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WOMEN AND SCIENCE-LED DEVELOPMENT*

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I. INTRODUCTION

1. The application of science and technology to development in Africa remains a major challenge even after numerous attempts to implement strategies (1, 2, 3) for the promotion of a science-led modernization of all economic sectors. These strategies have portrayed development as a process of social transformation whose success depends on the involvement of all levels of society in Africa, where 70 to 80 per cent of the population reside in rural areas. Successful application of science to development will be measured by the amelioration of the quality of life of the majority of the population. It must ensure improvements in food production, nutrition, health and educational services, and the arrest and reversal of environmental degradation which has become a widespread phenomenon in the continent.

2. The inability to merge science, technology and development at the practical level may be attributed to the many socio-cultural, economic and political factors which have influenced the course of events in Africa in the past 20-30 years. These factors, coupled with a series of natural disasters such as drought, have precipitated what has come to be known as the "economic crisis" which intensified in the 1980s and persists to the present day.

3. Many believe that one of the most essential steps to be taken towards the harnessing of science and technology in Africa is the building of indigenous capacities to devise long-term strategies for science-led development, based on the socio-economic realities of the continent. This means that priority must be given to the generation of human resources to direct the scientific endeavour towards a total social transformation, not only in terms of industrialization but also in terms of the provision of basic needs and the improvement of the quality of life of the majority of Africa's people.

4. It is in this context that the role of women in the scientific development of the continent is examined and seen as a critical means of building and strengthening the continent's scientific capacity, through mobilizing this group whose perceptions of the problems may add dimensions hitherto unforeseen. Women in Africa constitute more than half of the population and their under-representation in science and technology at the leadership and research levels deprives the continent of a substantial and essential output, and amounts to a neglect of 50 per cent of the human potential - which the continent can hardly afford, especially at this time. The following account attempts to present aspects of women's roles and to make recommendations for their use as a base in the construction of a scientific plan of action which will recognize women's strength and pave the way for their involvement in Africa's scientific leadership and research.

II. WOMEN'S SOCIAL ROLES

5. Over centuries and in almost all societies, a separation of roles for men and women has existed and formed the basis for social organization and cohesion. Some roles, such as child-bearing, can be said to be "divinely decreed" but others have emerged as societies evolved from the diverse socio-economic and cultural structures which richly endow the world. Africa shares with the rest of the world a multiplicity of cultures which, although diverse, nevertheless have sufficient common factors to allow important generalizations to be made. For example, in most African cultures, men's and women's roles are separate but specific and functional and therefore complement each other and none is perceived as more important than or inferior to the other (4). Women's traditional roles confine them close to the family and engage them in the provision of food, energy and water and in the general physical sustenance of families and communities. In this role, they are involved in the tillage of the soil, in harvesting fruits and fuel from the forests and in the search for an maintenance of water resources. Their role remains crucial in the physical usage of the environment to meet society's basic needs and there is no doubt that they have accumulated a wealth of knowledge based on their experience. Women also play a critical role in the transmission of social values and norms from generation to generation and conversely can also be promoters of social change - an important prerequisite for many aspects of sustainable development. These roles are fundamental to the survival and stability of societies and continue to be important at this stage when all of Africa is in a state of flux, undergoing major socio-political and economic changes. The roles constitute a potential strength which

would enable women scientists to make a major impact by influencing scientific agenda to take into account social concerns and, through their own scientific involvements, influencing society to embrace the positive aspects of science and technology.

6. Society "values" the specific roles of women but also believes that because of their closeness to basic human life, women's perceptions of social and economic issues are always tinged with humane considerations (5). Although this is often regarded as a weakness, it is actually a strength in the formulation of development strategies that touch upon the human condition. It is a strength that can form a basis for mobilizing women scientists to undertake scientific activities with a difference, collaborating with people in the social sciences and the humanities.

7. Since 1975, the United Nations has provided extensive information on the global situation of women and has documented their under-representation in decision making and their limited participation in key areas such as education. It has been acknowledged that although the United Nations initiatives succeeded in raising awareness in the discrimination against women among member States, much remains to be done. Perhaps it is now time to seek new approaches to promoting women's participation in development and, in particular, in science and technology.

8. Whereas most past strategies for promoting the role of women in development have tended to consider women as one homogenous group, it is proposed that women be separated into appropriate groupings during the formulation of strategies for their advancement. This approach should not be seen as divisive and weakening the "together we stand" approach but rather as a way of providing manageable assignments for researchers and others seeking to advance the cause of women. Women in science are one group who share common problems with other women but who need special attention in a specific manner to progress in their field.

9. Since education is a prerequisite to scientific development, a brief review of relevant aspects of women's education in Africa will provide a basis for discussing their strengths in science. The problems of the education of girls at the primary and secondary levels is acknowledged as the main source of the problems at the higher levels, but this paper will concentrate on the tertiary level without in any way losing sight of the broader and complex problems at the lower levels.

III. EDUCATION AND TRAINING IN AFRICA

10. African countries have long recognized the value of education as the means for the production of appropriate human resources to carry out the diverse development tasks, including the utilization of science and technology. This is evidenced by the huge public expenditure on education during the post-independence decades even through the years of the so-called economic "crisis" (see table 1).

11. The World Bank reports that between 1960 and 1983, the number of students enrolled at all levels in Africa quintupled to about 63 million and it also notes an impressive rise in university enrolment and graduate output (6). Table 2 shows numbers of students in higher education per 100,000 inhabitants: a steady rise in female enrolment is indicated. It is noteworthy that, in spite of this impressive enrolment, figures remain well below 1 per cent in all sub-Saharan Africa and are among the lowest in the world (7). There is, however, a critical imbalance between the numbers of students in the natural sciences, engineering, medical and agricultural sciences and those in areas such as the humanities and social sciences; the proportion of women in these areas is very low indeed in many countries (see table 3). The seriousness of the problem is highlighted when the numbers of scientists and engineers per 1 million inhabitants and the proportional expenditure on scientific research and development in Africa is compared to that of other regions of the world (see table 4). There is no doubt that sub-Saharan Africa has a long way to go in the production of science and technology manpower and must devise ways to tap the potential of women in science.

12. The praiseworthy developments in higher education have not stamped out the tendency for the best graduates to go abroad for post-graduate training. Large numbers of African students are enrolled in higher education institutions in the United States of America, in the United Kingdom and in Canada (8). African institutions of higher learning have, therefore, serious inhibitors to the development of post-graduate studies and of strengthened regional cooperation among themselves. This situation is being exacerbated by the economic difficulties which universities continue to face, preventing them from doing more than teach the basic undergraduate programmes.

13. These problems have important implications for the training of women who, because of socio-cultural pressures, tend to get married and start a family soon after obtaining a first degree. Once married, family responsibilities prevent them from travelling abroad for advanced studies which may not be available at local institutions. Women are thus unable to undertake the kind of training required for a strong career in science. It is, however, not just the lack of training opportunities that hinder women from pursuing careers in science; it is also the kind of devotion required for successful scientific pursuits. Women's multiple roles do not permit them to devote the time required for scientific and technological research and the other demands in these fields.

14. From the above discussion, the following conclusions can be drawn:

(a) In spite of the heavy investment in higher education, the numbers of students enrolled in tertiary institutions in Africa are lower than those in other regions of the world. Women are generally under-represented in higher education although a steady increase in female enrolment is observed. There is thus need to re-examine and analyze the performance of higher education in Africa and the participation of women at this level, in particular;

(b) The numbers of students graduating in science and in the science-based disciplines are much lower than in other disciplines and are among the lowest in the world. The numbers of women graduating in these fields are much lower than those of men. There is an urgent need to revitalize science and technology education in African institutions of higher learning, both at the undergraduate and post-graduate levels. Special attention must also be paid to the development of post-graduate training in the sciences as a way of strengthening each institution's production of science and technology manpower and also as a means of providing greater opportunities for women to pursue advanced studies in science without jeopardizing their family commitments.

IV. WOMEN IN SCIENCE IN AFRICA

15. In order to assess the participation of women in science, it is necessary to make a brief reference to the participation of girls in science at the secondary level of education. Studies commissioned by the Economic Commission for Africa (ECA) in 1988 evaluated women in science- and technology-based training programmes and professions in Kenya, Sierra Leone and Swaziland. It was reported that girls and women were marginally represented in these areas and this was the case even in Swaziland where there is almost equal enrolment of girls and boys at both the primary and secondary schools (9).

16. For example, in the 1985 Cambridge Overseas School Certificate (COSC) examination in Swaziland, 27 per cent of the male and 16 per cent of the female candidates respectively registered for science subjects. Similar proportions were observed in the 1992 examinations. In Sierra Leone, low enrolment and poor performance of girls in science subjects were also reported (10) and this seems to be the situation in many African countries. The low participation of girls in science education in schools in Africa sets the stage for their small number in science and technology disciplines at universities.

17. From table 4 it may be seen that among the African countries, Lesotho and Swaziland, which have almost equal participation of girls and boys in education at the primary and secondary levels, have relatively

high female enrolment in the natural sciences, an indication that greater access of girls to education at the lower levels may increase their entry into scientific disciplines.

18. Table 5 shows student subject choices in the second year of the Bachelor of Science degree at the University of Swaziland. There is a clear female preference for biology/chemistry, a trend which is reported in many other institutions. It is also interesting to note that the female students perform quite well, on average, in their chosen fields.

19. Table 6 has been compiled from an inventory of third world women scientists provided by the Third World Organization for Women in Science (TWOWS). Women's disciplinary choices are very clear and this seems to be the position in each of the regions of the third world.

20. Table 7 shows the paucity of female leadership in university faculties of science, engineering and medicine in selected African universities. Women are concentrated at the lower ranks of academic scientific leadership, and thus young female undergraduates aspiring to study science beyond the first degree lack role models to demonstrate that women have the capacity to rise to the top of scientific professions. This endorses the belief that science and technology are masculine preserves and perpetuates the lack of confidence to embark on scientific careers among young women.

21. From the above discussion, it can be concluded that women in Africa are under-represented in science and technology at the undergraduate level while those who study science tend to favour the biological, medical and agricultural sciences and few select physics and mathematics. This tendency strongly suggests that women may also lean towards biotechnology as a field of study. There is an indication, although not well documented, that women may also select computer science as a favoured field. It is interesting to note that those women who have elected to study physics and mathematics, particularly in West Africa, have done well.

22. When the overwhelming problems of Africa are considered, it would appear that women tend to choose scientific areas of study which are of direct relevance to these problems. Some of Africa's greatest concerns today include finding ways to increase food production, to manage natural resources and the environment, nutrition, improved health and education. These areas are in many ways related to those in which women have traditionally found their functions. It is perhaps in these areas that a plan of action could be considered to enable women scientists to exercise their research skills without giving up their social responsibilities which are essential for the survival and stability of society. The following interventions are presented as ways of leading women's strengths towards building Africa's scientific capacity.

A. Strengthening science and technology education in Africa

23. There is no doubt that improving the quality of general education and of science education in particular is essential in building science and technology capabilities in Africa. In both contexts, the participation of girls and women requires special attention. Whereas there is a lot of information on the numbers of girls and women enrolled at the primary, secondary and tertiary levels, information about girls and women in science in scarce. There is need to gather this information in order to facilitate the formulation of appropriate interventions.

24. There are various initiatives, already under way, aimed at strengthening African institutions of higher learning. These could be expanded to take into account the problems of women's education in science and technology. The Association of African Universities (AAU) is undertaking various strategies to revitalize higher education in Africa. These attempts deserve support because African universities have a central role to play in capacity building in the continent.

25. One of AAU's concerns is strengthening post-graduate education and research. It is in this context that a special programme on science and technology training, paying special attention to the participation of women, could be considered. Selected institutions might contemplate developing or strengthening post-graduate research and training in areas of female strength and accept to design mechanisms intended to facilitate the admission of women. Such mechanisms could include upgrading programmes for candidates seeking admission after several years out of formal education and staggering graduate timetables to take into account women's varied roles. This experiment might work at the post-graduate level where rigid institutional requirements might be modified.

B. Supporting women's scientific organizations

26. The formation of special programmes and organizations for women always elicits a lot of debate on the wisdom of such action in view of the expressed desire to bring women into the mainstream of international scientific activities. This is a valid concern but when the very poor involvement of women in such activities is examined, special action is clearly justified. The programmes and organizations already in operation must be supported. These include:

(a) The African Academy of Sciences Programme on Research Priorities for the Education of Girls and Women in Africa: This programme targets all female education at all levels. As suggested earlier, there should be a special focus on higher education in science as a means of cultivating female leadership in science and technology;

(b) The Third World Organization for Women in Science (TWOWS): Formed under the auspices of the Third World Academy of Sciences (TWAS) in 1989 and officially launched in January 1993, with its headquarters in Trieste, Italy, TWOWS has as its overall objective the promotion of women in science and technology in the third world. It lays emphasis on strengthening women's research activities. TWOWS also aims to promote scientific cooperation at the regional and global levels. In this context, the formation of regional and inter-regional research networks, involving African women scientists, might be one way of supporting women's research efforts in their areas of strength.

27. TWOWS is already running a programme of travel grants to all third world women to enable them to attend conferences and short courses. The Organization has a membership approaching 2,000 with nearly 500 members from Africa.

28. In conclusion, it must be emphasized that although the above discussion has been confined to women scientists at the tertiary level, it is accepted that the major problems of women in science lie in the lower levels of education. This paper however has attempted to highlight the scientific strengths of women and their potential for enabling women to take up influential leadership in the development of science and technology in Africa.

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Table 1. Public expenditure on education as a percentage of GNP and of all public expenditure for selected African countries

Country	Expenditure as % of GNP				As % of total government expenditure			
	1975	1980	1985	1989	1975	1980	1985	1989
Botswana	8.5	7.8	8.0	8.2	18.8	16.1	15.4	16.3
Burkina Faso	1.9	2.2	2.0	2.3	19.0	19.8	21.0	17.5
Burundi	...	3.0	2.5	3.2	...	17.5	15.5	16.7
Cameroon	3.9	3.2	3.0	3.3	21.3	20.3	14.8	18.7
Central African Republic	4.9	3.8	2.6	2.9	20.1	20.9	...	16.8
Congo	8.1	7.0	5.1	...	18.2	23.6	9.8	...
Côte d'Ivoire	6.6	7.0	...	...	19.0	22.6	...	...
Egypt	5.1	5.7	6.3	6.8	...	9.4	...	...
Ethiopia	3.3	3.3	4.3	4.4	14.5	10.4	9.5	9.4
Gabon	2.1	2.7	4.5	5.6	...	...	9.4	...
The Gambia	3.2	3.3	4.2	4.0	...	...	...	8.8
Ghana	5.9	3.1	2.6	3.4	21.5	17.1	19.0	...
Kenya	6.3	6.8	6.4	6.5	19.4	18.1	...	27.0
Lesotho	4.5	5.1	3.7	4.0	23.5	14.8	...	...
Liberia	1.9	5.7	...	...	11.6	24.3	...	...
Libyan Arab Jamahiriya	5.9	3.4	8.2	...	14.5	...	19.8	...
Madagascar	2.5	4.4	2.8	1.8	18.5	...	...	...
Malawi	2.4	3.4	3.5	3.3	9.6	8.4	9.6	...
Mali	...	3.8	3.7	3.3	...	30.8	...	17.3
Mauritius	3.6	5.3	3.8	4.1	9.6	11.6	9.8	10.4
Morocco	5.1	6.1	7.4	7.3	14.3	18.5	26.7	25.5
Niger	2.4	3.1	...	3.1	18.7	22.9	...	9.0
Nigeria	2.9	5.5	1.0	...	....	24.7	8.7	...
Rwanda	2.3	2.7	3.2	4.2	25.3	21.6	25.1	25.4
Seychelles	4.4	5.8	10.7	9.1	9.5	14.4	21.3	15.2
Sierra Leone	3.4	3.8	...	...	...	11.8	...	...
Somalia	2.1	1.0	0.5	...	12.5	8.7	4.1	...
Sudan	5.5	4.8	...	...	14.8	9.1	...	...
Swaziland	3.7	6.2	6.0	6.2	...	...	...	...
Tanzania, United Republic of	5.4	4.4	3.6	3.7	17.8	11.2	14.0	14.0
Togo	3.5	5.5	4.9	5.2	15.2	19.4	19.4	21.2
Tunisia	5.2	5.4	5.9	...	16.4	16.4	14.1	...
Uganda	2.5	1.2	3.1	...	17.0	11.3	...	...
Zaire	...	2.5	1.0	0.9	...	24.2	7.3	6.4
Zambia	6.7	4.5	5.5	...	11.9	7.6	16.3	...
Zimbabwe	3.6	6.6	9.2	8.5	...	13.7	15.0	...

Source: Compiled from UNESCO Statistical Yearbook 1993.

... Data not available.

Table 2. Number of students at tertiary level per 100,000 inhabitants and percentage of female students, selected countries

Country	1975		1980		1985		1989/1990	
	No. per 100,000	% female	No. per 100,000	% female	No. per 100,000	% female	No. per 100,000	% female
Benin	70	15	139	...	227	16	198	14
Botswana	62	32	120	35	179	...	255	45
Burkina Faso	17	20	24	22	57	23	65	...
Central African Republic	33	...	74	8	100	11	...	13
Congo	224	10	435	15	551	16	...	15
Côte d'Ivoire	106	17	240	...	200	...	...	...
Egypt	1,323	30	1,751	32	1,837	30	...	18
Ghana	92	16	144	...	132	...	127	...
Guinea	299	18	409	19	176	14	...	...
Kenya	65	...	78	...	108	26	135	...
Lesotho	46	42	141	...	158	63	...	72
Libyan Arab Jamahiriya	549	18	663	25	792	...	1,548	46
Madagascar	110	52	258	...	374	38	319	44
Malawi	42	14	56	31	54	29	...	25
Mali	48	10	41	11	86	13	73	13
Morocco	262	19	580	...	822	32	983	36
Niger	11	10	26	20	48	18	60	15
Nigeria	68	...	191	...	290	26	...	...
Rwanda	25	...	24	10	33	14	48	19
Senegal	171	20	246	18	209	...	253	...
Sudan	133	16	154	27	171	37	246	40
Swaziland	210	...	334	39	415	...	426	42
Tanzania, United Rep. of	19	14	23	15	22	14	20	...
Tunisia	365	26	499	30	573	36	784	38
Uganda	49	18	45	23	65	23	...	28
Zambia	174	14	131	...	126	...	178	28
Zimbabwe	138	...	117	...	372	...	585	...
Argentina	2,291	47	1,741	50	2,790	52	...	...
Chile	1,446	44	1,305	43	1,629	43	1,938	...
Mexico	908	...	1,387	33	1,598	38	1,552	43
Afghanistan	80	14	142	16	154	15	147	32
Bangladesh	207	13	272	15	454	20	382	17
China	54	34	117	24	166	31	186	35
Saudi Arabia	364	22	662	31	917	45	1,035	49
United Arab Emirates	...	...	282	68	576	75	642	83
Denmark	2,179	44	2,074	48	2,271	49	2,781	51
Italy	1,762	38	1,981	41	2,074	45	2,519	46
Netherlands	2,109	32	2,545	39	2,795	40	3,205	44

Source: Compiled from UNESCO Statistical Yearbook 1991 and 1993.

Table 3. Enrolment[a] for selected faculties in selected universities, showing total number of students and the percentage representation of females

Country	Date of data	Humanities		Law		Social sciences		Natural sciences		Mathematics/ Computer science		Medical courses		Engineering		Agriculture	
		Total	% F	Total	% F	Total	% F	Total	% F	Total	% F	Total	% F	Total	% F	Total	% F
Burkina Faso	1990	936	39	493	27	1203	23	563	12	433	5	414	18	-	-	110	8
Ethiopia	1991	704	28	222	10	2591	22	1700	6	468	9	929	6	2070	5	1387	9
Ghana	1990	2339	31	39	50	804	27	955	15	206	11	824	23	635	3	479	11
Lesotho	1991	459	65	132	43	69	58	312	36	*	*	-	-	-	-	19	84
Niger	1989	709	14	851	3	636	21	280	6	*	*	432	26	98	4	164	6
Swaziland	1991	287	63	205	40	233	51	341	33	*	*	-	-	-	-	90	28
Zimbabwe	1991	1321	38	345	32	1885	29	1031	19	*	*	866	27	725	30	357	16
Kuwait	1991	2257	66	602	50	1580	74	1593	65	1636	72	791	63	1342	39	-	-
Brazil	1991	140566	74	159390	44	161214	57	41158	49	70898	38	137602	64	150015	17	38700	30
Mexico	1990	15003	57	121621	40	80792	59	39541	54	51751	41	94622	54	279989	16	24620	21
Italy	1991	207046	80	244446	53	375341	47	97945	51	49910	42	110644	50	165480	11	32097	34
Sweden	1991	2763	64	5174	54	5606	74	3425	53	6504	19	8994	62	20124	21	1205	45

Source: Compiled from data in the UNESCO Statistical Yearbook, 1993.

[a] Figures represent enrolment at ISCED Level 6, i.e., in courses leading to a first degree.

* Not separated from natural science figures.

Table 4. Scientific and technical manpower and expenditure on research and development: estimates for 1980, 1985 and 1990

Continents, major areas and groups of countries	Year	R&D scientists and engineers per million population	R&D expenditure as % of GNP
World total	1980	894	1.85
	1985	920	2.22
	1990	1,000	2.55
Africa	1980	111	0.28
	1985	106	0.25
	1990	117	0.25
America	1980	1,268	1.85
	1985	1,390	2.35
	1990	1,509	2.87
Asia	1980	310	1.40
	1985	342	1.77
	1990	401	2.05
Europe	1980	1,859	1.81
	1985	1,927	2.02
	1990	2,206	2.21
Oceania	1980	1,774	1.25
	1985	1,414	1.20
	1990	1,610	1.38
Former USSR	1980	5,172	4.69
	1985	5,385	5.03
	1990	5,892	5.66
Africa (excluding Arab States)	1980	84	0.30
	1985	72	0.28
	1990	74	0.29
Asia (excluding Arab States)	1980	304	1.41
	1985	336	1.80
	1990	396	2.08
Arab States	1980	330	0.97
	1985	336	0.94
	1990	363	0.76
North America	1980	2,734	2.23
	1985	3,024	2.66
	1990	3,359	3.16
Latin America and the Caribbean	1980	242	0.44
	1985	312	0.43
	1990	364	0.40

Source: Compiled from UNESCO Statistical Yearbook 1993

Table 5. Subject choices in Year 2, by gender and performance in 1993/94, University of Swaziland

Subjects chosen	No. of students		Gender as % of year total		Examination average score	
	Male	Female	Male	Female	Male	Female
Biology/chemistry	18	9	33	50	57/59	63/61
Biology/geography	4	4	7	22	55/62	62/65
Geography/mathematics	2	1	4	5.5	62/56	70/63
Chemistry/mathematics	15	3	27	17	62/65	67/68
Mathematics/computer	4	1	7	5.5	57/63	59/63
Physics/mathematics	12	0	22	0	65/57	-
Year totals	55	18	100	100	-	-

Source: University registry records.

The first-year students all take introductory courses in all science options. In Year 2, a choice of two subject majors is made. Performance here is the average score in the end-of-year examinations.

Table 6. Third World Organization of Women Scientists: African membership by discipline

Discipline of study	No. of members	No. as % of total
Agricultural sciences	29	11
Biological sciences	80	29
Medical and veterinary sciences	62	24
Earth and environment	22	8
Chemistry	39	14
Physics	10	4
Mathematics	11	4
Engineering	3	1
Social and management sciences	13	5

Source: TWOWS Report.

Table 7. University staff (expatriate and local), in science-related faculties, by rank and gender in selected African universities

Country	Professors		Senior lecturers		Lecturers	
	Male	Female	Male	Female	Male	Female
Botswana	7	0	15	1	47	1
Ghana*	73	1	136	17	294	40
Kenya/Nairobi	111	3	139	15	289	40
Lesotho	9	0	15	1	22	2
Malawi	24	1	45	7	64	13
Nigeria/Ibadan	134	6	169	25	174	38
Swaziland	6	1	18	0	42	11
Tanzania	56	2	101	3	137	10
Zambia	26	3	36	0	178	21
Zimbabwe	35	2	70	10	181	38

Source: Compiled from Commonwealth Universities Yearbook, 1993.

* Conflated data from Legon, Cape Coast and University of Science and Technology at Kumasi.

Science: Natural sciences, agriculture, engineering, earth and environmental sciences, mathematics and computer science, medicine and veterinary science.