

## **The state of science in Africa: a survey. Methods and indicators**

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The following papers are based on a survey recently carried out in Africa. It was commissioned by the European Commission (DG XII: Science) and by the French Ministry of Foreign Affairs. At a time when the doctrines of scientific co-operation are undergoing brisk change in the world, both parties felt that it would be useful to have an assessment of the state of science in developing countries, and of Africa in particular, where it a number of figures and institutions that were previously well established partners were no longer able or willing to respond to calls to tender.

The IRD<sup>1</sup> team *Science, Technology and Development* designed the study. A consortium of 20 researchers, mostly from the countries concerned, was set up to carry out the investigations (co-ordinators: R. Waast & J. Gaillard). The study was carried out during the period of 1999-2001. Four tools were utilised:

- A *Bibliometric* survey over time [1989-1999, of all African countries. Two databases: ISI and PASCAL];
- A *Questionnaire* addressed to 1700 senior researchers through the whole of the Continent (recipients of scientific co-operation contracts from the INCO-DC programme of the European Commission; and from the IFS grants programmes<sup>2</sup>). This questionnaire focused on professional life, research funding, and their evolution.
- An *Enquiry* about the local research institutions: their history, their present state, and their on-going or contemplated reforms (Field study, 15 countries)
- An *Enquiry* using interviews of researchers and research heads (Field study, 15 countries). This enquiry focused on the life and working conditions, and the tensions and initiatives generated by their change.

**15 countries** were examined in detail. These were South Africa; in North Africa: Egypt, Tunisia, Algeria, Morocco; in French-speaking Africa : Senegal, Burkina, Côte d'Ivoire, Cameroon, Madagascar; in English-speaking Africa : Nigeria, Kenya, Tanzania, Zimbabwe; and in Portuguese-speaking Africa : Mozambique.

**Current progress:** The raw material has been collected: 700 questionnaires bearing full information were analysed; 500 interviews have been gathered, 250 of which have been transcribed; a significant amount of documentation on institutions has been accumulated at IRD.

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<sup>1</sup> IRD: Institut de Recherches pour le Développement, a French Government owned Institute for Development Studies. With about 1 000 researchers scattered through the Developing World, it specialises in Agriculture Sciences, Marine Sciences, Life Sciences and Social Sciences. It is divided into Research Units, one of which deals with *Knowledge and Development*. The Science and Technology team belongs to this Unit.

<sup>2</sup> INCO-DC: International Co-operation with Developing Countries, a Programme of the European Commission (DG XII: Science). IFS: International Foundation for Science, a Stockholm based institution carved to help young scientists from developing countries to carry on research in their home countries (special interest: Agriculture Sciences).

**Sixteen reports are available<sup>3</sup>:**

**Four general reports: The Synthesis; The Bibliometrical results; The Questionnaire results; and a special report on the International Cooperations.**

**Twelve country reports: South Africa (Vol. 1 & 2); Tanzania, Nigeria, Cameroon, Ivory Coast, Burkina, Mozambique, Madagascar; Morocco, Algeria, Egypt.**

**Several papers, a special issue of the *Science, Technology and Society* Journal, and two books are in print or in the making.**

**The following slides capture the main characteristics of the study. Some figures and tables from the study follow to give the reader an idea of the size of the scientific communities, and the proportions and trends of the scientific output throughout Africa.**

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(Slides prepared by Dr Jacques Gaillard)

## Science in Africa at the Dawn of the 21st Century



Roland Waast and Jacques Gaillard  
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in collaboration with

Rigas Arvanitis, Fatiha Barouni, Zahira Belhocine, Nelius  
Boschoff, Robert Cabanes, Hocine Khelifaoui, Mina Kleiche,  
Yann Lebeau, Omar Massoud, Johann Mouton, Nora  
Narvaez, Ifeanyi Onyeonoru, Saadia Radi, Erver Ravat, N.  
Ravjee, Jane Russell and Zeyneb Samandi

### Context



- Weak home-based scientific potential in 1960
- 1970-1980
  - intensive development of institutions
  - student population explosion
  - steady growth in the number of scientists

This development was underpinned by "aid"  
and the set-up of national research systems.
- Regarded in terms of comparable investments,  
scientific results have been modest though visible.

### Funding sources



- DG RTD (ex. DG XII), European Commission  
(Grant No. IC 18CT989164)  
635 KF (approx. 96,800 EUROS)
- Ministry of Foreign Affairs - France  
(Grant No. 9801 14 9800)  
400 KF (approx. 60,980 EUROS)
- Institut de Recherche pour le Développement (IRD)  
Mainly salaries for IRD staff members
- International Foundation for Science (IFS)  
Support staff mainly for questionnaire survey

### Context (end)



Mid 80s beginning 90s: the crisis.

African science is part of the ongoing globalisation  
and privatisation.

What is the state of science in Africa ?  
What are the modalities of its scientific production ?  
What is its "reproduction" capacity ?  
How to free from dependency ?

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<sup>3</sup> Ask: [waast@bondy.ird.fr](mailto:waast@bondy.ird.fr). Other country reports should be released later (Zimbabwe, Kenya, Senegal, Tunisia) as well as 2 volumes of interviews.

## Methodological approaches



- ♦ Bibliometric studies (ISI & PASCAL)
- ♦ Country case studies
- ♦ Interviews
- ♦ Questionnaire survey

## Country case studies



- ♦ North Africa: Algeria, Egypt, Morocco and Tunisia
- ♦ West Africa: Burkina Faso, Côte d'Ivoire, Cameroon, Nigeria and Senegal
- ♦ Southern Africa: South Africa and Zimbabwe
- ♦ East Africa: Tanzania, Mozambique and Madagascar

## Interviews



|                   |              |
|-------------------|--------------|
| South Africa: 120 | Morocco: 40  |
| Algeria: 30       | Nigeria: 45  |
| Burkina Faso: 21  | Senegal: 36  |
| Cameroon: 48      | Tanzania: 32 |
| Côte d'Ivoire: 25 | Tunisia: 16  |
| Egypt: 30         | Zimbabwe: 25 |
| Madagascar: 30    | Others: 30   |

In total some 500 interviews carried out of which some 200 were transcribed.

## Questionnaire survey



- ♦ 1677 questionnaires sent out (one reminder) during 2000 to IFS grantees and INCO beneficiaries
- ♦ 702 returned (41.8%)

## Outputs



- ♦ Series of reports (Synthesis, Country Case Studies, Questionnaire Survey) for MAE and DG RTD - EC
- ♦ Special issue in *Science, Technology & Society*  
Articles in Scientific Journals  
Book(s) in preparation
- ♦ Archiving of Interviews
- ♦ Science In Africa Symposium

## APPENDIX

### 15 African countries. Scientific Indicators

| Indicators          | No.                      | No.                                 | No.                                  | No.                              | No.                              | Research<br>ers       | No.                                | No. of<br>Articles<br>per<br>year | No.<br>Articles<br>/<br>10 <sup>6</sup><br>inhabita<br>nts | No.<br>Articles<br>/<br>10 <sup>9</sup> \$<br>GNP |
|---------------------|--------------------------|-------------------------------------|--------------------------------------|----------------------------------|----------------------------------|-----------------------|------------------------------------|-----------------------------------|--|---|
| Countries           | Staff,<br>Higher<br>Educ | Research<br>ers<br>public<br>sector | Research<br>ers<br>Private<br>sector | FTE<br>Research<br>ers<br>theor* | FTE<br>Research<br>ers<br>prob** | /M<br>inhabita<br>nts | Scientifi<br>c<br>Articles<br>1998 | per<br>research<br>er             |  |   |
| Algeria             | 16<br>000                | 1 200                               | 700                                  | 5 000                            | 3 000                            | 100                   | 241                                | 1/12                              | 8  | 5,5   |
| Tunisia             | 9 000                    | 800                                 | 400                                  | 3 000                            | 3 000                            | 350                   | 491                                | 1/6                               | 55   | 26  |
| Morocco             | 10<br>000                | 700                                 | 500                                  | 3 200                            | 3 200                            | 120                   | 510                                | 1/6                               | 20   | 14,5  |
| Egypt               | 40<br>000                | 1500                                | ?                                    | 15 000                           | 10 000                           | 230                   | 1 313                              | 1/8                               | 20   | 17  |
| Madagasca<br>r      | 900                      | 260                                 |                                      | 500                              | 300                              | 35                    | 50                                 | 1/6                               | 3  | 13,5  |
| Senegal             | 1 000                    | 435                                 |                                      | 700                              | 600                              | 80                    | 106                                | 1/6                               | 12   | 21  |
| Burkina-<br>Faso    | 700                      | 200                                 |                                      | 350                              | 350                              | 30                    | 72                                 | 1/5                               | 7  | 26  |
| Côte<br>d'Ivoire    | 1 200                    | 500                                 |                                      | 800                              | 600                              | 55                    | 87                                 | 1/7                               | 6  | 8   |
| Cameroon            | 1 800                    | 300                                 |                                      | 800                              | 800                              | 60                    | 167                                | 1/5                               | 12   | 18  |
| Nigeria             | 14<br>000                | 1 300                               | ?                                    | 5 000                            | 3 000                            | 40                    | 450                                | 1/7                               | 4  | 14,5  |
| Kenya               | 1 800                    | 600                                 | ?                                    | 1 000                            | 1 000                            | 35                    | 506                                | 1/2                               | 17   | 53  |
| Tanzania            | 1 400                    | ??                                  |                                      | 800                              | 600                              | 70                    | 196                                | 1/3                               | 6  | 30  |
| Zimbabwe            | 1 100<br>+priv<br>é      | 300                                 | ?                                    | 600                              | 600                              | 30                    | 176                                | 1/4                               | 16   | 21  |
| Mozambiq<br>ue      | 600                      |                                     |                                      |                                  |                                  |                       |                                    |                                   |  |   |
| Rep South<br>Africa | 17<br>000                | 8 500<br>*                          | 5 000                                | 13000<br>*                       | 13000<br>*                       | 350                   | 2 738                              | 1/3                               | 72   | 21  |

\* FTE = Full Time Equivalent; théor = theoretical; prob = probable (after survey).

Sources: Indicators = Educ & Research: Our survey;

No. Scientific Articles: SCI (North Af, South Af, East Af); Pascal (West Af)

**15 African countries: Social Indicators**

| Indicators                  | Life      | Alphab Adults | % scol. 2 <sup>nd</sup> lev | % scol. all levels | Public Expendi t. Educati on | Public Expendi t. Health | No. of Student s | Student s/M inhab |
|-----------------------------|-----------|---------------|-----------------------------|--------------------|------------------------------|--------------------------|------------------|-------------------|
| Country                     | No. years | %             | %                           | Levels             | (% GNP)                      | (%GNP)                   |                  |                   |
| Algeria                     | 68,9      | 60,3          | 68,5                        | 68                 | 5,20%                        | ?                        | 430 000          | 20 000            |
| Tunisia                     | 69,5      | 67            | 74,3                        | 70                 | 6,70%                        | 1 à 2%                   | 180 000          | 20 000            |
| Morocco                     | 66,6      | 45,9          | 37,7                        | 49                 | 5,30%                        | ?                        | 290 000          | 10 500            |
| Egypt                       | 66,3      | 52,7          | 75,1                        | 72                 | ?                            | 1,70%                    | 1 200 000        | 18 000            |
| Madagascar                  | 57,5      | 47            | ?                           | 39                 | 1,90%                        | 1,10%                    | 36 000           | 2 500             |
| Senegal                     | 52,3      | 34,6          | 19,8                        | 35                 | 3,50%                        | 1,20%                    | 23 000           | 2 550             |
| Burkina-Faso                | 44,4      | 20,7          | 12,8                        | 20                 | 3,60%                        | 4,70%                    | 8 000            | 750               |
| Côte d'Ivoire               | 46,7      | 42,6          | 34,1                        | 40                 | 5,00%                        | 1,40%                    | 105 000          | 7 000             |
| Cameroon                    | 54,7      | 71,7          | 39,8                        | 43                 | 2,90%                        | 1,00%                    | 72 000           | 5 100             |
| Nigeria                     | 50,1      | 59,5          | ?                           | 54                 | 0,90%                        | 0,30%                    | 300 000          | 2 500             |
| Kenya                       | 52        | 79,3          | 61,1                        | 50                 | 6,60%                        | ?                        | 45 000           | 1 500             |
| Tanzania                    | 47,9      | 71,6          | ?                           | 33                 | ?                            | 2,50%                    | 30 000           | 950               |
| Zimbabwe                    | 44,1      | 90,9          | 59,2                        | 68                 | ?                            | 1,70%                    | 14 000           | 1250              |
| Mozambique                  | 45,2      | 40,5          | 7,9                         | 25                 | ?                            | ?                        | 12 000           | 700               |
| Republic of South Africa    | 54,7      | 84            | 94,9                        | 93                 | 7,90%                        | ?                        | 600 000          | 16 000            |
| Africa: South of the Sahara |           |               |                             | 41,4               |                              |                          |                  |                   |

**Sources: Social Indicators = World Bank, World Development Report, 2000; No. of Students: Our Survey.**

**15 African countries. Economic Indicators**

| <b>Indicators</b>    | <b>Pop. Million</b><br><b>Inhabitants</b> | <b>Inhabitants / km<sup>2</sup></b> | <b>% rural population</b> | <b>Population 75-97 Mean / year</b> | <b>GNP 10<sup>9</sup> \$ 99</b> | <b>GNP / head \$ 99</b> | <b>GNP/head 75-97 ppp Mean./ year</b> | <b>Inflation 85/96 Mean / year</b> |
|----------------------|---|-------------------------------------|---------------------------|-------------------------------------|---------------------------------|-------------------------|---------------------------------------|------------------------------------|
| <b>Algeria</b>       | <b>29</b>                                 | <b>12</b>                           | <b>43</b>                 | <b>2,8 %</b>                        | <b>43,5</b>                     | <b>1 500</b>            | <b>0</b>                              | <b>21 %</b>                        |
| <b>Tunisia</b>       | <b>9</b>                                  | <b>58</b>                           | <b>36,6</b>               | <b>2,2 %</b>                        | <b>18,8</b>                     | <b>2 090</b>            | <b>2,5 %</b>                          | <b>5,6 %</b>                       |
| <b>Morocco</b>       | <b>28</b>                                 | <b>59</b>                           | <b>46,7</b>               | <b>2 %</b>                          | <b>35</b>                       | <b>1 250</b>            | <b>1,7 %</b>                          | <b>4,9 %</b>                       |
| <b>Egypt</b>         | <b>66</b>                                 | <b>58</b>                           | <b>54,9</b>               | <b>2,3 %</b>                        | <b>78</b>                       | <b>1 180</b>            | <b>3,6 %</b>                          | <b>14,8 %</b>                      |
| <b>Madagascar</b>    | <b>14,6</b>                               | <b>23</b>                           | <b>72,4</b>               | <b>2,9 %</b>                        | <b>3,7</b>                      | <b>250</b>              | <b>-2 %</b>                           | <b>20,1 %</b>                      |
| <b>Senegal</b>       | <b>9</b>                                  | <b>43</b>                           | <b>55</b>                 | <b>2,8 %</b>                        | <b>5</b>                        | <b>550</b>              | <b>-0,3 %</b>                         | <b>4,4 %</b>                       |
| <b>Burkina-Faso</b>  | <b>11</b>                                 | <b>38</b>                           | <b>83,1</b>               | <b>2,7 %</b>                        | <b>2,7</b>                      | <b>240</b>              | <b>1,2 %</b>                          | <b>3,3 %</b>                       |
| <b>Côte d'Ivoire</b> | <b>15</b>                                 | <b>44</b>                           | <b>55,3</b>               | <b>3,4 %</b>                        | <b>10,5</b>                     | <b>690</b>              | <b>-1,2 %</b>                         | <b>3,2 %</b>                       |
| <b>Cameroon</b>      | <b>14</b>                                 | <b>29</b>                           | <b>53,6</b>               | <b>2,8 %</b>                        | <b>9</b>                        | <b>650</b>              | <b>0,1 %</b>                          | <b>3,1 %</b>                       |
| <b>Nigeria</b>       | <b>118</b>                                | <b>122</b>                          | <b>58,7</b>               | <b>2,8 %</b>                        | <b>30,7</b>                     | <b>260</b>              | <b>-0,5 %</b>                         | <b>34,1 %</b>                      |
| <b>Kenya</b>         | <b>29</b>                                 | <b>47</b>                           | <b>69,6</b>               | <b>3,4 %</b>                        | <b>9,6</b>                      | <b>330</b>              | <b>0,5 %</b>                          | <b>12,2 %</b>                      |
| <b>Tanzania</b>      | <b>31</b>                                 | <b>34</b>                           | <b>74,3</b>               | <b>3,1 %</b>                        | <b>6,5</b>                      | <b>210</b>              | <b>?</b>                              | <b>?</b>                           |
| <b>Zimbabwe</b>      | <b>11</b>                                 | <b>28</b>                           | <b>66,8</b>               | <b>2,8 %</b>                        | <b>8,3</b>                      | <b>750</b>              | <b>0</b>                              | <b>18,7 %</b>                      |
| <b>Mozambique</b>    | <b>17</b>                                 | <b>21</b>                           | <b>63,5</b>               | <b>2,6 %</b>                        | <b>1,7</b>                      | <b>90</b>               | <b>1,1 %</b>                          | <b>50,9 %</b>                      |
| <b>Rep South Af</b>  | <b>38</b>                                 | <b>30</b>                           | <b>50,3</b>               | <b>2,1 %</b>                        | <b>129</b>                      | <b>3400</b>             | <b>-0,6 %</b>                         | <b>12,8 %</b>                      |

**Sources : Economic Indicators = World Bank, World Development Report, 2000.**

**TABLE 2b. Production of scientific articles by African countries**

| Country       | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | Total | Rank 1991 | Rank 1997 | Trend | Articles / 91/97 Pop* |
|---------------|------|------|------|------|------|------|------|-------|-----------|-----------|-------|-----------------------|
| South Africa* | 2629 | 2379 | 2692 | 2724 | 2906 | 2738 | 2716 | 18784 | 1         | 1         | =     | 35                    |
| Egypt         | 1434 | 1352 | 1292 | 1202 | 1116 | 1284 | 1190 | 8870  | 2         | 2         | ↓     | 20                    |
| Morocco       | 242  | 293  | 329  | 326  | 384  | 510  | 595  | 2679  | 5         | 3         | ↑↑    | 18                    |
| Kenya*        | 436  | 505  | 557  | 521  | 531  | 535  | 536  | 3621  | 6         | 6         | =     | 10                    |
| Tunisia       | 296  | 334  | 415  | 461  | 359  | 451  | 454  | 2770  | 4         | 4         | ↑     | 50                    |
| Nigeria       | 854  | 756  | 561  | 448  | 442  | 452  | 422  | 3935  | 3         | 5         | ↓↓    | 4                     |
| Tanzania*     | 102  | 124  | 141  | 146  | 171  | 169  | 186  | 1039  | 12        | 11        | ↑     | 5                     |
| Algeria       | 147  | 161  | 187  | 181  | 147  | 193  | 170  | 1186  | 7         | 7         | =     | 6                     |
| Ivory Coast   | 119  | 111  | 115  | 101  | 78   | 87   | 149  | 760   | 8         | 8         | ↓     | 10                    |
| Cameroon      | 117  | 118  | 148  | 131  | 116  | 127  | 135  | 892   | 10        | 9         | =     | 10                    |
| Senegal       | 82   | 89   | 87   | 97   | 84   | 124  | 135  | 698   | 13        | 9         | ↑     | 16                    |
| Zimbabwe      | 119  | 132  | 100  | 103  | 84   | 107  | 112  | 757   | 8         | 12        | =     | 10                    |
| Ethiopia      | 91   | 74   | 91   | 66   | 89   | 112  | 94   | 617   | 11        | 13        | =     | 2                     |
| Burkina Faso  | 21   | 45   | 37   | 40   | 31   | 55   | 82   | 311   | 26        | 14        | ↑     | 8                     |
| Ghana         | 49   | 65   | 48   | 63   | 79   | 75   | 81   | 460   | 17        | 15        | ↑     | 5                     |
| Uganda        | 13   | 24   | 32   | 31   | 30   | 67   | 59   | 256   | 33        | 16        | ↑     | 3                     |
| Malawi        | 17   | 13   | 24   | 28   | 25   | 42   | 56   | 205   | 29        | 17        | ↑     | 6                     |
| Sudan         | 64   | 73   | 60   | 41   | 46   | 68   | 55   | 407   | 14        | 18        | ↓     | 2                     |
| Gabon         | 50   | 38   | 26   | 18   | 24   | 25   | 50   | 231   | 16        | 19        | ↓     | 45                    |
| Zambia        | 24   | 35   | 21   | 17   | 32   | 26   | 45   | 200   | 25        | 20        |       | 5                     |
| Benin         | 42   | 32   | 38   | 26   | 25   | 42   | 45   | 250   | 19        | 20        |       | 8                     |
| Mali          | 30   | 33   | 35   | 50   | 26   | 30   | 42   | 246   | 21        | 22        |       | 4                     |
| Togo          | 19   | 20   | 21   | 34   | 31   | 27   | 42   | 194   | 27        | 22        |       | 10                    |
| Gambia        | 29   | 24   | 30   | 23   | 26   | 34   | 40   | 206   | 22        | 24        |       | 45                    |
| Congo         | 51   | 49   | 58   | 30   | 29   | 33   | 36   | 286   | 15        | 25        | ↓     | 14                    |
| Madagascar    | 19   | 19   | 34   | 58   | 69   | 60   | 35   | 294   | 27        | 26        |       | 3                     |
| Niger         | 27   | 28   | 28   | 30   | 32   | 18   | 30   | 193   | 23        | 27        |       | 3                     |
| Botswana      | 26   | 13   | 26   | 15   | 15   | 19   | 24   | 138   | 24        | 28        |       | 16                    |
| Zaire         | 48   | 37   | 49   | 29   | 30   | 28   | 23   | 244   | 18        | 29        | ↓     | 1                     |
| Burundi       | 14   | 12   | 10   | 12   | 6    | 15   | 20   | 89    | 30        | 30        |       | 3                     |
| Libya         | 39   | 33   | 26   | 21   | 14   | 10   | 14   | 157   | 20        | 31        |       | 3                     |
| Mauritania    | 3    | 7    | 1    | 9    | 4    | 12   | 12   | 48    | 40        | 32        |       | 5                     |
| Guinea        |      | 7    | 3    | 3    | 6    | 9    | 12   | 40    | -         | 32        |       | 2                     |

|                      |             |             |             |             |             |             |             |             |      |      |   |   |
|----------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------|------|---|---|
| Mozambique           | 6           | 8           | 22          | 6           | 16          | 15          | 11          | 84          | 37   | 34   | ↑ | 1 |
| Rwanda               | 14          | 14          | 15          | 7           | 11          | 11          | 11          | 83          | 30   | 34   |   | 2 |
| Rep.Centre<br>Afric. | 14          | 14          | 3           | 8           | 7           | 6           | 9           | 61          | 30   | 36   |   | 3 |
| Guinea<br>Bissau     |             |             | 3           |             | 2           | 5           | 9           | 19          | -    | 36   |   | 8 |
| Namibia              | 9           | 13          | 5           | 10          | 11          | 7           | 7           | 62          | 35   | 38   |   | 4 |
| Mauritius            | 9           | 4           | 4           | 11          | 6           | 10          | 8           | 52          | 35   | 38   |   | 7 |
| Chad                 | 1           | 3           | 5           | 4           | 6           | 9           | 7           | 35          | 42   | 40   |   | 1 |
| Sierra Leone         | 11          | 13          | 9           | 5           | 6           | 15          | 4           | 63          | 34   | 41   |   | 1 |
| Angola               | 2           |             | 2           | 3           | 5           | 2           | 2           | 16          | 41   | 42   |   | 0 |
| Swaziland            |             | 1           | 8           | 4           | 3           | 2           | 1           | 19          | -    | 43   |   | 1 |
| Lesotho              | 5           | 3           | 8           | 4           |             | 3           | 1           | 24          | 38   | 43   |   | 1 |
| Others               | 13          | 3           | 4           | 8           | 6           | 5           | 1           | 40          | ≥ 42 | ≥ 42 |   | 2 |
| <b>Total</b>         | <b>7337</b> | <b>7111</b> | <b>7410</b> | <b>7155</b> | <b>7175</b> | <b>7772</b> | <b>7787</b> | <b>5174</b> |      |      |   |   |

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Source: PASCAL Data base, except for \*: in their case, ISI Database (bias in their favour).

**Table 4a. Geo-linguistic zones: Performance, evolution  
Production of Articles, and % of the African production (1991-1997)  
Source: Databases PASCAL (or ISI if \*)**

|                       | Population<br>(Million<br>Inh.) | %<br>Population<br>of Africa | % total<br>Articles<br>(1997) | Articles<br>1997 /<br>1991 | Trend of<br>the<br>scientific<br>production |
|-----------------------|---------------------------------|------------------------------|-------------------------------|----------------------------|---|
| Northern Africa       | 130                             | 16 %                         | 36 %<br>(*ISI: 31<br>%)       | + 20 %                     | Egypt<br>Maghreb                            |
| Rep South Africa      | 45                              | 6%                           | 29 %<br>(*ISI: 33<br>%)       | + 2 %                      |   |
| Anglophone Zone*      | 420                             | 53 %                         | 22 %<br>(*ISI: 26<br>%)       | + 7 %                      | or  |
| Francophone<br>Zone** | 175                             | 22 %                         | 12 %<br>(*ISI: 9<br>%)        | + 30 %                     | or  |
| Rest of Africa        | 30                              | 3 %                          | 1 %                           |                            |   |
| <b>TOTAL</b>          | <b>800</b>                      |                              | <b>100 %</b>                  | <b>+ 6,5 %</b>             |   |

Number of Articles: Source: PASCAL (R. Arvanitis) & SCI (L. Rossi)

\* Anglophone Zone = except the Republic of South Africa;

\*\* Francophone Zone = except the Maghreb

**Table 4. Geo-linguistic zones: Preferred fields**

| Zone<br>Field | / | Anglopho<br>ne (except<br>Rep SA) | Francopho<br>ne (except<br>Maghreb) | North<br>Africa | Republic<br>of South<br>Africa | Mean,<br>Africa | Mean,<br>World |
|---------------|---|-----------------------------------|-------------------------------------|-----------------|--------------------------------|-----------------|----------------|
|---------------|---|-----------------------------------|-------------------------------------|-----------------|--------------------------------|-----------------|----------------|



|                       |             |             |             |             |             |             |
|-----------------------|-------------|-------------|-------------|-------------|-------------|-------------|
| <b>Agriculture</b>    | <b>22 %</b> | <b>16 %</b> | <b>8 %</b>  | <b>10 %</b> | <b>13 %</b> | <b>7 %</b>  |
| <b>Health</b>         | <b>46 %</b> | <b>63 %</b> | <b>28 %</b> | <b>35 %</b> | <b>39 %</b> | <b>44 %</b> |
| <b>Other sciences</b> | <b>32 %</b> | <b>21 %</b> | <b>64 %</b> | <b>55 %</b> | <b>48 %</b> | <b>49 %</b> |

**ISO Code of Countries mentioned.**

The ISO Code is familiar to all librarians. It is an international norm to point to countries. We use it often in the following tables. In the next table, the names in bold letters point to the 12 most important producers of science on the Continent. Ethiopia, Ghana and Sudan are their immediate followers. The names in italics point to smaller scientific countries, which were nonetheless included in our detailed study for various reasons (quick growth of the scientific production, quick decline, or target for interesting scientific co-operations).

| Country                     | Code ISO   | Our Enquiries | Ranking<br>(scientific<br>production, 1998) |
|-----------------------------|------------|---------------|---|
| <b>Rep. of South Africa</b> | <b>ZAF</b> | *             | <b>1</b>                                    |
| <b>Algeria</b>              | <b>DZA</b> | *             | <b>8</b>                                    |
| <i>Burkina Faso</i>         | <i>BFA</i> | *             | <b>17</b>                                   |
| <b>Cameroon</b>             | <b>CIV</b> | *             | <b>9</b>                                    |
| <b>Côte d'Ivoire</b>        | <b>CIV</b> | *             | <b>12</b>                                   |
| <b>Egypt</b>                | <b>EGY</b> | *             | <b>2</b>                                    |
| <b>Ethiopia</b>             | <b>ETH</b> |               | <b>14</b>                                   |
| <b>Ghana</b>                | <b>GHA</b> |               | <b>13</b>                                   |
| <b>Kenya</b>                | <b>KEN</b> | *             | <b>4</b>                                    |
| <i>Madagascar</i>           | <i>MDG</i> | *             | <b>28</b>                                   |
| <b>Morocco</b>              | <b>MAR</b> | *             | <b>3</b>                                    |
| <i>Mozambique</i>           | <i>MOZ</i> | *             | <b>34</b>                                   |
| <b>Nigeria</b>              | <b>NGA</b> | *             | <b>6</b>                                    |
| <b>Senegal</b>              | <b>SEN</b> | *             | <b>11</b>                                   |
| <b>Sudan</b>                | <b>SDN</b> |               | <b>15</b>                                   |
| <b>Tanzania</b>             | <b>TZA</b> | *             | <b>7</b>                                    |
| <b>Tunisia</b>              | <b>TUN</b> | *             | <b>5</b>                                    |
| <b>Zimbabwe</b>             | <b>ZWE</b> | *             | <b>10</b>                                   |

**TABLE 7:**

**List of the 50 institutions that produced most of the scientific articles indexed by ISI during the last 10 years in Africa (South of the Sahara, excluding the Republic of South Africa). Trend of their production (1990-1999)**

| Country | Institution           | Score 90-99 | Rank | Country | Institution                  | Score 90-99 | Rank |
|---------|-----------------------|-------------|------|---------|------------------------------|-------------|------|
| KEN     | Univ Nairobi          | 1355        |      | TZA     | Univ Agric Sokoine           | 134         | 34   |
| KEN     | Ken Inst Med Res      | 1044        | 2    | KEN     | Medical Inst Trypano         | 128         |      |
| NGA     | Univ Ibadan           | 980         |      | NGA     | 8 Agric Res Institutes       | 121         |      |
| ZWE     | Univ Zimbabwe         | 838         | 4    | KEN     | Univ Kenyatta                | 117         |      |
| CMR     | Univ Yaounde          | 539         |      | NGA     | Ogun State Univ              | 103         |      |
| SDN     | Univ Khartoum         | 537         | 6    | CIV     | ORSTOM                       | 99          |      |
| NGA     | Univ Obafemi Awolowo  | 533         |      | KEN     | Univ Moi                     | 90          | 40   |
| NGA     | Univ A. Bello         | 473         |      | KEN     | Ministry of Health           | 90          | 41   |
| ETH     | Univ Addis Ababa      | 445         | 9    | NGA     | 3 Nat Inst of Health         | 82          | 42   |
| NGA     | Univ Nigeria          | 442         |      | KEN     | Fisheries Inst               | 80          |      |
| SEN     | Univ Cheikh Anta Diop | 403         |      |         | And some others (non Univ)   |             |      |
| TZA     | Univ Med Muhimbili    | 348         | 12   | SDN     | Med Res Council              | 75          | 44   |
| NGA     | Univ Benin            | 308         |      | KEN     | Co-operation USA             | 74          | 45   |
| KEN     | ILRAD                 | 283         | 14   | SEN     | Ecole interétats vétérinaire | 67          | 48   |
| TZA     | Univ Dar es Salaam    | 269         | 15   | KEN     | African Med Res Foundation   | 65          | 51   |
| GHA     | Univ Ghana            | 263         |      | CMR     | ORSTOM                       | 63          | 52   |
| NGA     | IITA                  | 252         |      | TZA     | 8 Agric Res Inst             | 62          | 54   |
| NGA     | Univ Lagos            | 232         |      | CIV     | Project Retro-CI             | 60          | 55   |
| NGA     | Univ Jos              | 227         |      | ETH     | A. Hansen Res Inst           | 60          | 55   |
| NGA     | Univ Calabar          | 214         |      | KEN     | Wellcome Trust Lab (Med)     | 60          | 55   |
| SEN     | ORSTOM                | 210         |      | NGA     | ILCRA                        | 56          |      |
| NGA     | Univ Ilorin           | 207         |      | ZWE     | Blair Res Inst (Med)         | 49          | 67   |
| ETH     | ILCRA                 | 202         | 23   | ZWE     | 7 Agric Res Inst             | 47          | 69   |

|     |                          |     |  |    |     |                             |    |  |    |
|-----|--------------------------|-----|--|----|-----|-----------------------------|----|--|----|
| CIV | Univ Abidjan             | 200 |  |    | CMR | OCCGE                       | 41 |  | 79 |
| KEN | KARI (Inst of Agric Res) | 188 |  | 25 | ETH | Inst Agric & Veterinary Med | 41 |  | 79 |
| GHA | Univ Sc & Tec            | 186 |  |    | KEN | ICRAF                       | 40 |  |    |
| TZA | Nat Inst Med Research    | 182 |  | 27 | CMR | OCEAC                       | 33 |  | 87 |
| KEN | Parks & Museums          | 177 |  | 28 | CMR | Inst Agric + Veterinary Med | 33 |  | 87 |
| NGA | Univ Maiduguri           | 169 |  |    | KEN | KFRI (Forêts)               | 32 |  | 89 |
| KEN | ILCRA                    | 159 |  |    | SEN | Agric Res Inst              | 27 |  |    |
| KEN | Nairobi Hospital         | 157 |  | 31 | CIV | Inst Pasteur Abidjan        | 25 |  | 94 |
| NGA | Univ Port Harcourt       | 150 |  | 32 | CMR | Inst Pasteur Cameroun       | 25 |  | 94 |
| SEN | Inst. Pasteur Dakar      | 146 |  |    | KEN | KETRI                       | 24 |  | 96 |

N.B. The score of the public Universities of Uganda (Makerere) and of Malawi could not be taken into account. There is no doubt that these institutions belong among the 30 first of this list.

Source: ISI files, compiled by N. Narvaez and revised by R. Waast.

Legend: The column displays continuous trends of production between 1990 and 1999.

The names that are highlighted point to international institutions posted in a specific country.

Some of the institutions ranking between 50<sup>th</sup> and 100<sup>th</sup> have been mentioned. We chose to quote those in quick growth or decline, and the Research Institutes (often under estimated by the bibliographic databases).

ORSTOM is the acronym used for an Institute that has changed names several times during this period (now:IRD).

**Table 7. Institutions producing a mean of more than 50 articles per year (1990-1999, North Africa and the Republic of South Africa).**

*Source* Narvaez/SCI, revised by Waast.

*Legend:* 50 % = top producers participating in 50 % of the production of the country.

| Institutions        | Score | Country | 50 % | Institutions                         | Score | Country | 50 % |
|---------------------|-------|---------|------|--------------------------------------|-------|---------|------|
| <b>Universities</b> |       |         |      | <b>National Research Institutes</b>  |       |         |      |
| Cape Town           | 5144  | ZAF     | *    | National Res. Centre                 | 1274  | EGY     | *    |
| Witwatersrand       | 4500  | ZAF     | *    | Medical Research Council             | 940   | ZAF     |      |
| Pretoria            | 2538  | ZAF     | *    | Groote Schuur Hospital               | 874   | ZAF     |      |
| Cairo               | 2397  | EGY     | *    | Atomic Energy Auth                   | 651   | EGY     |      |
| Natal               | 2311  | ZAF     | *    | CSIR                                 | 477   | ZAF     |      |
| Stellenbosch        | 2145  | ZAF     | *    | S A Institute Medical Research.      | 465   | ZAF     |      |
| Ain Shams           | 1616  | EGY     | *    | Tygerberg Hospital                   | 456   | ZAF     |      |
| Alexandria          | 1466  | EGY     | *    | Baragwarnath Hospital                | 291   | ZAF     |      |
| Assiut              | 1288  | EGY     | *    | National Accelerator                 | 286   | ZAF     |      |
| Orange Free St      | 1188  | ZAF     |      | South African Astromical Observatory | 281   | ZAF     |      |
| Mansoura            | 1138  | EGY     |      | IAV Hassan 2                         | 248   | MAR     | *    |
| Tunis               | 1088  | TUN     | *    | Onderstep Vet I                      | 246   | ZAF     |      |
| Rhodes              | 650   | ZAF     |      | Hop Ch Nicolle                       | 222   | TUN     |      |
| Rand Afrikaans      | 647   | ZAF     |      | Red Cross Hosp                       | 206   | ZAF     |      |
| Al Ahzar (Girls)    | 621   | EGY     |      | Joburg Hosp                          | 194   | ZAF     |      |
| Tanta               | 576   | EGY     |      | Rabat Instituts                      | 172   | MAR     | *    |
| Zagazig             | 535   | EGY     |      | Sea Fish Res I                       | 148   | ZAF     |      |
| Marrakech           | 477   | MAR     | *    | INRST                                | 145   | TUN     |      |
| Alger               | 471   | DZA     | *    | S Af Museum                          | 137   | ZAF     |      |
| Potchefstroom       | 462   | ZAF     |      | Petrol. Res Inst                     | 124   | EGY     |      |

|                  |     |     |   |  |     |     |     |
|------------------|-----|-----|---|--|-----|-----|-----|
| Casablanca       | 460 | MAR | * | T. Bilharz R. I.                                 | 123 | EGY |     |
| Menia            | 444 | EGY |   | MINTEK   | 120 | ZAF |     |
| Rabat            | 443 | MAR | * | ENS  | 113 | MAR |     |
| Menoufia         | 407 | EGY |   | Inst Nat Neuro                                   | 111 | TUN |     |
| Port Elizabeth   | 382 | ZAF |   | Nat Bot Inst                                     | 106 | ZAF |     |
| Assiut           | 334 | EGY |   | JLB Smith Icthyolgy                              | 104 | ZAF |     |
| Med South Af     | 330 | ZAF |   | Transvaal Museum                                 | 103 | ZAF |     |
| Durban Westvilel | 309 | ZAF |   |  |     |     |     |
| Suez Canal       | 281 | EGY |   | International institutions (operating in Africa) |     |     |     |
| UNISA            | 277 | ZAF |   |  |     |     |     |
| Monastir         | 267 | TUN |   | ILCRA  | 417 | INT | *   |
| Oran             | 251 | DZA | * | ORSTOM   | 394 | INT | *** |
| Western Cape     | 209 | ZAF |   | Inst. Pasteur                                    | 388 | INT | *** |
| Fès              | 177 | MAR |   | ILRAD  | 375 | INT | *   |
| Benha            | 176 | EGY |   | ICIPE  | 283 | INT | *   |
| Helwan           | 164 | EGY |   | IITA   | 252 | INT | *   |
| Meknès           | 163 | MAR |   | OCEAC  | 81  | INT | *   |
| Sousse           | 154 | TUN |   |  |     |     |     |
| Constantine      | 152 | DZA |   |  |     |     |     |
| USN              | 146 | EGY |   |  |     |     |     |
| Sfax             | 145 | TUN |   |  |     |     |     |
| Kenitra          | 145 | MAR |   |  |     |     |     |
| Annaba           | 113 | DZA |   |  |     |     |     |

**Table 8 a. By field, countries producing more than 5% of the African articles.  
Biology & Medicine.**

**Legend: \* 5-10%; \*\* 10-20%; \*\*\* 20-30%; \*\*\*\* 30-40%;  
£ 40-50%; ££ 50-60%; £££ 60-70%; ££££ ≥ 70%.**

**Column % = Sub-Fields in % of the total production of Africa in the field.**

**Source Narvaez/SCI (1991-99).**

|               | ZAF      | EGY      | MAR | TUN | DZA | NGA      | KEN | TZA | ZWE | CMR | SEN | GHA | %    |
|---------------|----------|----------|-----|-----|-----|----------|-----|-----|-----|-----|-----|-----|------|
| Internal Med  | ££       |          |     |     |     | *        | **  |     |     |     |     |     | 30,7 |
| Odonto        | £££      | **       |     |     |     |          | *   | *   |     |     |     |     | 3,3  |
| Nephro        | £££      | **       |     | *   |     |          |     |     |     |     |     |     | 1,2  |
| Anaesthesia   | ££££     | **       |     |     |     |          |     |     |     |     |     |     | 1,0  |
| Surgery       | ££££     | **       |     |     |     | *        |     |     |     |     |     |     | 2,1  |
| Cardio        | £££      | *        | *   | **  |     | **       |     |     |     |     |     |     | 2,0  |
| Cancer        | ££       | ***      |     | *   |     |          |     |     |     |     |     |     | 3,3  |
| Dermato       | ***      | **       |     | *** |     | **       |     |     |     |     |     |     | 1,5  |
| Gastro        | ££       | ***<br>* |     | *   |     |          |     |     |     |     |     |     | 2,5  |
| Endocrino     | ££       | *        |     | *   |     | *        |     |     |     |     |     |     | 1,7  |
| Haematology   | ££       | **       |     | **  | *   |          |     |     |     |     |     |     | 2,0  |
| Neuro         | ***<br>* | *        | **  | **  |     | **       |     |     |     |     |     |     | 2,3  |
| Ophtalmo      | ***      | ***      |     |     |     | **       | *   | *   |     |     |     |     | 0,7  |
| ORL           | ££       | £        |     |     |     |          |     |     |     |     |     |     | 0,7  |
| Pharmaco-Tox  | ***<br>* | ***<br>* |     |     |     | **       | *   |     |     |     |     |     | 5,2  |
| Pneumo        | ££       |          |     | *   | *   |          | **  | *   |     |     |     |     | 1,2  |
| Psycho        | £        | **       |     |     |     | ***<br>* |     |     | **  |     |     |     | 1,6  |
| Radiology     | £        | ***      | **  |     |     |          |     |     |     |     |     |     | 1,8  |
| Rhumato       |          |          |     |     |     |          |     |     |     |     |     |     | 0,7  |
| Uro           | ***      | ££       |     |     |     | *        |     |     |     |     |     |     | 1,3  |
| Paediatrics   | ***      | **       |     | **  |     | ***      |     |     |     |     |     |     | 2,4  |
| Fertility     | £        | **       |     |     |     | **       | **  |     |     |     |     |     | 1,5  |
| Gynae/Obst    | ***<br>* | **       |     |     |     | ***      |     |     |     |     |     | *   | 2,3  |
| Immuno        | ***      | *        |     |     |     |          | *** | *   |     |     |     |     | 7,6  |
| Tropical Med  |          | *        |     |     |     | **       | *** | **  |     | *   |     |     | 6,1  |
| Public Health | ***      | **       |     |     |     | **       | *   |     |     |     |     |     | 2,0  |
| Diverse       | £        | **       |     |     |     | **       | *   |     |     |     |     |     |      |
| Veterinary    | ***      | *        |     |     |     | *        | *** |     | *   |     |     |     | 8,4  |

|                    |   |    |  |  |  |   |   |  |  |  |  |  |            |
|--------------------|---|----|--|--|--|---|---|--|--|--|--|--|------------|
| <b>Med</b>         |   |    |  |  |  |   |   |  |  |  |  |  |            |
| <b>CLINICAL Me</b> | £ | ** |  |  |  | * | * |  |  |  |  |  | <b>100</b> |

|                        |          |          |    |    |  |     |          |   |   |   |    |  |             |
|------------------------|----------|----------|----|----|--|-----|----------|---|---|---|----|--|-------------|
| <b>General Biology</b> | £££<br>£ |          |    |    |  |     |          |   |   |   |    |  | <b>24,0</b> |
| <b>Physiology</b>      | £££      |          | ** |    |  |     |          | * | * |   |    |  | <b>2,0</b>  |
| <b>Ana-Path</b>        | ££       | ***      |    |    |  | **  |          |   |   |   | *  |  | <b>2,0</b>  |
| <b>Biochemistry</b>    | ££       | **       |    | *  |  | *   |          |   |   |   |    |  | <b>13,5</b> |
| <b>Molecular Bio</b>   | £        |          |    |    |  |     |          |   |   |   |    |  | <b>2,5</b>  |
| <b>Genetics</b>        | £        | **       |    | ** |  | *   |          |   |   |   |    |  | <b>12,0</b> |
| <b>Microbiology</b>    | ***<br>* | ***      |    |    |  | **  | *        |   |   |   |    |  | <b>12,5</b> |
| <b>Nutrition</b>       | ***      | *        |    |    |  | *** | **       | * |   |   |    |  | <b>6,0</b>  |
| <b>Parasitology</b>    | **       | *        |    |    |  | *   | ***<br>* |   |   | * | *  |  | <b>10,0</b> |
| <b>Virology</b>        | £        | *        |    |    |  |     |          |   |   | * | ** |  | <b>4,5</b>  |
| <b>Bio-Engineering</b> | ***      | ***<br>* |    | *  |  | *** |          |   |   |   |    |  | <b>6,5</b>  |
| <b>Diverse</b>         | ££       | *        |    |    |  | **  | *        |   |   | * |    |  | <b>4,5</b>  |
| <b>MEDICAL BIO</b>     | ££       | **       |    | *  |  | *   | *        |   |   |   |    |  | <b>100</b>  |

|                            |          |     |   |   |     |     |          |   |     |  |  |     |             |
|----------------------------|----------|-----|---|---|-----|-----|----------|---|-----|--|--|-----|-------------|
| <b>Zoology</b>             | £££<br>£ | (*) |   |   | (*) | *   |          |   |     |  |  | ETH | <b>10,7</b> |
| <b>Marine &amp; Hydro</b>  | ££       | *   |   |   |     | *   | **       |   |     |  |  |     | <b>9,3</b>  |
| <b>General Biology</b>     | ***      | *** |   | * |     | *   | **       |   |     |  |  |     | <b>4,3</b>  |
| <b>Botany</b>              | £        | **  |   |   |     | **  | *        |   |     |  |  |     | <b>26,6</b> |
| <b>Ecology</b>             | £        | *   |   |   |     | **  | **       | * | *   |  |  |     | <b>10,1</b> |
| <b>Entomology</b>          | ***      | *   |   |   |     |     | ***<br>* | * | *   |  |  |     | <b>7,1</b>  |
| <b>Agric &amp; Forests</b> | ***      | **  |   |   |     | *** | *        |   | (*) |  |  | (*) | <b>26,1</b> |
| <b>Cattle breeding</b>     | **       | **  | * | * |     |     | *        |   | *   |  |  | **  | <b>5,8</b>  |
| <b>BIO (non med)</b>       | £        | **  |   |   |     | **  | **       |   |     |  |  | (*) | <b>100</b>  |



**Table 8 a. By field, countries producing more than 5% of the African articles. Other Sciences.**

**Legend: \* 5-10%; \*\* 10-20%; \*\*\* 20-30%; \*\*\*\* 30-40%;  
£ 40-50%; ££ 50-60%; £££ 60-70%; ££££ ≥ 70%.**

**Column % = Sub-Fields in % of the total production of Africa in the field.**

**Source Narvaez/SCI (1991-99).**

|                          | ZAF  | EGY | MAR | TUN | DZA | NGA | KEN | CIV | %           |
|--------------------------|------|-----|-----|-----|-----|-----|-----|-----|-------------|
| <b>Astro</b>             | £££  | **  | *   |     | (*) | *   |     |     | <b>17,4</b> |
| <b>Geophysics</b>        | **** | *** |     |     |     | *   | *   |     | <b>19,9</b> |
| <b>Geology</b>           | ££   | **  | *   |     |     | *   |     |     | <b>23,2</b> |
| <b>Oceano/Limno</b>      | ££   | *   | *   | *   | *   |     | *   | *   | <b>3,1</b>  |
| <b>Space</b>             | ££   | *   |     |     |     | **  | *   | *   | <b>3,1</b>  |
| <b>Environment</b>       | £££  | **  |     |     |     | *   | (*) |     | <b>33,3</b> |
| <b>Earth &amp; Space</b> | ££   | **  | (*) |     |     | *   | *   |     | <b>100</b>  |

|                         | ZAF | EGY | MAR | TUN | DZA | NGA | KEN | TZA | %           |
|-------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-------------|
| <b>Applied Math</b>     | £   | *** | **  | *   |     | *   |     |     | <b>29,3</b> |
| <b>General Math</b>     | £   | **  | **  | **  | *   | *   |     |     | <b>64,0</b> |
| <b>Proba/Statistics</b> | £££ |     | *   | *   |     |     | *   | *   | <b>6,7</b>  |
| <b>MATH</b>             | £   | **  | **  | **  | (*) |     |     |     | <b>100</b>  |

|                            | ZAF  | EGY  | MAR | TUN | DZA | NGA | KEN | %           |
|----------------------------|------|------|-----|-----|-----|-----|-----|-------------|
| <b>Aeronautics</b>         | £££  | ***  |     |     |     |     |     | <b>2,4</b>  |
| <b>Nuclear</b>             | ***  | £££  | (*) |     | *   |     |     | <b>2,4</b>  |
| <b>Computer Sc</b>         | **** | £    |     | **  |     |     |     | <b>9,1</b>  |
| <b>Elec &amp; Electron</b> | **** | £    | *   |     | *   |     |     | <b>16,0</b> |
| <b>Mechanic Eng.</b>       | ***  | ££   | *   |     |     | *   |     | <b>7,5</b>  |
| <b>Management</b>          | **** |      | **  | *** | *   | *   |     | <b>1,1</b>  |
| <b>Materials</b>           | ***  | ££   | *   |     | **  |     |     | <b>28,6</b> |
| <b>Metallurgy</b>          | **** | ***  | **  |     | *   | *   |     | <b>15,3</b> |
| <b>Chemical Eng</b>        | **** | £    |     |     | (*) |     |     | <b>9,9</b>  |
| <b>Civil Eng</b>           | **** | ££   | *   |     | *   |     |     | <b>1,0</b>  |
| <b>Diverse</b>             | ***  | **** | (*) | *   |     | **  | (*) | <b>6,7</b>  |
| <b>ENGINEERING</b>         | ***  | £    | *   | (*) | *   | (*) |     | <b>100</b>  |

|                       | ZAF  | EGY | MAR | TUN | DZA | NGA | %                  |
|-----------------------|------|-----|-----|-----|-----|-----|--------------------|
| <b>General Chem.</b>  | **   | £   | **  | **  | *   |     | <b>24,7</b>        |
| <b>Applied Chem.</b>  | **   | ££  |     |     |     | **  | <b>1,3</b>         |
| <b>Analytic Chem</b>  | ***  | ££  |     |     |     | **  | <b><u>12,7</u></b> |
| <b>Physical Chem.</b> | ***  | £   | **  | **  | *   |     | <b>27,1</b>        |
| <b>Organic Chem.</b>  | **** | *** | **  | **  | *   |     | <b>8,9</b>         |
| <b>Inorganic Chem</b> | ***  | ££  | *   |     |     | *   | <b><u>14,6</u></b> |
| <b>Polymers</b>       | **   | £££ | *   |     | *   | *   | <b>10,7</b>        |
| <b>CHEMISTRY</b>      | ***  | £   | **  | *   | *   |     | <b>100</b>         |

|                        | ZAF  | EGY  | MAR | TUN | DZA | NGA | %                  |
|------------------------|------|------|-----|-----|-----|-----|--------------------|
| <b>General Physics</b> | **** | ***  | **  | *   | **  |     | <b>45,8</b>        |
| <b>Nuclear Phys</b>    | ££   | **   | **  |     | **  |     | <b>8,7</b>         |
| <b>Acoustics</b>       | ***  | £    | *   |     | *   | *   | <b>2,0</b>         |
| <b>Solid state</b>     | **   | **** | **  | *** | **  |     | <b>7,1</b>         |
| <b>Applied Phys</b>    | £    | ***  | *   | *   | **  |     | <b><u>22,3</u></b> |
| <b>Chem Phys</b>       | £    | ***  | **  | *   | *   |     | <b>6,4</b>         |
| <b>Plasmas</b>         | **** | **** | (*) | *   | **  |     | <b>2,4</b>         |
| <b>Optic</b>           | £    | £    |     |     | *   |     | <b>5,3</b>         |
| <b>PHYSICS</b>         | **** | ***  | **  | *   | **  |     | <b>100</b>         |

**Table 10 a. Strengths and Weaknesses by country, field and sub-field. Medical Sciences.**  
**Indicators calculated by Waast. Data from Narvaez/ISI.**

| Relative Prod in | ZAF | EGY      | MAR     | TUN     | DZA     | NGA     | KEN | TZA | ZWE | CMR     | SEN | CIV | GHA | ETH |
|------------------|-----|----------|---------|---------|---------|---------|-----|-----|-----|---------|-----|-----|-----|-----|
| Internal Med     | +   | --       | -       |         | -       |         |     |     |     |         |     |     |     |     |
| Odonto           | ++  |          | 0       | --      | 0       | -       |     | +   |     | 0       | -   | --  |     | --  |
| Nephro           | ++  |          | +       |         |         | --      | --- | 0   | 0   | 0       | -   | 0   | --- |     |
| Anaesth          | +++ |          | 0       |         | 0       | ---     | 0   | --  |     | 0       | -   | 0   |     | --  |
| Surgery          | ++  |          | --      |         |         |         | --  | 0   |     | --      | 0   | 0   |     | --  |
| Cardio           | +   | -        | ++      | ++      |         |         | --- | --- |     |         | --  |     | --- | --  |
| Cancer           |     | ++       |         |         | ++      | -       | --- | -   |     | +       | --  | --  | --  |     |
| Dermato          | --  | +        |         | ++<br>+ | ++<br>+ |         | --  |     | --  |         | +   | 0   |     | ++  |
| Gastro           |     | ++<br>+  |         | +       | -       | --      | 0   | --- | --  |         |     | -   |     |     |
| Endocrino        |     |          | +       |         | ++      |         | --  |     | --  | ++      |     | --  |     |     |
| Haemato          |     |          | --      | ++      | ++<br>+ |         | --- | --  |     | -       | 0   |     |     |     |
| Neuro            |     |          | ++<br>+ | ++      | ++      |         | --  |     |     | 0       |     | +   | -   | --  |
| Ophtalmo         | -   | ++       | -       |         |         | +       |     | ++  |     |         | 0   | 0   | +   |     |
| ORL              |     | ++<br>+  | 0       |         | 0       | -       | --  |     | 0   | 0       | 0   | 0   |     |     |
| Pharmaco-Tox     |     | ++       |         |         |         |         |     | -   | +   | +       |     |     |     |     |
| Pneumo           |     | --       |         | +       | ++      | -       |     |     |     |         | -   | ++  |     |     |
| Psycho           |     |          |         | -       |         | +       |     | ++  | ++  | 0       |     | ++  | +   | --  |
| Radiology        |     | ++       | ++<br>+ | -       | +       |         | --- | -   | 0   | --      | 0   | 0   | --- |     |
| Rhumato          |     | +        |         | ++<br>+ | +       | -       | 0   | 0   | ++  | 0       |     | 0   |     |     |
| Uro              | -   | ++<br>++ | 0       |         | 0       |         | -   |     |     | ++      | -   | 0   |     |     |
| Paediatrics      | -   |          | -       | ++      |         | ++<br>+ | -   |     |     |         |     | -   |     |     |
| Gynaeco-Obst     | -   |          | 0       | --      | 0       | ++<br>+ |     |     |     |         | ++  | 0   | ++  | --- |
| Immuno           | --  |          |         |         |         | -       | ++  | +   |     | ++<br>+ | ++  | ++  |     | +   |
| Tropical Med     | --- |          | ---     | -       | --      | +       | ++  | ++  |     | ++<br>+ | ++  | ++  | +   | ++  |
| Public Health    | --  |          | --      | -       |         |         |     | ++  |     | ++      | ++  | ++  | ++  | ++  |
| Diverse          |     | ++       |         |         | ++      | ++      | +   |     | ++  |         | +   | ++  |     |     |
| CLINICAL M.      |     | -        | -       |         | --      |         | +   | +   |     |         |     |     |     |     |

**Table 10 a. Medical Biology. Strengths and Weaknesses.**

| Relative Prod in | ZAF | EGY     | MAR     | TUN     | DZA     | NGA | KEN     | TZA     | ZWE | CMR     | SEN     | CIV | GHA     | ETH     |
|------------------|-----|---------|---------|---------|---------|-----|---------|---------|-----|---------|---------|-----|---------|---------|
| Microscopy       |     | 0       | ++<br>+ | ++<br>+ | ++<br>+ | 0   | 0       | 0       | 0   | 0       | 0       | 0   | ---     | ---     |
| Bio-engineering  | -   | ++<br>+ |         |         |         | ++  | --      | ---     | -   | --      | 0       | 0   |         |         |
| Ana-Path         |     | +       | 0       | --      |         |     |         |         | --- | 0       | 0       | 0   | ++<br>+ | ---     |
| Bio Chemistry    |     |         | +       | +       |         |     |         | ---     |     |         | -       | -   |         | --      |
| Molecular Bio    |     |         | ++      |         | -       |     | +       | 0       |     |         | ++<br>+ |     | ---     |         |
| Embryology       |     |         | ++<br>+ | --      | 0       |     | 0       | 0       | 0   | 0       | 0       | 0   | ++<br>+ | ---     |
| Genetics         |     |         |         | ++      | ++      |     |         |         |     | --      | -       |     |         | +       |
| Microbiology     |     | ++      |         |         |         |     |         |         | +   |         | +       |     |         |         |
| Nutrition        | -   |         |         |         |         | ++  |         | ++<br>+ |     |         |         | --  | ++      | ++<br>+ |
| Parasitology     | --  |         |         | -       | --      |     | ++<br>+ | ++      |     | ++      | ++      | ++  |         | -       |
| Virology         |     |         |         |         |         |     | -       |         |     | ++      | ++<br>+ | ++  | +       |         |
| Diverse          | ++  | -       | ++      | -       | -- *    |     |         |         |     | ++<br>* |         | -   | ++      |         |
| MEDICAL Bio      | +   | -       |         |         |         |     |         |         |     |         | +       |     |         |         |

**Table 10 a. Non Medical Biology. Strengths and Weaknesses.**

| Relative Prod in | ZAF | EGY | MAR | TUN | DZA | NGA | KEN     | TZA | ZWE | ETH     | GHA | CMR  | SEN | CIV |
|------------------|-----|-----|-----|-----|-----|-----|---------|-----|-----|---------|-----|------|-----|-----|
| Zoo, Marine bio  | ++  |     | +   |     | +   | -   |         |     | --  | --      |     | --   | -   | ++  |
| General Bio      | +   |     |     | +   |     |     |         |     |     |         | - * | -- * |     |     |
| Botany           |     |     |     |     |     |     |         |     |     |         |     |      |     | +   |
| Ecology          |     |     | -   | -   | --  |     |         | +   |     | -       |     |      | --  | --  |
| Entomology       |     |     |     |     | -   | --  | ++<br>+ | +   | +   |         |     |      | +   |     |
| Agriculture      | -   |     |     |     |     | ++  |         |     |     |         | +   |      |     |     |
| Cattle breeding  | -   | +   | +   | ++  |     |     |         |     | +   | ++<br>+ | +   |      |     | -   |
| BIOLOGY          |     | -   |     |     | --  | +   | +       | +   | +   |         |     | +    |     | +   |

**Table 10 b. Earth and Space. Strengths and Weaknesses.**

| Relative Prod in         | ZAF | EGY | MAR | TUN | DZA | NGA | KEN | TZA | ZWE | ETH     | GHA | CMR | SEN | CIV     |
|--------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|---------|-----|-----|-----|---------|
| <b>Astro</b>             |     |     |     | --- | +   |     |     | 0   | 0   | ---     | --- | 0   | -   | 0       |
| <b>Geophysics</b>        |     | +   |     |     |     |     |     |     |     | ++<br>+ | -   | ++  | +   | --      |
| <b>Geology</b>           |     |     | +   |     |     |     |     |     | +   |         |     |     | -   | -       |
| <b>Oceanography</b>      |     | -   | +   | ++  | ++  | 0   | +   | 0   | 0   | ---     | --  |     |     | ++<br>+ |
| <b>Space</b>             |     | -   | -   |     | 0   | +   | +   | 0   | ++  | ---     | --- | 0   |     |         |
| <b>Environment</b>       |     |     | -   |     | --  |     |     |     |     | ---     | +   |     | +   |         |
| <b>Earth &amp; Space</b> |     |     |     |     |     |     |     |     |     |         |     | -   |     |         |

**Table 10 b. Engineering. Strengths and Weaknesses.**

| Relative Prod in           | ZAF     | EGY     | MAR | TUN     | DZA | NGA | KEN | TZA | ZWE | ETH  | GHA | CMR | SEN | CIV |
|----------------------------|---------|---------|-----|---------|-----|-----|-----|-----|-----|------|-----|-----|-----|-----|
| <b>Aeronautics</b>         | ++<br>+ | -       | 0   | ---     |     |     |     | 0   | 0   | ---  | --- | 0   | 0   | 0   |
| <b>Nuclear</b>             |         | +       |     | ---     |     | -   | 0   | 0   | 0   | ---  | --- | 0   | 0   | 0   |
| <b>Elec &amp; Electron</b> |         |         |     |         |     | -   | +   |     |     |      | --  | +   | 0   | 0   |
| <b>Computer Sc</b>         |         |         | -   | ++<br>+ | --  | --  | -   | 0   |     | ---  | --- | ++  | 0   |     |
| <b>Indus Engin</b>         |         | ++<br>+ | 0   | ---     | 0   | 0   | 0   | 0   | 0   | ---  | --- | 0   | 0   | 0   |
| <b>Mechanic Eng</b>        |         | +       |     | -       | -   |     |     |     |     | ---  | --- | 0   | 0   | 0   |
| <b>General Eng</b>         | -       | ++      | -   | ---     | -   | 0   | +   | 0   | ++  | ---  | --- | 0   | 0   | 0   |
| <b>Management</b>          |         | 0       | ++  | ++<br>+ |     | +   | 0   | 0   | 0   | ---- | --- | ++  | 0   | 0   |
| <b>Materials</b>           |         |         |     | --      | +   |     | -   | -   |     |      | +   |     | +   | 0   |
| <b>Metallurgy</b>          |         | -       | ++  |         |     |     | -   |     | +   | +    |     | 0   |     | ++  |
| <b>Chemical Eng</b>        |         |         |     |         |     | +   |     | +   |     | ---- |     |     | 0   | +   |
| <b>Civil Eng.</b>          |         |         |     | ---     |     | 0   | +   | 0   | 0   | ---  | --- | 0   | 0   | 0   |
| <b>Diverse</b>             | -       |         |     |         |     | ++  | +   | +   | +   |      |     |     |     |     |
| <b>ENGINEERING</b>         |         | ++<br>+ | +   |         | ++  |     | --  | --  | --  |      |     | --  | --- | --  |

**Table 10 b. Chemistry. Strengths and Weaknesses.**

| Relative Prod in | ZAF | EGY     | MAR | TUN | DZA | NGA     | KEN | TZA | ZWE | ETH | GHA | CMR | SEN | CIV |
|------------------|-----|---------|-----|-----|-----|---------|-----|-----|-----|-----|-----|-----|-----|-----|
| General Chem.    |     |         | +   | +   | +   |         |     |     |     |     | --  | +   | +   |     |
| Organic Chem.    | +   | -       | +   |     |     |         |     |     | --  | -   | ++  |     |     | -   |
| Applied Chem.    |     |         | -   | --- | --  | ++<br>+ |     | 0   | 0   | --- | --- |     | 0   | +   |
| Analytic Chem    |     |         |     |     |     |         |     |     | ++  |     |     | 0   |     | 0   |
| Mineral Chem.    |     |         |     | -   | -   | +       |     |     | 0   |     |     | 0   | -   |     |
| Polymers         |     | +       | -   | --  |     | +       |     | 0   | -   | --  | --  |     |     | 0   |
| CHEMISTRY        | -   | ++<br>+ | ++  |     | +   | -       | --- | --- | --  |     |     |     | -   | -   |

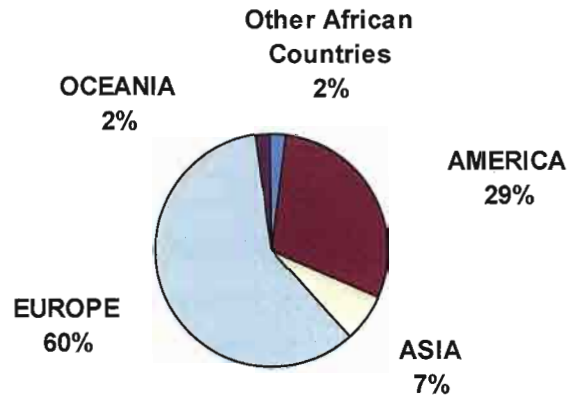
**Table 10 b. Physics. Strengths and Weaknesses.**

| Relative Prod in | ZAF | EGY | MAR | TUN     | DZA     | NGA | KEN | TZA | ZWE | ETH | GHA | CMR | SEN | CIV |
|------------------|-----|-----|-----|---------|---------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| General Physics  |     |     |     |         |         |     |     | 0   |     |     |     | +   |     |     |
| Nuclear Physics  | ++  | -   |     | -       |         | 0   | 0   |     | 0   | --- |     | 0   |     | 0   |
| Acoustic         |     | +   |     |         |         | +   | 0   | 0   | ++  |     |     | 0   | 0   | +   |
| Solid state      | --  |     |     | ++<br>+ |         | --  | 0   | 0   |     | +   | ++  | ++  |     | 0   |
| Applied Physics  |     |     |     |         |         |     |     |     |     |     |     | --- | +   | 0   |
| Chemist Physics  |     |     |     |         |         |     | 0   | 0   | 0   |     | -   | 0   |     | +   |
| Plasmas          |     |     | -   |         |         | 0   | 0   | 0   | ++  | ++  | --- |     | 0   | 0   |
| Diverse          |     | +   |     |         |         |     |     |     | 0   |     |     |     |     |     |
| PHYSICS          |     | ++  | ++  |         | ++<br>+ | --  | --- | --- | --- |     |     |     | -   | --- |

**Table 10 b. Mathematics. Strengths and Weaknesses.**

| Relative Prod in | ZAF | EGY | MAR | TUN | DZA | NGA | KEN | TZA | ZWE | ETH | GHA | CMR | SEN | CIV |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Applied Math     |     | +   |     |     |     |     |     | 0   |     | +   | --- |     | 0   | 0   |
| General Math     |     |     |     |     |     |     |     | 0   |     | --- |     | 0   |     |     |
| Proba/Statistics |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| MATH             |     |     | ++  |     |     |     | --- | --  | --  |     |     |     |     |     |

**International Collaboration of 15 African countries  
with the World (1991-1999)**

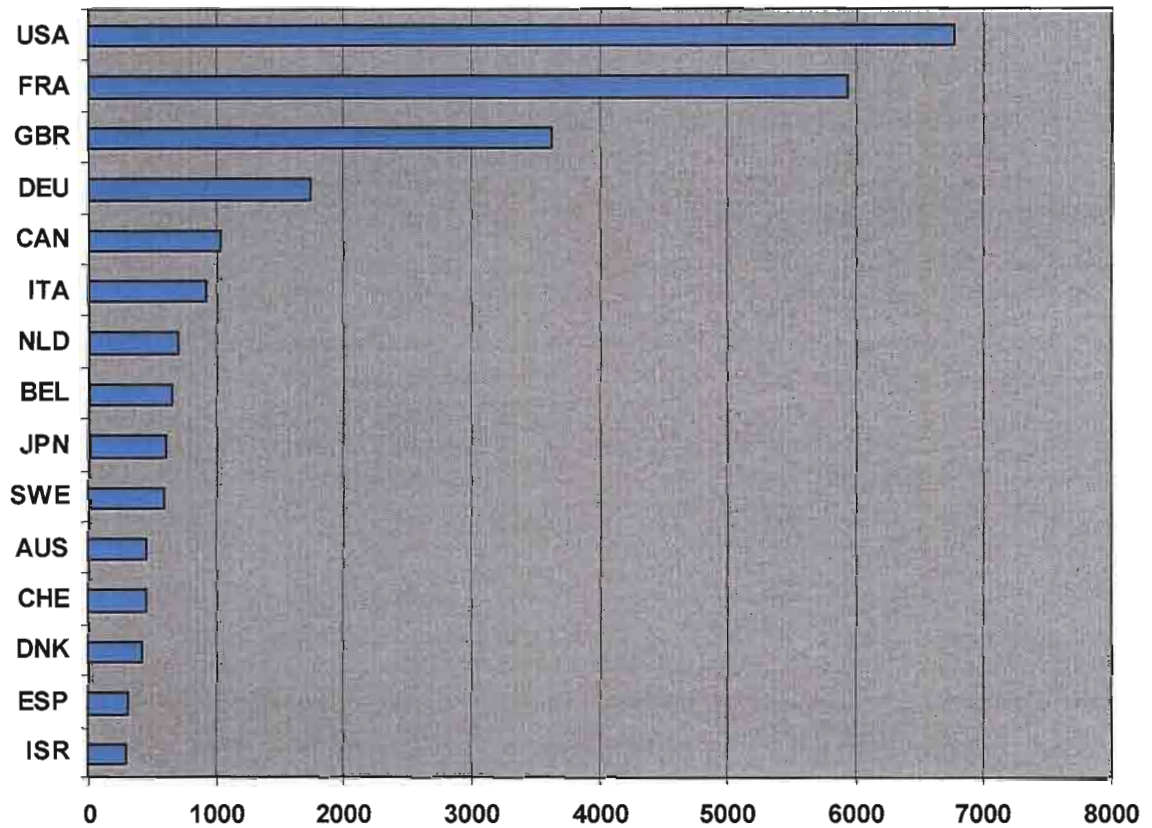


**Source: Narvaez; ISI Database (1991-99)**

**Measure: Number of co-authorships (1991-99)**

**15 African countries = 15 main producers of articles in Africa.**

**International collaborations of 15 African countries, and their  
15 first partners (1991-1997)**



% of co-authorships. Source: Narvaez, (1998, SCI). **Bold** = Main partner for the African country; Underlined: Important target for the developed country.

| %      | ZWE | ZAF       | TZA       | KEN       | ETH       | SDN       | NGA       | GHA       | CMR       | CIV       | SEN       | MAR       | DZA       | TUN       | EGY       |
|--------|-----|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Cnd    | 3   | 4         | 3         | 6         | 5         |           | 5         | 6         | 1         | 2         | 1         | 2         | 1         | 2         | 4         |
| Usa    | 22  | <u>31</u> | <u>21</u> | <u>31</u> | <u>11</u> | <u>22</u> | <u>26</u> | <u>28</u> | <u>15</u> | <u>14</u> | <u>9</u>  | <u>9</u>  | <u>5</u>  | <u>9</u>  | <u>37</u> |
| Uk     | 22  | <u>16</u> | <u>19</u> | <u>25</u> | <u>12</u> | <u>15</u> | <u>22</u> | <u>22</u> | <u>8</u>  | <u>7</u>  | <u>5</u>  | <u>2</u>  | <u>4</u>  | <u>2</u>  | <u>7</u>  |
| Deu    | 2   | <u>10</u> | 4         | 3         | 8         | <u>10</u> | 7         | 6         | 6         | 4         | 1         | 2         | 3         | 2         | <u>10</u> |
| Aut    |     | 1         |           |           |           |           |           |           |           |           |           |           |           |           | 2         |
| Ndl    | 5   | 2         | <u>10</u> | 3         | <u>7</u>  | 5         | 1         | 2         | 4         | 2         | 3         | 1         |           | 1         | 2         |
| Dnk    | 4   |           | 5         | 3         |           | <u>12</u> |           | 5         |           |           | 3         |           |           |           |           |
| Swe    | 6   |           | <u>10</u> | 2         | <u>17</u> | <u>11</u> | 2         | 1         | 2         | 1         |           | 1         |           | 1         | 2         |
| Fin    |     |           | 1         |           |           | 1         |           |           |           |           |           |           |           |           | 1         |
| Nor    | 1   |           | <u>4</u>  | 2         | 3         | 1         |           |           |           |           |           |           |           |           |           |
| Che    | 3   | 2         | <u>6</u>  | 2         |           |           | 1         | 1         | 2         | 3         |           | 1         | 1         | 1         | 1         |
| Ita    |     | 3         | 2         | 2         | 5         |           | 5         | 3         | 2         |           | 3         | 5         | 4         | 2         | 5         |
| Esp    |     | 1         | 1         |           |           |           |           |           |           |           |           | 4         | 2         | 1         |           |
| Fra    | 3   | 4         |           | 1         | 4         | 3         | 3         | 1         | <u>38</u> | <u>43</u> | <u>43</u> | <u>65</u> | <u>69</u> | <u>68</u> | 4         |
| Bel    | 2   | 2         | 1         | 3         | 3         |           |           |           | 4         | <u>7</u>  | 5         | 3         | 2         | 2         | 2         |
| Others | 27  | 24        | 13        | 17        | 25        | 20        | 28        | 25        | 18        | 17        | 27        | 5         | 9         | 9         | 23        |



Number of co-authorships between European and African countries (1987-97)  
 Database: ISI

|           | FRA               | BEL               | GBR               | DEU               | AUT | NLD               | FIN | DNK              | SWE              | ITA | ESP               |
|-----------|-------------------|-------------------|-------------------|-------------------|-----|-------------------|-----|------------------|------------------|-----|-------------------|
| ZAF       | <b><u>351</u></b> | 188               | 1506              | 911               | 125 | 187               | 47  | <b><u>64</u></b> | <b><u>88</u></b> | 265 | 125               |
| EGY       | 223               | <b><u>115</u></b> | <b><u>470</u></b> | 594               | 89  | <b><u>114</u></b> |     |                  |                  | 196 |                   |
| MAR       | 1978              | 76                | 88                | 66                |     |                   |     |                  |                  | 92  | <b><u>107</u></b> |
| DZA       | 1128              |                   |                   | 56                |     |                   |     |                  |                  | 54  |                   |
| TUN       | 989               |                   |                   | 50                |     |                   |     |                  |                  |     |                   |
| GAB       | 173               |                   |                   |                   |     |                   |     |                  |                  |     |                   |
| MDG       | 148               |                   |                   |                   |     |                   |     |                  |                  |     |                   |
| CGO       | 143               |                   |                   |                   |     |                   |     |                  |                  |     |                   |
| BFA       | 127               |                   |                   |                   |     |                   |     |                  |                  |     |                   |
| NER       | 110               |                   |                   |                   |     |                   |     |                  |                  |     |                   |
| MLI       | 103               |                   |                   |                   |     |                   |     |                  |                  |     |                   |
| CMR       | <b><u>338</u></b> |                   | 96                | 54                |     |                   |     |                  |                  |     |                   |
| CIV       | <b><u>374</u></b> | 59                |                   |                   |     |                   |     |                  |                  |     |                   |
| SEN       | <b><u>484</u></b> | 55                |                   |                   |     |                   |     |                  |                  |     |                   |
| RDCo<br>n |                   | 225               |                   |                   |     |                   |     |                  |                  |     |                   |
| RWA       |                   | 80                |                   |                   |     |                   |     |                  |                  |     |                   |
| BDI       |                   | 65                |                   |                   |     |                   |     |                  |                  |     |                   |
| GMB       |                   |                   | <b><u>327</u></b> |                   |     |                   |     | <b><u>59</u></b> |                  |     |                   |
| GHA       |                   |                   | 135               |                   |     |                   |     |                  |                  |     |                   |
| ZMB       |                   |                   | 134               |                   |     |                   |     |                  |                  |     |                   |
| MWI       |                   |                   | 140               |                   |     |                   |     |                  |                  |     |                   |
| ZWE       |                   |                   | 225               |                   |     | 58                |     |                  |                  |     |                   |
| KEN       |                   | <b><u>111</u></b> | 671               | <b><u>122</u></b> |     | <b><u>96</u></b>  |     | 94               | 60               | 46  |                   |
| NGA       |                   |                   | 535               | <b><u>166</u></b> |     | 44                |     |                  | 52               | 97  |                   |
| TZA       |                   |                   | <b><u>297</u></b> | 51                |     | <b><u>137</u></b> |     | <b><u>73</u></b> | 115              |     |                   |
| UGA       |                   |                   | 113               | 56                |     |                   |     |                  |                  |     |                   |
| ETH       |                   |                   | 124               | 67                |     |                   |     |                  | 136              |     |                   |
| SDN       |                   |                   | 141               | 70                |     |                   |     |                  | 67               |     |                   |
| MOZ       |                   |                   |                   |                   |     |                   |     |                  | 52               |     |                   |
| SOM       |                   |                   |                   |                   |     |                   |     |                  | 50               | 47  |                   |

**Bold=** Main targets of a European country; ***Italics underlined:*** secondary targets.

**Trend of the co-operations to growth or decline (1990-1998).**

**Legend: Bold if important target for a European country. Symbols suggest the trend (1990-98).**

**Source: P.L. Rossi, revised by Waast. Database: ISI.**

|                        | FRA | BEL | GBR | DEU | AUT | NLD | FIN | DNK | SWE | ITA | ESP |
|------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| ZAF                    |     |     |     |     |     |     |     |     |     |     |     |
| EGY                    |     |     |     |     |     |     |     |     |     |     |     |
| MAR                    |     |     |     |     |     |     |     |     |     |     |     |
| DZA                    |     |     |     |     |     |     |     |     |     |     |     |
| TUN                    |     |     |     |     |     |     |     |     |     |     |     |
| MOZ                    |     |     |     |     |     |     |     |     |     |     |     |
| KEN                    |     |     |     |     |     |     |     |     |     |     |     |
| NGA                    |     |     | =   |     |     |     |     |     | =   |     |     |
| ZWE                    |     |     |     |     |     |     |     |     |     |     |     |
| ZMB                    |     |     |     |     |     |     |     |     |     |     |     |
| TZA                    |     |     |     |     |     |     |     |     |     |     |     |
| UGA                    |     |     |     |     |     |     |     |     |     |     |     |
| MWI                    |     |     |     |     |     |     |     |     |     |     |     |
| ETH                    |     |     |     | =   |     |     |     |     |     |     |     |
| SDN                    |     |     |     |     |     |     |     |     |     |     |     |
| SOM                    |     |     |     |     |     |     |     |     |     |     |     |
| GHA                    |     |     |     |     |     |     |     |     |     |     |     |
| GMB                    |     |     |     |     |     |     |     |     |     |     |     |
| CMR                    |     |     |     |     |     |     |     |     |     |     |     |
| CIV                    |     |     |     |     |     |     |     |     |     |     |     |
| SEN                    | =   |     |     |     |     |     |     |     |     |     |     |
| RDCon                  |     |     |     |     |     |     |     |     |     |     |     |
| RWA                    |     |     |     |     |     |     |     |     |     |     |     |
| BDI                    |     | =   |     |     |     |     |     |     |     |     |     |
| GAB                    |     |     |     |     |     |     |     |     |     |     |     |
| MDG                    |     |     |     |     |     |     |     |     |     |     |     |
| CGO                    |     |     |     |     |     |     |     |     |     |     |     |
| BFA                    |     |     |     |     |     |     |     |     |     |     |     |
| NER                    |     |     |     |     |     |     |     |     |     |     |     |
| MLI                    |     |     |     |     |     |     |     |     |     |     |     |
| <b>Africa (North)</b>  | ↑   | ↑   | =   | =   | =   | =   | ↑↑  | ↑   | ↑   | ↑↑  | ↑↑  |
| <b>Africa (South)</b>  | ↑   | ↑   | ↑   | ↑   | ↑↑  | ↑   | ↑↑  | ↑↑  | ↑   | =   | ↑↑  |
| <b>Africa (middle)</b> |     | =   | ↑   | =   | ↑↑  | ↑   | =   | ↑↑  | ↑   | =   | =   |
| <b>Africa</b>          | ↑   | =   | ↑   | ↑   | ↑↑  | ↑   | ↑   | ↑↑  | ↑↑  | ↑   | ↑↑  |

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