Agricultural Scientists in America and in LDC's: similarities and differences.

by

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Even though modern science began its development in the Western world in the seventeenth century, agriculture only became a subject of scientific investigation in the 19th century, and it is only since the start of the 20th century that agricultural sciences have really come into their own.

In the USA one can trace the prehistory of agricultural sciences back to the approval of the Land Grant College Act in 1862, although it was not clear at that time whether the agricultural colleges should do research at all. Agriculture was certainly not yet considered as a science. As J.M. Gregory of Illinois Industrial University put it in 1869: "Botany is a science - chemistry is a science - but agriculture is not a science in any sense.....it is simply a mass of empiricism" (1). The late nineteenth and early twentieth centuries were a period of rapid development and increasing professionalization for the agricultural sciences in the USA (2).

In the developing world, with the exception of a few countries such as India, the development of agricultural sciences has only become significant during the post-independance period. Before independance, agricultural research in developing countries focused as a rule on export crops, whereas research on staple food crops of importance to the diet of tropical people was very largely neglected. Furthermore, at the time of independance, scientific institutions were staffed and administered almost entirely by Europeans and the scientific work performed in these institutions was mostly attuned to European economic interests. At the time when the newly Independant States came into being, efforts were made to create

autonomous research institutions and the demand for trained manpower increased considerably - this being considered as a necessary part of achieving self reliance (3). The following figure among the most imortant teaching and research institutions in developing countries: The Agricultural University of Pantnagar, The College of Agriculture of the University of the Philippines at Los Banos and L'Institut Agronomique et Vétérinaire Hassan II at Rabat in Morrocco. It should be noted that this latter institution only came into being at the end of the 1960's, and was not officially inaugurated until 1974.

Whatever their original features may be, the setting-up of these institutions was influenced by models established in western countries. Thus the American model of agricultural research was partially adopted, above all immediately following the Second World War, by countries like India and Brazil amongst many others. Similarly, the system established in France served in large part as a model for the francophone African countries. The diffusion of these models was facilitated by the fact that, until relatively recently, students from Developing Countries had to go to countries in the West to pursue university studies and to obtain diplomas so as to become researchers.

To what extent does the (even partial) adoption of western models and the training of students from developing countries in universities in the West influence the practice of agricultural researchers in LDC's, and the perception that they have both of their own work and of the practice of research in general in their countries? What are their social origins? What institutions do they work in? To what extent are these same researchers different from researchers in the countries in the West where they were trained?

We propose to offer some elements of a response to this question by comparing the results of an enquiry that we carried out on a population of 489 researchers working in 67 LDC's with those obtained by Busch and Lacy based on an enquiry studying 1400 American researchers in the agricultural sciences (4).

Although our population presents certain peculiarities, we think that it is in general representative of researchers in LDC's. To be more precise, the researchers we studied represent the four continents and are located in the tropics and sub-tropics; principally and in order of importance they

come from Asia 42%, Africa (38%) and Latin America (18%) and are active in high-priority and dominant areas of research in LDC's, viz the agricultural and biological sciences. The most significant individual feature of the population studied stems, however, from the fact that the researchers who constitute it all received a research grant from the International Foundation for Science (IFS), and that they are thus the products of an internationally operated selection procedure.

So as to sharpen the comparison, we will also refer to other work, and in particular to the ISNAR data base on national agricultural research systems (5).

1. Socio-professional backgrounds: a relatively stronger influence of farming backgrounds for agricultural scientists in the USA than for those in developing countries

Many researchers in LDC's, as is the case for their fellow citizens with advanced educational qualifications, are the first in their families to receive an education at secondary level and above. Many of them, particularly the Africans, come from a rural environment: "I come from a rural village situtated in the eastern part of Ghana. My parents are illiterate, but they struggled to provide an education for their children, because they were convinced that with education goes interesting work and a good position in life. I am the second of a family of 10 children. I have four brothers and five sisters. It was an eminent academic from my village who filled me with desire for further education. When I was a small boy, every time he came to the village, I went to see him. This man is now Professor of Linguistics at the University of Ghana. However, it was only when I arrived at the university that I discovered my vocation for science and for scientific research through becoming aware of the numerous problems crying out for solution confronting Ghanaian agriculture ...".

What a path he has followed this young Ghanaian, who now holds a Phd from a prestigious English university and was as a result able to spend time at no lesser an establishment than the Experimental Station at Rothamsted and work under the direction of researchers with international reputations in their field like Dr Barbara Mosse and Dr David Hayman before returning to Ghana.

1961/1962, that is to say 8% (7). The percentage of sons or daughters of 'blue collar workers' is, on the other hand, lower: but this can be easily explained by the fact of the lower rate of industrialisation in LDC's.

The high percentage of researchers (24%) coming from the social category 'liberal professions and management' confirms the phenomenon of inequality of opportunity, and this is so much the more striking since this category only represents a very small part of the population in LDC's.

Interestingly, Busch and Lacy's survey of agricultural scientists in the U.S.A. also reflects the strong influence of a farming background. Although the farm population of the U.S.A. is now under 4% of the total population, 38% of all agricultural scientists come from a farming background (8). As was the case for our results, scientists in agronomy and in the animal sciences in the U.S.A. are more likely to come from an agricultural background, as compared to only 14% of foresters and 22% of food scientists.

As can be seen from a study of Table 2 below, it is researchers in the field of crop science who have the largest probability among the researches in LDC's of having a farming background, followed by those from the field of animal production. In contrast, only 23% of food scientists come from a farm background, while 40% report having fathers who were professional or white collar workers, and 17% had fathers who were owners of small commercial enterprises or workshops. With the exception of labourers and other blue collar workers, who are under-represented in the group of fathers of food scientists, this last result is again very similar to that of Busch and Lacy in their survey of American agricultural scientists.

For the other fields, the further one goes from those that have a direct relation to agriculture, the wider the social base of the researchers' family origin and the less the latter are likely to have a farming background. This is particularly true for aquaculture, a domain in which only 19% of the researchers have a father with a farm background.

Taking into account the relative weight of the farm population with respect to the total population in the U.S.A. (4%) and in the LDC's (78% in Africa and in Asia; 40% in Latin America), one could expect to find higher percentages of researchers with a farm background in the LDC's than in the U.S.A. That this is by no means the case and that on the contrary we found

Table 2 : Father's occupation of scientists in LDC's by discipline

Disciplines	Farm Background	Father's Occupation (%) Lib Profs Management	Artisans Commerce	White Collar	Labourers Blue Collar
Crop Science	45	18	16	5	10
Animal Production	36	24	11	13	12
Forestry	29	16	21	21	10
Rural Technology	26	6	21	16	25
Natural Products	25	24	24	14	12
Food Science	23	40	17	6	10
Aquaculture	19	26	24	14	13
Total	30	24	20	11	13

a relatively high percentage (24%) of researchers coming from the category 'Liberal professions and Management' despite the fact that this social category represents only a very small proportion of the population in LDC's suggests that inequality of opportunity is even more significant in the LDC's than in the U.S.A.

2. Gender: a larger participation of women in agricultural research activities in LDC's than in the U.S.A., with significant differences between the continents.

When we learn that women represent only 16.56% of the total population of researchers, we have to conclude that they are under-represented. A rapid comparison of the situation in the developed world leads us, however, to modify this first reaction. In effect, in the United States in 1982 only 13% of scientists and engineers were women, although their total had increased by 200% between 1972 and 1982. This percentage is clearly much lower than that of women in the workforce in the United States, that is to say 45%.

In a country like Sweden, which is, nevertheless, well known for its efforts in the domain of sexual equality (11), only 12% of the population trained to perform research were women (12), and the higher one goes up the various levels of university education, the less women one finds. Thus although more than half of the students in secondary education are women, only a quarter of those studying for doctorates (forskarstuderande) are ... and only 3% of university teachers (13).

Taking the mean percentage of women over all the countries we studied hides regional disparities and important differences between countries. Thus the percentage of women researchers in our population are as follows for the different continents: 9% for Africa, 15% for Latin America and 23% for Asia.

The Philippines and Thailand display the highest percentages, with respectively 36% and 33%, while we find only 10% of women researchers in our Sri Lankan population.

Some African countries, such as Tunisia and Tanzania with respectively 27% and 23% women, have a laudably high percentage when compared to the continent as a whole, whereas countries like Burkina Faso, Morocco and Senegal have much lower scores than the average.

Detailed comparisons allow us to affirm that, leaving aside those countries for which we only have a very small sample, the percentage of women in our population corresponds relatively well to that in the whole of the population of researchers in the countries studied. Thus according to a recent study (1984) carried out by ISNAR of the 1400 researchers and technicians of the Department of Agriculture in Thailand, 38% were women. This same study also brings out a strong degree of disciplinary specialisation, which means that women tend to choose those domains which are principally involved with laboratory work and which permit them to work in the capital (15). As for Senegal, we were able during our last study visit to this country in 1984 to verify that taking the scientific and technical personnel of the Institut Sénégalais de Recherche Agronomique (ISRA) as a whole, only 4.5% were women. Equally, a quick analysis of the statistics for the people teaching at the University of Dakar for the year 1982/1983 has allowed us to establish that there were 8.5% women in this group (including expatriate women - who made up more than half the total), 7% being located in the Faculty of Medicine and

Pharmacy and the Faculty of Arts and the Humanities. For Sudan as a whole and in all categories there were in 1980 4 women researchers in the total of 123 agricultural researchers, that is to say 3%, and these worked in the field of food science and nutrition (16).

Equally, we find a strong degree of disciplinary specialisation as a function of gender in our population, the women tending to concentrate in the more traditionally feminine disciplines which necessitate mostly if not exclusively laboratory work based in the capital or in a large town.

Table 3 : Gender distribution of scientists in LDC's by scientific area

Research Area	Men %	Women %
Food Science	62	38
Forestry	77	23
Natural Products	80	20
Aquaculture	85	15
Crop Science	88	12
Rural Technology	90	10
Animal Science	95	5
Total	84	16

The three domains in which women are over-represented as a proportion of the mean, that is to say in Food Science, Forestry and Natural Products are equally those which are over-represented in Asia, the continent in which we find the highest percentages of women in research.

In the domain of Food Science, the research work of the women in our sample all has a direct bearing on nutrition and the production of foodstuffs: the improvement of traditional procedures of fermentation of foods, the production of microbial proteins, studies linked to the contamination of foods by mycotoxins or by aflatoxins. In the field of Forestry, their work bears principally on research into mycorrhyzal associations and mostly on the isolation, determination and culture of mycorrhizal strains in the laboratory and to studies attached to the fields of taxonomy and ecology. Although some are responsible for field experiments, forestry research, which necessitates prolonged periods away from home, rests a male domain.

The field of Natural Products draws almost exclusively on laboratory work. With aquaculture, we come to a discipline at the crossroads, but here again it is interesting to note that the women in this field concentrate their research above all on nutrition and the development of foods for diverse aquatic organisms, on the development of vaccines and on the parasitology of diseases affecting fish.

These three latter are most typically male domains, which very often entail permanent or temporary posting to an isolated research unit outside of the capital and the big towns. Disciplinary specialisation is not the only factor that explains the greater concentration of women in the cities. Other factors such as matrimonial status, the number of children to support as well as the spouse's profession can also influence the geographical placement of researchers and as a result their research practice.

While in the U.S.A. in 1982, as we have seen, women represented only 13% of all employed scientists and engineers, Busch and Lacy found in their sample that a little over 4% of agricultural scientists were women. Women agricultural scientists in the U.S.A. are, however, highly concentrated in the fields of nutrition (41%), social science (19%) and food science (10%). For the fields of agronomy, animal science and forestry, 1% or less were women (17).

While we must recognise that women are globally under-represented among the agricultural scientists in the LDC's, they are much more so in the U.S.A., where in certain fields such as forestry, agronomy and animal science they only represent, as we have just seen, 1% or less, whilst for these same fields we have found for our population 23%, 12% and 5% respectively were women.

Further, we have established a very large disparity in the participation of women in research activities in the LDC's in different continents, to such an extent that in several Asian countries, such as Thailand, women are significantly present in all fields, even if one can still discern a marked disciplinary specialisation which tends to concentrate women in the laboratories in the capital.

3. Education

Until relatively recently and with the exception of a few countries like India, study abroad was for many students from LDC's the only way to pursue university courses and to obtain diplomas allowing them to become researchers. In this context, the path followed by this young Fijian researcher is fairly representative of that followed by many researchers from LDC's: "I was born in Fiji, where I completed my primary and secondary studies. At the secondary school - the Marist Brothers High School of Suva - I got my Fiji Junior Certificate, an overseas examination set by Cambridge University. Then I studied for one year at Suva Grammar School where I got my certificate for entry into a university. I wanted to go to university to continue my studies, but as at that time there weren't any universitities in Fiji, I left for New Zealand in 1964 to study at Canterbury University. I stayed there for five years, during which time I got my Bachelor of Science degree and my Masters" ... . This Fijian researcher of Indian stock ended up spending two more periods overseas, going to Queensland University in Australia in 1976 to get his Phd in the field of Rural Economy. Between times, that is to say at the end of the 1960's, the South Pacific University at Suva was created. Thus it was only after three periods overseas, where he stayed in all for 9 years alternating with periods of work for the Ministry of Agriculture in Fiji, that he got his Phd.

Although this phenomenon of overseas training is neither new nor in any way specific to LDC's, it should be noted that the proportion of students from LDC's in the total of overseas students has increased significantly since the 1960's in most western countries. Thus in the United States the number of overseas students has increased tenfold over the last 30 years, going from a little more than 1% to 2.5% of the total student population (18). The five western countries that take the most overseas students are, in descending order of importance, as follows: the United States of America (326,299 in 1981), France (134,566 in 1982), the Federal Republic of Germany (71,393 in 1982), Great Britain (42,267 in 1983) and Canada (35,363 in 1983). Among these overseas students, at least 80% come from LDC's, except in West Germany where they constitute only 60% of the overseas student population (19). It is in France, with more than 13% of the total number of students, that the percentage of overseas students is highest. Then come West Germany, the United Kingdom and Canada with about 5% and the United States with 2.5% (20).

During the colonial period, overseas education was very restricted, and took place almost exclusively in the colonising country. During the years preceding independance, there was an increased demand on the part of students in LDC's for overseas education and the number of scholarships given by the industrialised countries increased considerably. This reflects in part a sharper awareness of the value and the rôle of tertiary education and of science for development, as well as the desire of the donor countries to maintain or to acquire political and economic influence in the newly independant states (21).

This does not mean to say that there were no universities in many LDC's before independance; but these latter clearly did not, at the time of independance, cover all disciplines in science and technology and above all did not for the most part offer postgraduate degrees. Thus there were 23 universities in Latin America during the colonial era, from which nearly 150 students had got degrees by about the end of the eighteenth century (22). In 1857, British colonials opened the first Asian universities, at Calcutta, Madras and Bombay (23). Cairo University was founded in 1908 (24). The first universities in black Africa are of more recent origin. In fact, it was only in 1948 that the first courses were given at University College in Ibadan, Nigeria, and in 1950 that the first two science graduates emerged from the same institution (25). The official opening of the University of Dakar, the oldest of the francophone universities in black Africa, only took place in 1957, and it only became Senagalese after Independance in 1960.

In some countries, the rate of evolution after the creation of the first university was rapid, and the movement accelerated particularly rapidly during the 1960's. Thus there are at the present time in Brasil no fewer than 60 universities and 800 tertiary institutes outside of the universities, while before 1965 there scarcely any institutions other than the University of Sao Paulo offered university education, and that for a limited number of students. The number of students has increased considerably since, reaching approximately 200,000 in 1968 and more than 1.1 million in 1977. At the present time in Brazil there are about 600 'graduate programmes' in about 30 universities and independant institutes. Two thirds of these programmes lead to a Masters and one third to a doctorate. The University of Sao Paulo alone offered in 1977 no less than 100 Masters and 66 doctorate programmes covering all fields. However, even in the

opinion of Brazilain officials these programmes are of extremely variable quality, and it is considered that only one third of the doctorate programmes are of a good academic standard, and that less than one half of these are offered at the University of Sao Paulo.

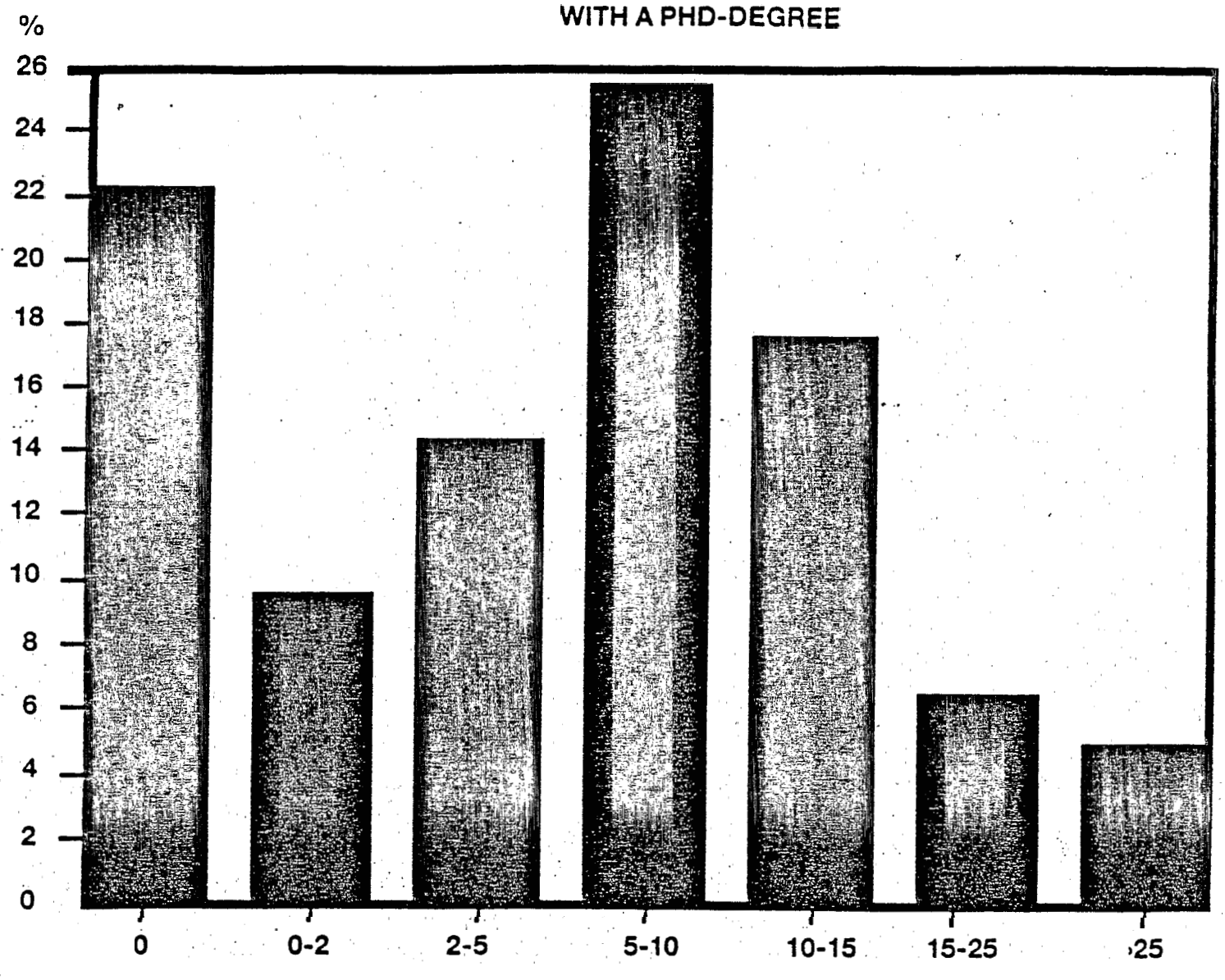
This is one of the reasons for which the Conselho Nacional de Desenvolvimento Cientico e Tecnologico (the National Council for Scientific and Technological Development of Brazil) offered more than 1000 scholarships for Brazilian students in 1984 for doctoral or post-doctoral research, mostly in the following countries: the United States, Great Britain, France, Belgium, Canada, West Germany, Australia, Italy, Sweden and Spain (27). This is, however, only the tip of the iceberg, for overseas training in research is a field that LDC's find difficult to master, and much overseas training depends more on the personal initiative of the students than on any controlled planning at governmental level. It is a field where there has been an increased diversification of host countries since the start of the 1960's, although the LDC's are still marked by their respective colonial heritages, whatever may have been the vagaries of post-colonial political evolution.

Very few studies have been made of the educational level of agricultural scientists in LDC's. The most recent and the most accurate study has been made by ISNAR. From this survey, it can be concluded that a significantly large number of agricultural research institutions are staffed by relatively few researchers with doctoral training. Figure 1 on the next page shows the frequency distribution of agricultural scientists with Phd's. Of the countries for which ISNAR has obtained data for 1983-1984, almost 50% have less than 5% of their agricultural scientists holding doctorates, and only four countries have a proportion over 20%.

Although there is little information available on the level of experience of research personnel in LDC's, there is also some evidence that it is very low, at least in countries in sub-Saharan Africa. In Kenya in the early 1980's, 76% of agricultural research personnel had less than 5 years' work experience; the equivalent figures were 46% for Nigeria, 69% for Senegal and 67% for Zimbabwe (29).

Figure 5

RELATIVE FREQUENCY DISTRIBUTION OF COUNTRIES BY PERCENTAGE OF AGRICULTURAL RESEARCHERS WITH A PHD-DEGREE



Sample Size: 63 countries

Source: ISNAR Databas

These statistics must, however, be taken with a grain of salt, because despite efforts that have recently been made in this domain, few LDC's have a very precise picture of their scientific and technical potential. There are also problems in the interpretation of definitions, and these frequently render comparison hasardous. As far as Sudan goes, Lacy proposes percentages that are even higher than those previously cited for the researchers at the Agricultural Research Corporation (ARC): of the 161 researchers who made up the ARC in 1980, 81 held doctorates. The percentage of Phd's was still higher if one excludes research assistants. Further, 12 of the 13 researchers at the ARC who were not attached to the institution that same year also held Phd's (30).

In their survey, Busch and Lacy found that more than 92% of currently active public sector agricultural researchers in the U.S.A. had received their doctorates. Of the thirteen agricultural disciplines under review, only two - forestry (81%) and agricultural engineering (63%) - had fewer than 90% with doctorates.

More than 60% of the researchers in our population held a doctorate or equivalent diploma. Clearly, this high percentage results from the selection and cannot be claimed to represent the prevailing situation in LDC's. It does however appear to us to be of interest that we can observe a significant variation in this percentage between the disciplines. Thus in the field of crop science, 72% of the researchers had a Phd whereas no more than 51% did in forestry and 48% in rural technology.

Although the percentage of doctorates obtained in LDC's has increased constantly since the beginning of the 1970's, the dependance on other countries for training in research still remains very marked. The more years spent abroad, the higher the student's chance of passing a doctorate. In other words, researchers who have spent 10 years or more abroad have 3.5 times as much chance of gaining their doctorate as those who followed all their studies in their own countries. This dependance on other countries for education is, equally, directly proportional to the level of diploma obtained. The more advanced the diploma, the greater the dependance. Thus, where more than three quarters got their doctorates in foreign universities, only 45% got their Masters abroad and this percentage falls to 10% at first degree level.

Three quarters (76%) of the researchers in LDC's comprising our

population studied in the universities of 16 industrialised countries to get their doctorates. Three countries dominate in large part the international scene of countries providing doctorates for students from LDC's, and furnish of themselves 80% of the doctorates obtained abroad by the researchers in our population; these are the United States (34%), Great Britain (26%) and France (20%), followed some way behind by Australia, Canada and West Germany. This diversity of education is incontestably an enriching source of ideas and of multiple contacts. In addition, the movement of individuals with knowledge is probably one of the most efficient ways of transferring knowledge. This eclecticism can also be a source of confusion, and can render the evaluation of the value of certain diplomas and training received abroad difficult. These difficulties are reinforced in the case where the thesis is presented in a foreign language not understood by almost all the researchers and administrators in the student's country of origin.

Most agricultural scientists in the U.S.A. received their education at land-grant institutions. In addition, many agricultural scientists got multiple degrees from the same institution and are employed by the same institution after the completion of their formal education. Furthermore, a small number of universities dominate the education process. At the doctoral level, nearly three of every five agricultural scientists have been educated at one of the top dozen land-grant universities, the top three being the University of Wisconsin, Cornell University and Michigan State University. According to Busch and Lacy, the tendancy for scientists to be employed by their degree-granting institution and the dominance of a small number of institution in the educational process suggests a potential insularity of both agricultural education and agricultural research in the U.S.A. (31).

Clearly not all students with doctoral training are destined to become researchers - this is far from being the case. In trying to establish the determining criteria in the choice of this profession for the researchers in our population, we came to realise that the culmination of a course of tertiary education by a career in research seemed less determined by a rational *a priori* choice than by the vicissitudes of the selection procedure and the possibility of obtaining at an opportune moment a scholarship for overseas study. This factor seems to be so significant that several authors are prepared to affirm that "the fact that a scientist is involved in a particular scientific specialisation does not necessarily signify that this

interests him" (32). What does the choice of research subject involve? This is what we propose to look at now.

4. Criteria for research subject choice

The choice of research subject can be influenced by a series of factors, of which some are external to the science involved. In fact most often, as Busch and Lacy have shown, several factors intervene simultaneously in this choice: "decisions made by scientists regarding problem choice emerge from a complex process of negotiation within themselves and with other scientists, administrators and clients" (33).

In order to try and determine the relative importance of the different factors which may have played a part in the choice of research subject of researchers from LDC's, we have adapted the list of criteria established by Busch and Lacy and tested in different enquiries in the United States and Sudan (34) to the requirements of our study by eliminating a few factors and adding a few new ones. Taking as a base the means obtained from a system based on a scale of five numbers (going from 1 as 'primordial' to 5 'not important at all'), we have established a classification of the 20 criteria for choice offered to the researchers. Table 4 on the next page presents this classification.

The criterion at the head of the classification, 'importance to society', refers to that which was in second place for the choice of profession of researcher, that is to say 'social utility'. Here we find the researcher's need to justify his or her raison d'être with respect to society as a whole. When we interrogated researchers so as to know what this concept meant for them, we realised that apart from the aspect of social utility, that is to say very roughly the capacity for the research to resolve the economic and social problems which are mostly posed at the level of their country as a whole, this criterion is relatively close to other criteria on the list like 'likelihood of clear empirical results' and to a lesser extent 'potential marketability of the final product', which came respectively in 9th and 12th places.

Table 4: Criteria for research problem choice

Rank LDC	Criterion	Mean (*) Score	Rank USA
1	Importance to society	1.76	2
2	Potential creation of new methods, useful materials, and devices	1.88	5
3	Enjoy doing this kind of research	2.06	1
4	Scientific curiosity	2.23	4
5	IFS priority areas	2.28	-
6	Publication probability	2.34	6
7	Availability of research facilities	2.40	3
8	Potential contribution to scientific theory	2.45	12
9	Likelihood of clear empirical results	2.65	8
10	Access to external funding	2.67	(9)
11	Currently a 'hot topic'	2.71	15
12	Potential marketability of the final product	2.71	17
13	Priorities of the research organization	2.71	11
14	Length of time required to complete the project	2.82	16
15	Credibility of other investigators doing similar research	3.07	14
16	Access to funding from your institution	3.21	(9)
17	Feedback from extension personnel	3.30	20
18	Colleagues' approval	3.33	18
19	Subject of your thesis	3.49	-
20	Demands raised by clientele	3.59	13

(*) Mean score based on five point scale (1 = primordial , 5 = not important at all).
(9) Funding

The fact that those criteria that come in the first four positions relate to a fairly heterogeneous assortment of concepts is probably significant and tends to confirm the hypothesis that the choice of a research subject does not depend on one factor alone but is influenced by a series of factors.

Equally, it is interesting to note that the placement of the first six criteria on our list corresponds (although in a different order for the first three and excepting criterion 5 which is different on the two lists) to that established for the United States by Busch working from a sample of 1431 American researchers employed in the domain of agricultural science. If one widens the comparison to take in the list as a whole, it becomes clear that the two lists are, with a few exceptions, relatively similar. Thus it seems that the researchers from the LDC's in our population have more or less integrated the same reference system as concerns criteria of choice of research subject as American researchers who work in comparable

research domains.

It seems however that researchers in the LDC's attach a relatively greater importance to criteria such as 'potential creation of new methods' and 'potential contribution to scientific theory', which tend to characterise fundamental research, than do American researchers. On the other hand, the fact that the criterion 'demands made by clientele' carries up the rear of our list doubtless refers to the marginal position occupied by science in LDC's and serves to reinforce the theory according to which researchers and scientific institutions in LDC's are alienated from production activities or marginalised from them as a result of lack of demand ('demand-pull') of the economic system over the local sytem of knowledge production (35). In the same way, it is probably significant that the importance of 'the availability of research facilities' is under-estimated by researchers from LDC's; as this criterion comes in seventh position for the choice of research subject while it is considered by these same researchers as the second most important factor restraining the advance of research work. Perhaps there is an effect of masking reality at the time of the choice of a research subject so as to gloss over the objective impossiblity of carrying out a given piece of research, the danger being that one comes up against the impossibility at a later date. Nor is it irrelevant that 'IFS priority areas' comes fifth and 'access to funding from your institution' sixth. The proportion of external financial aid represents an ever larger percentage of research budgets in LDC's, and serves at the same time to influence the choice of research subject (36).

5. Research grants and problem choice

For the LDC's as a whole, it has been estimated (37) that external aid represents approximately 40% of the totality of R&D expenditure in the field of agricultural research. In certain African countries, this can reach 70% or more (Mali, Mozambique, Senegal, Lesotho, Swaziland and Zambia). Here again there is a wide range of set-ups, for in countries like Cameroun and Sudan external aid represents less than 15% of their national R&D budget. It is true that in some countries the number of donors involved in the financing of research is so great that it is practically impossible to determine the proportion that comprises the national contribution. This, in any case, is the conclusion of a recent ISNAR report on research into agronomy and zootechnology in Burkina Faso (38). The authors of this

report point out, among other things, that this small African country receives every year no fewer than 340 official visits from foreign governmental, multilateral or international agencies for aid in research as part of development.

The more the financial resources diversify, the more the number of interlocutors increases and the more time must be spent entertaining the representatives of the organisations concerned, showing them around the research centres, organising requests for research grants, planning the management of the funds obtained as a function of the specific criteria and exigencies of the different donors, drawing up interim or final reports on work done, participating in evaluation procedures ... etc. Let us see the reaction of young African researcher who had, despite himself, become an administrator of research projects: "I have had my new position for a year and a half now, and could now devote some part of my time to research if we weren't totally submerged by the donors' requirements. At the moment I have 13 research projects going which are financed by external aid. Keeping the donors satisfied what with their demands for reports, for meetings, and their consultants ... etc ... takes up most of my time".

Another, Asian, researcher who we asked to describe the impact of IFS funding on his researchers responded quite sincerely: "To the extent that I am simultaneously associated with a large number of research programmes financed by diverse institutions, it is difficult for me to distinguish the contribution of the IFS and to evalute its impact on the whole of my achievements".

This situation explains, at least in part, the importance that funding external to the researcher's institution takes on in the choice of research subject. As we can see from Table 5 on this page, over half (53%) of the researchers from LDC's consider as a result that access to an external source of funds is primordial or very important as a criterion in the choice of research subject. Conversely, only about one third (34%) think that access to funding from their own institution is primordial or very important in their choice of research subject.

Table 5: Research problem choice : relative importance of different sources of funding

External Funding / *Funding from the institution*	primordial or very important	moderately important	not important at all	**Total**
Primordial or very important	48 %	21 %	16 %	34 %
Moderately important	34 %	62 %	34 %	43%
Not important at all	18%	17%	50 %	23 %
Total	53%	32%	15%	100%

We should specify that we discovered that in any case the researcher's institution in the LDC's only provides on average a little more than a quarter (27%) of the funding available to each researcher, and we know also that more than one fifth of the researchers questioned receive no financial support at all from their institution. We can, then, picture the influence and the responsibility that other funding agencies, most often foreign, can have on the choice of research topics. The publicity devoted to those topics for which it is possible to obtain funding can have the harmful effect of mobilising researchers into working on topics that have a secondary priority. This is particularly so for countries which do not have a co-ordinated research policy at the national level, and which have a very limited research potential.

Thus research programmes in the LDC's are swept by fashions whose origin can in many cases be traced to priority themes proposed by certain foreign organisations offering aid for research. Researchers in the LDC's who have spent many years abroad play the rôle of priviliged conduits in the process of the transmission of the priority themes that are proposed, among others, by the different international organisations for aid for research. In effect, it appears that the longer a researcher has spent overseas, the more she or he well have close relations with international organisations for aid for research. Half of those who have never stayed

abroad never communicate with these organisations.

In any case, the great majority of the researchers in our population do not seem to have their subject uniquely determined by the availability of funding. Only 16% of them responded negatively to the question 'Would you have pursued your research if IFS funding had been unavailable?', whereas IFS funding represents on average more than half of their budgets.

Table 6: Would you have pursued your research if IFS funding had been unavailable?

Yes, other support would have been available	15%
Yes without other support	5%
Yes, but on a reduced scale	45%
Yes, but in a substantially different form	17%
No	16%
Other	2%

The vast majority of the researchers in our population, then, would have been able to continue their research work in one way or another even if IFS financial support had not been available. Among those who told us that they would not have been able to continue their research work without the support of the IFS figure primarily those for whom IFS funding represented a very high percentage of their budget. Thus for 13% of the researchers, the IFS grant corresponds to 90% or more of their research budget. At the other extreme, it is not surprising to learn that 5% of the researchers could have continued their research with no other support when one realises that for roughly 10% of the researchers in our population, IFS support respresents less than 10% of the budget at their disposition.

In fact, the answers to this question principally show that the researchers we questioned are, for the most part, ready to modify and to adapt their objectives and methodologies as a function of available funding, but that they are nonetheless determined to continue their research whatever funding they dispose of.

However, if one takes into account the level of financial resources available to agricultural research institutions in the Third World, coupled with the increased research personnel, it is quite obvious that it is becoming more and more crucial to obtain external funding. Although detailed information on this subject is very hard to come by, the data collected by ISNAR suggest firstly that many research systems present severe distortions in the resource mix (human and financial resources), secondly that the proportion allocated for operating costs is less than 20% and in some cases as little as 5 to 6% and, thirdly, that there is a high annual variability in research spending (39).

Similarly, agricultural researchers in the U.S.A. are largely dependant on research grants from a variety of sources for finance for their projects. Although it is difficult to establish a clear description of the relationship between grant receipt and problem choice, Busch and Lacy concluded from their investigation that in most cases: "(1) scientists choose potential granting organizations according to their interests and the probability of receipt of funds, and (2) those granting organizations have an influence on the scientists" (40). They did not, however, find the fact that scientists might use research grants to 'bootleg' their own interests to be a determining factor.

Interestingly, they also found that grant recipients from two major public agencies providing funding for basic research gave less weight to clients and to the priorities of their own organization, than do their colleagues who have not received such grants. On the other hand, recipients of grants from private corporations and commodity associations appear significantly more concerned with clients than their colleagues who have not received such grants.

In both situations (that is to say in the U.S.A. and in LDC's) there is an obvious risk that the possibility of getting grants is diverting some scientists away from their own institutions' priorities. However, the major difference is that, in addition to obvious disparities in working conditions and the levels of funding available, American scientists address themselves to nationally based research funding agencies in their own country, whereas scientists in LDC's mostly apply to national or international foreign aid organizations based outside their own countries. This is what makes Leite Lopez say that scientists in LDC's: "are encouraged to look abroad

when defining the content of their research programmes" (41).

6. Research Orientation

We saw above that of the criteria of research subject choice, those which were more or less directly linked to or seemed to represent fundamental research were in favour with the researchers. It is of course practically impossible to provide operational definitions that permit the tracing of strict, consensual boundaries between applied and fundamental research. In this regard, Pasteur was certainly right to insist on the fact that: "there is not one branch of science that one could rightfully call applied science: there is just science, and its applications are so closely connected that they are as a piece of fruit to the tree that bears it" (42). Further, what can be called fundamental in a certain context can be considered as applied in another. The few detractors of the IFS criticise its research programme either because they consider it to be too applied or because they consider it too fundamental and not sufficiently tied to development. This latter point of view is shared by some Dutch and Belgian adminstrators. Moreover Belgium, partly for this reason, decided to stop contributing to the financing of the activities of the IFS a few month before the King Baudouin Foundation decided to bestow on the IFS the King Baudouin prize ... for development!

Anyway, it is symptomatic that a non-negligeable number of researchers had difficulty in characterising the distribution of their time between fundamental and applied research. So as to evaluate the general orientation of their research and in order to facilitate their evaluation, we offered them the same definitions as those that Busch and Lacy suggested to their American researchers (43). Thus we asked the researchers to indicate the division of their time between teaching, fundamental research, applied research and development, taking the proposed definitions as a base. Further, in order to have some idea of their degree of job satisfaction, we also asked them what for them would the ideal division.

In order to permit a comparison with their colleagues who had not benefitted from IFS research grants, we asked them to indicate the distribution of time in their department or research team. It is clearly impossible to verify the results obtained, for they depend on the personal

judgment of each researcher we questioned.

The first result that springs from the reading of Table 7 on this page is that the IFS grantees seem to spend more time on research (about 60% on average) than the rest of their colleagues in their department or research team, and on the other hand spend less time teaching. They estimate, as an average, that they spend more time (38%) on applied research than on fundamental research (22%) or on development (12%).

Table 7: Time distribution between teaching, basic research, applied research and development (mean scores)

a) in your department or research unit:

Actual		Ideal
38	Teaching	29
17	Basic research	22
30	Applied Research	32
13	Development	17

b) in your IFS funded research programme

Actual		Ideal
25	Teaching	21
22	Basic Research	23
38	Applied Research	38
12	Development	17

Given the choice, they would like to reduce the time spent teaching and spend more time on fundamental research and above all on development. On the other hand they are satisfied with the time devoted to applied research.

So as to permit a comparison with the results obtained by Busch and Lacy for the United States (44), we have put the time devoted to teaching to one side, and recalculated the percentage of time devoted to research and to development on a base of 100. The comparison is again revelatory, as Table 8, which follows, indicates.

Table 8 : Time distribution between basic research, applied research and development (mean scores)

scientists in LDC's		*American scientists*
30	Basic Research	30
52	Applied Research	55
17	Development	13

Thus researchers in LDC's spend exactly the same percentage of their time doing fundamental research as American researchers working in comparable fields. The time that they devote to applied research is slightly less, and that given to development slightly more, but these differences are not very significant. We should point out anyway that we are dealing with an estimate made by the researchers of the allocation of time devoted to research, and that time spent on other activities like teaching or administration does not enter into this calculation. We will see below that as it turns out American researchers spend much more time on research than their colleagues in LDC's. Once again there seems to be an almost complete correspondence between the evaluation by researchers from LDC's and that made by American researchers. However, we should not lose sight of the specificity of the reference population used for the researchers from LDC's. To what degree does the fact that these latter are the outcome of an international selection procedure and that they hold a research grant from an international organization influence the above results? We are not able to answer this question, and only a comparison with researchers from LDC's who are not in this position would permit the formulation of a response.

Further, these are only mean results; they mask disciplinary differences. Those engaged in research in chemistry and microbiology told us that they devoted 50% or more of their time to fundamental research. Inversely, researchers in the fields of vegetable and animal products devote between 15% and 20% of their time to fundamental research. Similar percentages were obtained by Busch and Lacy for American researchers.

7. Scientific Communication

"When I cast my mind back to the period of my life when I worked at Lahore, I feel that I was terribly isolated. If someone had proposed to me: 'we will give you the chance to be attached to an active research centre in Europe or the United States for three months during your holidays so you can work with your peers, would you then be happy to stay in Lahore for the other 9 months?' I would have answered affirmatively. But no-one made the suggestion" (45). Although this confidence from Abdus Salam refers back to other days, it could still be said to apply to many of the researchers comprising our population.

This feeling of isolation is the lot of many researchers from LDC's, particularly at the moment when they try to integrate into their national scientific community on their return from training in a developed country. Moravcsik captures nicely the impossibility for many researchers from LDC's of communicating with their peers and colleagues through his comparison of researchers in LDC's to birds whose wings have been clipped, (46). This feeling of isolation is probably reinforced by the fact that their places of education are dispersed over a wide variety of universities in developed countries. What is more, the researchers often must, over the phase of the constitution of national scientific communities, resign themselves to being the only specialists in their field in their institution, or even in their whole country.

However, all authors concur that science is impossible without communication, and that criticism of scientific work by colleagues is a necessary condition for the proper running of a scientific enterprise. Here again, researchers in LDC's are at a great disadvantage with respect to their colleagues in developed countries.

Scientific relationships and communications can take different forms. Access to scientific journals, is the most formal written mode and is possibly the best known of all modes of scientific communication. Other, more informal but equally important, communication modes are based on personal relationships between scientists, and take forms as varied as the exchange of letters, telephone calls and conversations between colleagues, which can take place more or less frequently inside the institution's four walls, on the occasion of trips, during conferences and so on. These different communication forms are interdependant and complementary. In

any case, most authors agree that discussion between colleagues is one of the most important sources for the acquisition of information.

As it turns out, the researchers in our population told us that they communicated a little less than once a week with colleagues in their research group or department. This result is identical to that obtained by Busch and Lacy for American agricultural scientists (47). On the other hand, they communicated much less often with other scientists in this country than did the American researchers. Thus they only communicate a little more than once a year on average with scientists from other institutions in their country.

This result may in part be explained by the fact that researchers in LDC's are often the only specialists in their field for the whole country. This is not, however, always the case.

Table 9 : Frequency of communication of researchers in LDC's (in decreasing order of frequency)

Rank	Actors	Mean score (1)
1	Scientists in your department	5,40
2	Scientists in another department in your institution	3,93
3	Other scientists outside your institution within your country	3,27
4	Extension staff	2,89
5	Scientists outside your country	2,88
6	Representatives of IFS secretariat	2,72
7	Representatives from other funding agencies	1,96

(1) mean score based on five point scale (1 = never; 2 = rarely ; 3 = annually; 4 = monthly; 5 = once every 15 days; 6 = once every week , 7 = every day)

As we have gone from institution to institution in the course of our work in LDC's we have frequently come across researchers in one country, or even within a single institution, who could have usefully worked together, but who did not even know each other. In fact, they scarcely

communicate more frequently with scientists from other institutions in their own country than with scientists from outside their own country. Thus 35% of them only communicate once a year with scientists from their own country working outside their own institution and 42% of them communicate once a year with researchers abroad. The frequency of communication with researchers abroad is obviously dependant on whether or not they have spent time overseas in the course of their education. This is confirmed by Table 10 on this page.

Thus we were able to establish that researchers who have spent time overseas communicate more frequently with foreign researchers working in the same research area than do the others. Almost twice as many of them communicate once a month with foreign researchers than those who have carried out their studies in their own countries. Inversely, five times more researchers who have never spent any time abroad have never communicated with foreign researchers than those who have.

Table 10 : Relative frequency of communication with foreign scientists of scientists from LDC's who have received their education abroad and those who have received it at home.

Frequency of communcation	Scientists who have been trained at home	Scientists who have been trained abroad	Total
Once every month	12%	20%	19%
Once every year	39%	46%	44%
rarely	33%	30%	31%
never	16%	3%	5%

Similarly, we were able to establish that researchers who have carried out all their research in their own countries are relatively more likely to work alone in doing their research. A little less than a quarter of the researchers in our population work alone, while more than a third of those who have never spent any time abroad do.

Equally, researchers who have carried out all their research in their own countries are less likely to maintain a scientific correspondence with

foreign researchers outside of international scientific meetings, although they make up almost three quarters of the population (74%) to do so.

The participation of researchers in national or international conferences is, equally, a priviliged period for meeting their colleagues, exchange information and discussing the progress of their work. From our own experience we know that researchers from LDC's are very frequently under-represented in international conferences and that they find it difficult to get a hearing there when they are present. The first result is that they have participated in twice as many conferences in their own countries than abroad. The mean participation by researcher and by year is 0.84 conferences in the researcher's own country and 0.43 conferences abroad. Equally, we could point out that a small number of researchers participate in a large number of conferences abroad.

Thus around 10% of the researchers participated in about half the conferences abroad, each one totalling on average 10 conferences abroad over a period going from 6 to 10 years, that is to say roughly two conferences per year, which is about four times the average. The champion in this domain participated in 15 conferences abroad over a three year period. Those who have participated in more than 10 conferences have all, with one exception, received IFS grants for at least 9 years. They are also the most productive researchers in terms of the number of publications; since they have published between 5 and 10 publications per year as sole author since they became IFS scholars.

At the other end of the spectrum it can be seen that there are researchers who are neither very 'mobile' nor very 'visible', since one third of them (34%) have never participated in any overseas conference at all, and almost one quarter (23%) in only one.

It should be noted that the researchers in our population produce 0.45 publications per researcher per year as sole author and 0.64 publications per researcher per year as co-author - that is to say about two times less than American researchers, to make the comparison with the results obtained by Busch and Lacy (0.9 publications per researcher per year as sole author and 1.3 publications per researcher per year as co-author).

8. Institutional contexts

Time devoted to teaching and to research depends on the nature of the institution that houses the researcher. Obviously the researchers with the heaviest teaching loads are to be found in the universities. Let us see how this works out for researchers in LDC's.

The first conclusion that can be drawn from a reading of Table 11 on this page is that more than half the researchers (55%) devote from 20% to 60% of their time to teaching activities, which is a very heavy load.

At the university, around half the researchers spend more than 40% of their time teaching. The time devoted to teaching seems to be relatively less important in the agricultural universities than in other universities. It is even the case that a proportion of the researchers in research institutes spend a non-negligeable part of their time in teaching activities, although 30% of them do not teach at all. Finally, it is important to note that there is no watertight barrier between the university and the research centres, since more than 40% of the researchers in research centres devote between 1% and 20% of their time to teaching.

Table 11: Percentage of time spent in teaching according to the host institution in LDC.

% teaching time	University	Agricultural University	Research Institute within a university	National Research Institute	Total
0	4	2%	30%	53%	17%
1-20	11%	15%	36%	42%	20%
21-40	36%	50%	27%	4%	30%
41-60	37%	28%	6%	1%	25%
61-80	10%	6%	–	1%	7%
81-100	1%	–	–	–	0,5%

The percentage of time spent teaching obviously also depends on the researcher's function within his or her host institution. This explains in large part the fact that only a little more than 4% of scientists working in

universities do not teach at all. These are, for the most part, scientists who hold posts higher up in the hierarchy, involving administrative duties that leave little or no time for teaching and research.

Inversely, and logically, it is within the research institutions that most time is devoted to research.

Table 12 : Percentage of time spent in research at universities and research institutes in LDC's

	0-30%	31-60%	61-99%
Universities	43%	51%	6%
Research Inst.	17%	40%	42%

Thus although 42% of the researchers in research institutes spend more than 60% of their time in research, only 6% of researchers in universiities do the same. Taking the mean percentages, it becomes apparent that the researchers in the institutes spend on average almost twice as much time doing research as those in the universities.

Table 13 : Repartition of time between different activities at universities and research institutes in LDC's

	% of time	
	University	Research Inst.
Research	34	66
Teaching	37	5
Administration	18	
Development	11	

If we now compare our results with those obtained by Busch and Lacy for the United States, we see that American university researchers spend on average less time teaching (27% as against 37%) than their colleagues in the Third World, and, above all, more time doing research (57% as against 34%) (48). The differences are much less significant for researchers working in research institutes, although Amercian researchers again spend more time (77%) doing research in these institutions than do their Third World colleagues (66%).

As for the research budgets the researchers control, Busch and Lacy found the differences between the two types of institution highly significant, since researchers in government research institutes have an average annual budget of $209,000, whereas their university colleagues only dispose of some $68,000 (49). Researchers in LDC's, for their own part, only dispose of $5,600 before their IFS research allocation, and around $14,000 annual budget on average after the granting of this research award. Even if we are dealing with estimates given by the researchers themselves, who very often do not know the precise total of the budget they dispose of, the differences observed are such that they require no further comment.

Conclusion

The significant disparities that we found between American researchers and those from LCD's with respect to, amongst other things, educational level, available resources, time spent doing research and the productivity of researchers bring out the fact that researchers from LCD's are at a significant disadvantage with respect to their American colleagues. This is, clearly, not particularly surprising. The results of our enquiry have the advantage, however, of giving some precise figures on the reality of the occupation of researcher in an LDC, as well as on the working conditions and the practice of research in general in LDC's.

Going beyond indicators respecting available resources and the productivity of the respective research systems, the comparison also brings out the fact that researchers in LDC's seem to be located in the middle of a permanent battle between a will to participate in the resolution of local problems and the attraction of models and reference systems supplied by the international scientific community, to which they would also very much like to belong.

Making the comparison between the U.S.A. and the LDC's, we had no intention of masking the very marked differences that exist between the different LDC's, even when they belong to a single region and seem to present very similar characteristics. So numerous are the disparities, that it would in fact be vain to seek to reduce all LDC's to a coherent and united group.

What, then, can we conclude from such a comparison? That the LDC's haven't got the means to support a research effort and that research is thus a luxury that only the richest western countries can afford? We think that this would be a bad decision and that each country must consider the formation of an endogenous scientific community as a priority objective, while taking into account the fact that the development of science is a long term enterprise which cannot be realised without real international cooperation. This does not mean to say that western science should be considered as the only valid model. On the contrary, each country must invent and adapt its own system for research and for research training as a function of its own social and economic conditions and of the development strategy that it has chosen.

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