PURCHASE, USE AND MAINTENANCE OF SCIENTIFIC EQUIPMENT IN DEVELOPING COUNTRIES

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The aim of this paper is to contribute to a better understanding of the conditions of research laboratories in developing countries and the way they function. We will, therefore, attempt to answer the two following central questions:

How is scientific equipment chosen, purchased, installed and maintained?

What are the specific problems encountered by researchers in developing countries when setting up facilities and how can they ensure their proper functioning into the future?

We propose to offer some elements of a response to these questions by using some of the results of an enquiry carried out on a population of 489 researchers working in 67 developing countries and holding research grants from the International Foundation for Science (IFS). These results have been supplemented with information and experiences from several research institutions and laboratories in various developing countries, particularly in Morocco (Ouattar and Berkat, 1984; Ouattar 1985).

Before going into the core of the subject we propose to give a rapid description of the IFS and to explain briefly the way the enquiry was carried out.

The IFS, which was founded in 1972 in Stockholm, is a non-governmental organization. It is multilaterally funded by a number of ministries and development agencies. It provides support and guidance to young scientists in and from developing countries in the agricultural and biological sciences and related technology. Researchers receive grants normally not in excess of US$ 10,000, a sum which can be renewed up to four times. The sums are used mainly for the purchase of equipment, expendable supplies and literature. To date over 1000 scientists in 87 countries have benefitted from IFS support.

The questionnaire enquiry was carried out during 1985. A 20 page questionnaire consisting of 76 questions was mailed in March 1985 to all IFS grantees (at that time 766 in 78 countries). Subsequent mailings were done in May, then in October, of the same year to those who had failed to respond previously. Altogether, 489 responses were received from 67 countries, corresponding to a response rate of 64%.

Although our population presents certain peculiarities, we think that it is, in general, representative of researchers in developing countries. To be more precise, the researchers studied represent four continents and are located in the tropics and sub-tropics; principally, and in order of importance, they come from Asia, Africa and Latin America (Table I); they are working in different types of institutions (Table II) and in the seven priority areas of the IFS (Table III) i.e. the agricultural and biological sciences which are high priority and dominant areas of research in developing countries. Thus, the most significant individual feature of the

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population stems from the fact that the researchers who constitute it are the products of an internationally directed selection procedure. In other words, we could hypothesize that the situation of researchers in developing countries is, in general, less favorable than that which faces the researchers who served as the object of our study.

Purchase of Scientific Equipment

Lack of information

Even when budgets for the purchase of scientific equipment are available, researchers in developing countries often lack basic information concerning the type of apparatus to be purchased. The results of our enquiry (Table IV) shows that about one third of the researchers studied do not have access to catalogues of scientific equipment.

For those that do have access, the catalogues' year of publication varies from the current year to more than five years before. Figure 1 shows that only 17% of researchers have access to current catalogues. A quarter (23.3%) have catalogues which are at least 5 years' old. Furthermore it is often the case that, even when they have access to catalogues, these are not diversified, that is, they represent only one or two firms, giving the researcher few options for appraising a price/quality ratio. In one research institution in Morocco, out of 112 purchasers, 67 used the same catalogue issued by a single concern. This problem is aggravated by language barriers. Another dominant attitude is the tendency of a significant number of researchers to buy the same type of apparatus they have used in the research laboratories of the industrialized countries where they have been trained (24 of the 112 purchases previously quoted fit this category). The latter is often observed in grant applications submitted to the I.F.S.: "I sometimes feel that the main purpose of an application is to secure the equipment which the applicant used during his research training, so that he can go on using the techniques in which he has confidence and skill" (Bunting, 1986).

Non-mastery of technical characteristics

Several factors are neglected at the time of the purchase of a piece of scientific equipment. The researchers are not always aware of or trained in the importance of taking electrical and electronic specifications into account. Basic mistakes are made, such

TABLE I

DISTRIBUTION OF RESEARCHERS BY GEOGRAPHICAL AREAS

	Africa	Latin America	Asia and the Pacific	Total
Number	182	86	221	489
%	37.2	17.6	45.2	100

TABLE II

DISTRIBUTION OF RESEARCHERS BY TYPE OF INSTITUTION

Type of institution	Number of researchers	%
National Research Institute	109	22.29
Agricultural University	55	11.25
Research Institute located within a university	33	6.75
Department within a Ministry	12	2.45
Development Organization	7	1.43
Regional Research Institution	5	1.02
Private Institute	2	0.41
Others	5	1.02
University (general)	216	53.37
Total	489	100

TABLE III

DISTRIBUTION OF RESEARCHERS BY SCIENTIFIC AREAS

Research areas	Number	%
Aquaculture	98	20.1
Animal Production	75	15.3
Crop Science	113	23.1
Forestation and Mycorrhiza	39	8.1
Fermentation and Applied Microbiology	53	10.4
Natural Products	90	18.4
Rural Technology	21	4.3
Total	489	100

TABLE IV

ACCESSIBILITY OF RESEARCH EQUIPMENT CATALOGUES

	Number of researchers	%
Accessible catalogues	338	69.1
Non-accessible catalogues	149	30.6
No answer	2	0.4
Total	489	100.0

as purchasing equipment which functions at 60 cycles for a country where 50 cycles is standard, buying 110 volt equipment for a 220 volt environment and vice versa. Often the electrical plugs and sockets of the equipment do not correspond to the installations of the laboratories of the developing countries. A common and simple example is the lack of three point sockets. All too often, the researchers remove the original plug and substitute it with a two point one which lacks ground. Malfunctioning of the equipment is the consequence. When the choices and decisions are made at the administrative level, technical errors are even more frequent and numerous.

The equipment: research tool or status symbol?

As it turns out, decisions concerning the choice of a particular type of scientific equipment can sometimes be determined much more by considerations of prestige than by specific scientific needs. Thus, in many developing countries an institution seeking scientific respect must have either its electron microscope, or its laboratory of radio-elements, or its X-Ray and NMR units, its liquid phase chromatograph or its computer — depending on current fashion.

In a dynamic research and training institution, researchers confided to us that the most visited laboratory of their institution is the one that has produced the least results since its inception. This modern laboratory, well-equipped with sophisticated machinery, is the pride of the institution — it has been inaugurated on three separate occasions by different officials! In fact, these highly sophisticated instruments are under-used, if they are used at all.

In his article on science in Arab countries in the Middle East, Zahlan (1970) notes that: "There is much unused equipment in the United Arab Republic. For example, there are four electron microscopes which have not been used in scientific research, a magnificent mass spectrometer which lies idle, X-Ray and NMR units and numerous high resolution spectrographs which are collecting dust".

It is true that it is often easier to obtain a costly and prestigious piece of equipment from donor countries than glassware or reagents, let alone more modest pieces of equipment which would be so much less visible. Furthermore, the acquisition of this equipment is most often negotiated without consulting the users, and without taking into account the technical implications of its functioning.

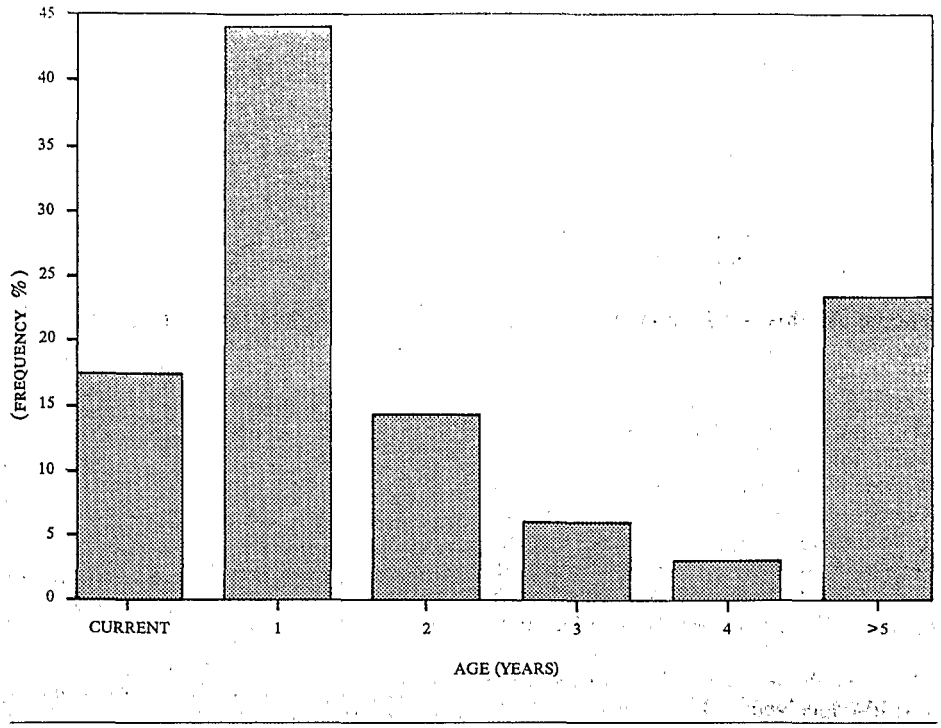

Fig. 1. Age of Research Catalogues used to order scientific equipment.

A recent survey carried out in 38 institutions utilizing scientific equipment in Ethiopia (SAREC, 1986) demonstrated that the total number of major items of scientific equipment in this country exceeds 6000 pieces, including the old as well as recently acquired equipment. The investment made for this equipment is about 50 million US $. Furthermore, it was found that only 10-15% of the organizations prepared the equipment specification themselves and purchased the equipment directly with funds of their own or through international services. In the remaining cases, purchases were made by donor countries or agencies with minimal or no participation of the Ethiopian organizations in selecting the equipment.

Receiving and Installing the Equipment

Bureaucratic delays and constraints

Even after the material is ordered, the researchers still come up against a multiplicity of constraints: red tape, inefficiency of the customs service and so on. In fact, once the equipment arrives at the airport or seaport, very often the researcher has to make several trips to meet and "convince" the customs officials. Even with a letter confirming a donation, which should normally exempt the equipment from customs duties, researchers have to furnish additional supporting documents. An example from Costa Rica gives a good illustration of these problems. The Universidad Nacional de Costa Rica had, in 1978, submitted a request to the Spanish Goverment to obtain different pieces of research equipment, including NMR for their Chemistry Department. When nothing arrived for several years, the researchers lost all hope... until they received a notification from Customs saying that an NMR had arrived at the beginning of 1985, and that they could come and collect it after paying customs duties which amounted to US$ 5,000.00. Since the university could not afford to pay such a sum and the Spanish Government could not come up with any other solution to the problem, the NMR still remained wrapped up at the airport one year after its arrival in San José. Such delays are clearly not compatible with the normal practices of modern science.

Installation

One of the most important problems concerned with installation of equipment is the lack of continuity. Sometimes costly instruments that have been ordered and delivered remain in

their packing cases for months, or even years, because the scientist who placed the order has left the institution either on a temporary leave or definitely, to some new job. The identification of research projects and scientific equipment with specific personalities is a handicap for ensuring a minimum of continuity and an efficient utilization.

Another serious problem is the inadequacy of premises and installations. At this level, dampness or temperature, or even rats, who can render new equipment completely inoperable in a matter of days, are difficult to control. The lack of space also precludes a rational organization of laboratories. In Morocco and in other African countries, it is not rare to see ovens, heating plates, inflammable chemical products, freezers, computers, Kjeldahl pads which give off acid vapors all crowded into a small, badly ventilated laboratory. Furthermore, electrical installations and running water, when available, are often maladapted and ill-conceived.

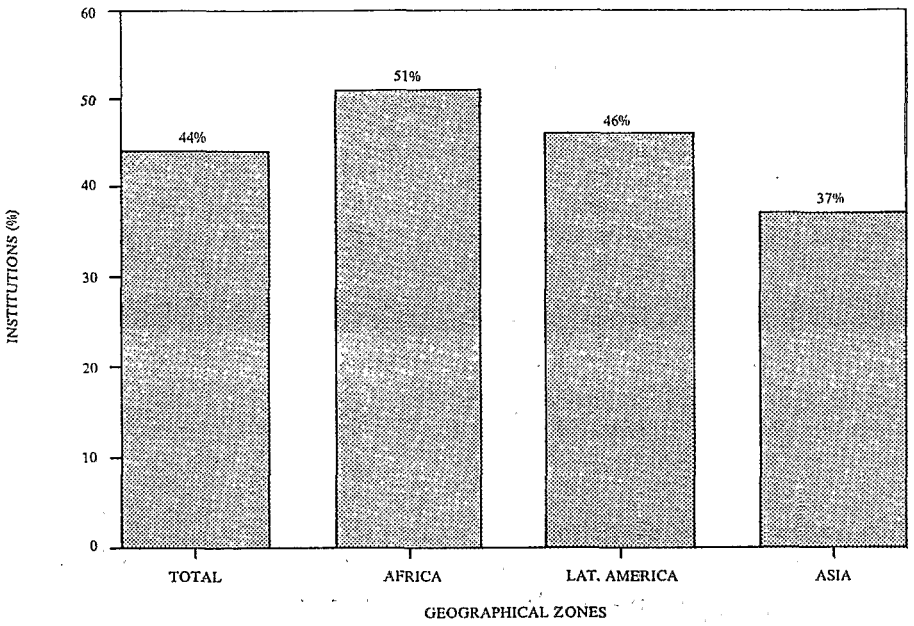

Fig. 2. Institutions for Repair and Maintenance without technicians.

Use and Maintenance of Equipment

Available statistics and visits to research laboratories in developing countries show that it is difficult to come up with *a priori* generalizations about so many contrasting situations. Thus it is possible to visit, within a single country, and sometimes within a single institution or department, laboratories which lack little or nothing in comparison with laboratories in industrialized countries, and the next minute or the following day to come face to face with a desultory laboratory furnished with rudimentary, old equipment, most of which does not work. Having said this, there are few laboratories in developing countries that can simultaneously claim availability of modern, operable and effective research equipment and competent, stable personnel to operate and maintain it.

Inaccessibility of information

In many cases, technical instructions accompanying the equipment purchased are inaccessible to technicians of developing countries because of language barriers (for example, instructions in English in francophone African countries) and technical difficulties related to the training level of the technicians themselves. Although instructions are necessary to ensure regular maintenance of the equipment, it is not rare to learn that people pay little attention to them. We have made some estimations in a few laboratories in Morrocco and have found that 46% of technical instructions are lost within two years after receiving the material, and that 62% of them are misplaced after 4 years.

We found that the electrodes of pH meters, or of equipment for distilled water, had become inoperative because the technicians no longer remembered and no longer carried out routine maintenance tasks. Furthermore, even when the origin of a breakdown is correctly diagnosed and the defective component found, how can a replacement be ordered from the firm that made the equipment if the instructions (in English, German, French...) with the name and reference for the part are no longer available?

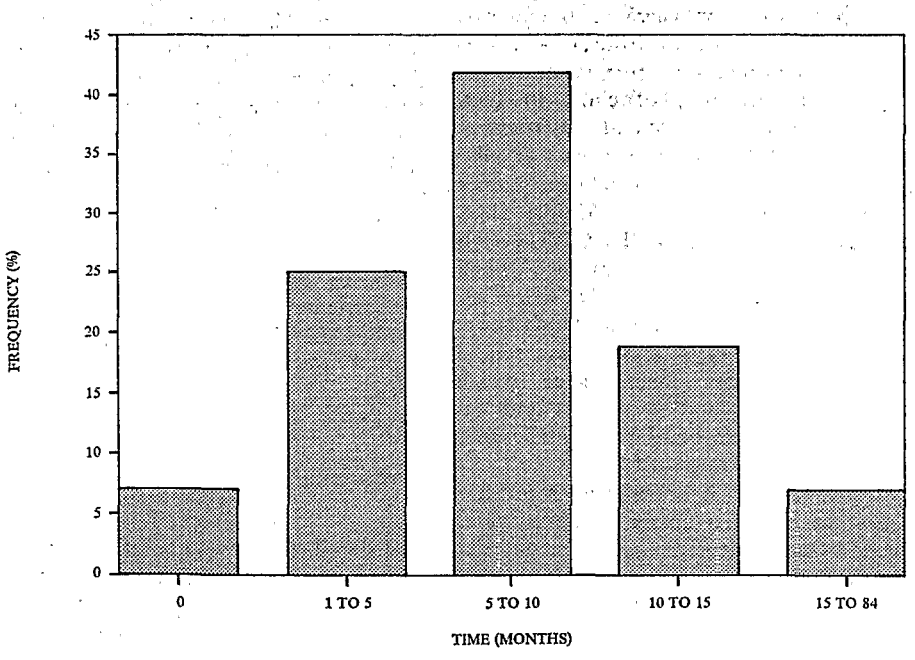

Fig. 3. Time Required to Repair Equipment when sent abroad.

Lack of competent technicians

The problem of an under-utilized, or not used at all, expensive research equipment is often tied to the lack of technicians. If one can rely on UNESCO's statistics, the ratio between the number of researchers and technicians in France is roughly 2 to 2, in Sweden 1 to 1.5, in Germany 1 to 1, whereas in Indonesia it is 6 to 1, in the Philippines 2.5 to 1 and in Egypt 3 to 1 (1985). In 1975, there were 1885 scientific workers to 314 technicians at the National Autonomous University of Mexico — this makes a ratio of 6 to 1. (Soberon and Mendoza de Flores, 1985). What is more, these statistics cover up difficulties in the definition and evaluation of competence. Thus, when one puts precise questions to researchers, it appears that the situation is even more critical. We asked researchers in our sample if their institution had any technicians who could install, ensure the maintenance of and repair the research equipment they used. Figure 2 presents the results obtained, in function of the continents in which the researchers worked. It turns out that 44% of the institutions do not have technicians that can install, ensure the maintenance of and repair research equipment. As in many other domains, Africa seems to be in a less advantageous position than Asia. A majority of institutions in the former continent (51%) do not have qualified technicians capable of overseeing the proper functioning of scientific equipment, compared to a little more than one third (37%) in Asia.

These percentages vary significantly in those disciplines which rely mostly on laboratory work and thus on research teams, such as the chemistry of natural products and microbiology (Table V).

Even in these domains, only 33% of the corresponding institutions do not have a qualified technician for equipment repair or for identification of a failure and the spare parts that must be replaced. On the other hand, 61% of the institutions attached to the domain of forestry and mycorrhiza studies do not have even one of such a technician.

One of the consequences of this situation is that many researchers have to appeal to foreign technicians, either by sending the equipment or the defective part to the foreign supplier or by requesting a visit of the foreign technician.

We questioned the researchers about how long such a repair took. Figure 3 presents in percentage form the answers of the 214 researchers concerned. The time, counted in months, varies from 0 to 84. Those who answered that their equipment has yet to be repaired are not represented in the figure.

More than two thirds of the researchers (68%) had to wait 5 months or more for their equipment to be repaired by a foreign technician, and more than a quarter waited 10 months or more. This is clearly a considerable delay which places researchers in developing countries at an enormous disadvantage regarding their colleagues in developed countries.

We observed that researchers in developing countries attempt to prevent the consequences of research equipment breakdowns or compensate for the lack of such equipment by adopting two attitudes:

—Locking up their equipment and limiting the number of users; this results in equipment under-utilization. Chromotographs and photospectrometers which could in principle make thousands of analyses a year end up being used for merely a few dozens.

—Sending samples to foreign laboratories for analyses. This solution of convenience, which permits researchers to acquire experimental data relatively quickly, turns their attention and efforts away from the creation of scientific structures and functional laboratories. Under these conditions, there is no possibility of accumulating local experience, either at the institutional or technical level, thus blocking progress. If the institution is university- based, this situation has harmful consequences for training future staff. How can anyone train chemists, technologists or biologists if all analyses and mixtures are made and prepared outside the institution where they work?

TABLE V

TECHNICIANS ACCESSIBILITY BY INSTITUTION AND RESEARCH AREAS

Research areas	Total	Without technicians	
		Number	%
Aquaculture	96	45	46.8
Animal Production	75	46	61.3
Crop Science	113	47	41.6
Forestry and mycorrhiza	39	22	56.4
Applied microbiology	52	17	32.7
Natural Products	90	30	33.3
Rural Technology	21	7	33.3
Total	486	214	44.3

Inadequacy of administrative structures
Administrative procedures

Operational rules in the financial services of developing countries are rigid, and make it difficult to have a budget dedicated to the maintenance and repair of scientific equipment. In some African countries, when an instrument breaks down, the rules of public finance demand that the apparatus be examined by three different technicians, each of whom must submit his or her diagnosis and give an estimate for the cost of the repair. Only after they have these three estimates can the researcher ask the administrative services for authorization to make the repair, always with the lowest estimate. Most of the time, this procedure is unworkable because the technicians do not wish to invest their time in giving a free diagnosis without having a good chance of landing the contract. As a consequence their reaction is to inflate the estimate. The administrative regulation, whose aim is to save money, in fact renders the operation longer and more costly. The process can drag on for months, even years. Thus, researchers quickly learn that it is easier and quicker to buy a new piece of equipment than to repair the one that has broken down! Some researchers admitted that, worn out by administrative procedures, they reluctantly opt for this solution.

Technicians' status

Public service regulations place technicians on a low-pay scale. Salaries are determined in function of diplomas, and not of real competence. Manual work is considered low social status. These two aspects, low pay rates and low social status lead to the departure of competent technicians from train-

ing and research institutions for the realm of private enterprise. We have found several cases of technicians earning from 4 to 10 times their former salary after offering their services to private companies. Sometimes these same technicians, without quitting their job, spend part of their time doing private work for small TV, radio, mechanical, or electrical repair shops. Researchers themselves turn to outside work to supplement their income.

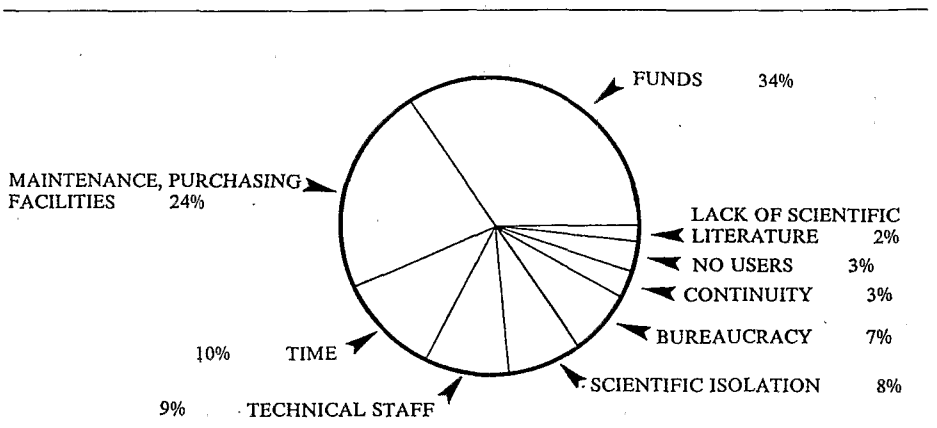

Fig. 4. Main Limiting Factors to Scientific Research Work.

Conclusions

The principal obstacles to the functioning of laboratories at the levels of purchasing, utilization and maintenance of scientific equipment in developing countries are dealt with herein. The regular functioning of Research and Development laboratories is subject to constraints and irregulaties incompatible with the necessities of Science. This is due to the fact that these questions, which are in fact vital, have been neglected for a long time, as much by local institutions as by international organizations. As a result, the efficacity of aid for and investment made in research is very small, and there is doubt as to the continuity of the established structures, as illustrated by the different concrete examples cited above.

The 489 researchers who were the object of the study were asked to identify "in terms of their actual local situations" the main factor limiting the development of research. The results, in Figure 4, are surprising and revealing: the purchasing and maintenance of equipment factor occupied second place. Furthermore, we have been able to show that, in fact, researchers spend most of the time they dedicate to research in the laboratory (Table VI).

The latter result is not unexpected and confirms the importance of laboratory work and availability of properly functioning research equipment to perform research activities in developing countries, even in scientific areas such as agronomy, forestry and animal sciences that are believed to be mainly field oriented.

Most of the results presented in this paper agree, quite well on the whole, with what experienced observers have previously said on the basis of more anecdotal data. We believe however, that a more systematic documentation of such opinion is important, if one wants to convince people to act. The actions to be undertaken must be integrated in such a way as to eliminate the main obstacles we have contemplated.

In that respect, it is striking to observe that very few donor organizations give proper recognition and attention to the procurement of and follow-up support for scientific equipment which they pay for and which constitute a considerable part of their contribution to research in developing countries. With a long term perspective there are considerable costs to be saved by taking measures to improve the support procedures for scientific equipment.

While external donors can and should assist developing countries to build up a research infrastructure, the ultimate responsability has to be with the developing countries themselves. Thus the most important and crucial roles in improving the equipment situation have to be played by national authorities and organizations in developing countries.

TABLE VI

TIME DISTRIBUTION DEDICATED TO RESEARCH IN DIFFERENT PREMISES

Premises	Time Percentage
Laboratory	30
Office	23
Field	20
Library	15
Agricultural facilities	5
Computer room	3
Elsewhere	4
Total	100

Coordinated actions should also be taken at an international level.

Finally, it is clear in any case, that whatever similarity there might be between the problems that confront researchers in developing countries, it is difficult to generalize about their situation. A global approach always runs the risk of hiding regional disparities, even when they belong to a single region and seem to have many of the same characteristics. There can be no universal solutions. This is why it is important that actions and programs established in the future take into account the specificity of each country, of each institution and of the researchers involved.

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