following manner.

1. Discussing between course participants and lecturers. This round table discussion takes place at the end of each course, when the following guidelines are concerned.

1.1. Have the objectives of the training programme been reached?
1.2. Have the lecturers, instructors, field trip guides, presented their material successfully?
1.3. Is the infrastructure of the RMTC adequate for the needs of the participants?

2. Completion of trainees questionnaire.

The participants fill out an anonymous questionnaire providing their individual assessment of the programme, scientific level of the course, and the transfer of technology process. The results are analyzed and form guidelines for the planning of the programme and its execution the following year.

Example of participants response.
EVALUATION OF STUDY TOURS (FIELD TRIPS) IN ISRAEL – AGROMETEOROLOGY, 1998

DID THE FIELD TRIP DEMONSTRATE THE APPLICATION OF AGROMET. TO AGRICULTURE?

Participants were required to rank answers from 1 (very poor) to 10 (excellent).
EVALUATION OF STUDY TOURS (FIELD TRIPS)
IN ISRAEL – AGROMETEOROLOGY, 1998

DID YOU GET A GENERAL IMPRESSION OF THE
AGRICULTURE OF NORTHERN ISRAEL?

PARTICIPANTS WERE REQUIRED TO RANK ANSWERS
FROM 1 (VERY POOR) TO 10 (EXCELLENT)
EVALUATION OF STUDY TOURS (FIELD TRIPS) IN ISRAEL – AGROMETEOROLOGY, 1998

WERE THE PROFESSIONAL EXPLANATIONS ADEQUATE?

PARTICIPANTS WERE REQUIRED TO RANK ANSWERS FROM 1 (VERY POOR) TO 10 (EXCELLENT)