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Indian National System of Innovation and Globalisation: Some Lessons for African National System of Innovation

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Themes of the Paper:

- **National Innovation System and Developing Countries**
- **Evolution of Indian National Innovation System**
- **Lessons for African National Innovation System**

NIS and Developing Countries

- **Concept of NIS helps to understand varied nature of the process of acquiring technological capabilities both the developed and developing world**
- **NIS evolves into different shapes due to national differences in institutions, incentive structures and the timing of entry into industrialisation process**
- **Example: East Asian experience**



Three major elements of NIS:

- **R&D Performing Institutions**
- **Incentive Structures**
- **Supporting Institutions**
- **Strong linkages between these three leads to an efficient NIS**
- **Selective linkages or absence of a particular element is likely to result in 'lopsided' or 'duality' Phenomenon in the NIS**

Figure 1: Three Major Elements of National Innovation System

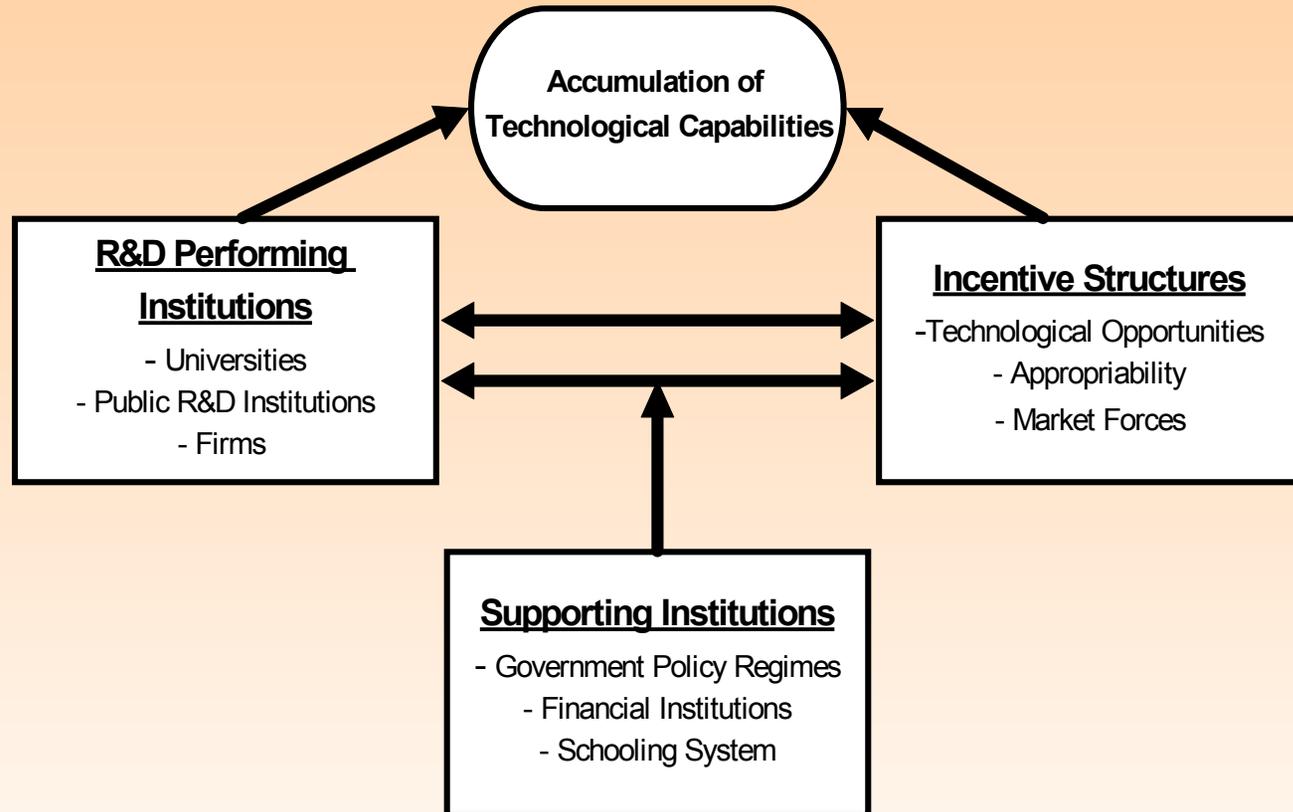
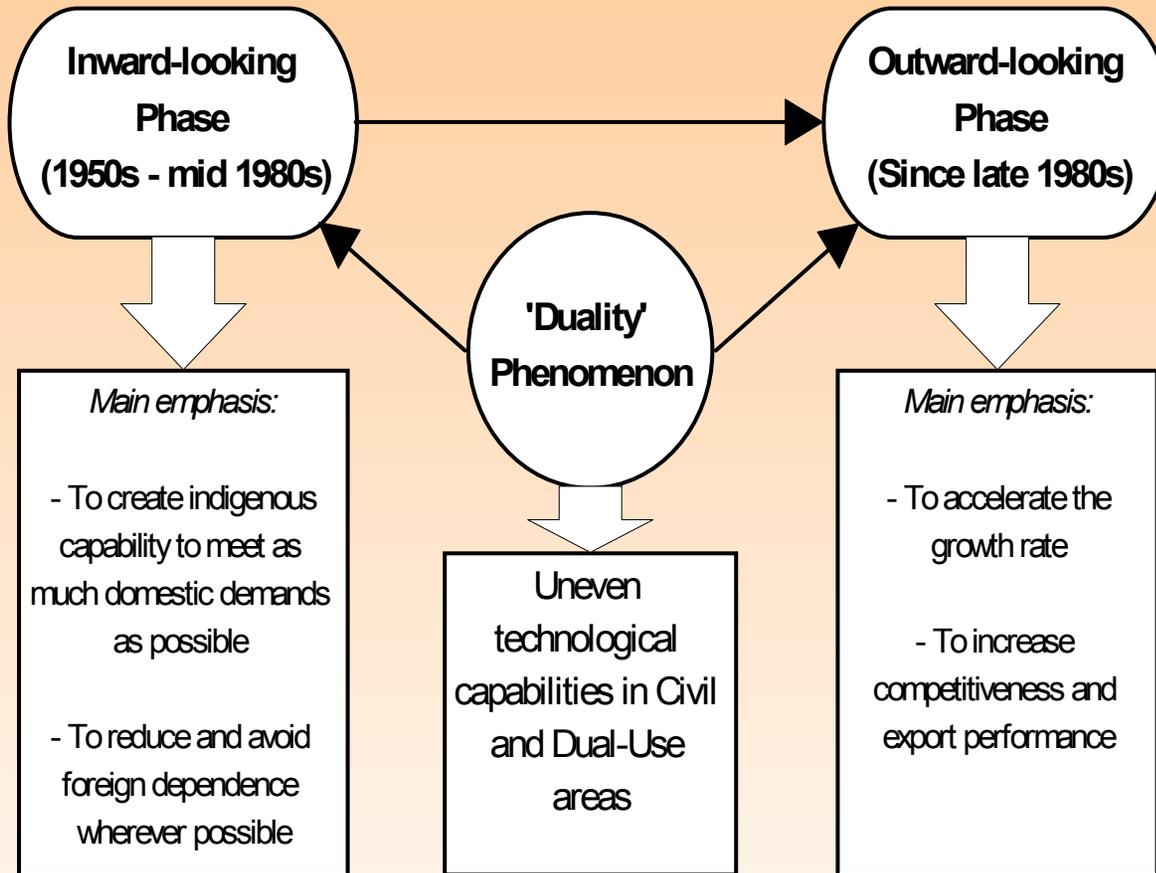


Figure 2: Three Major Features of Indian National Innovation System



Major Factors Driving Inward Looking Phase of Indian NIS (1950s-1980s):

- **'Blind faith' in S&T – Establishment of basic S&T infrastructure**
- **Inward looking 'self-reliance' policy – Aimed to local capabilities to meet domestic demands and reduce foreign dependence**

Self-reliance policy influenced the industrial policies, financial market, and technology import policy



Two major developments in the Inward-looking phase:

Positive side:

- **Developed a high level of technological capabilities in many areas of industry**
- **R&D institutions established a strong research base and became capable of conducting research at frontier level**

Negative side:

- **Indian firms hardly made major innovations**
- **Linkages between the R&D institutions and the industry was nearly absent**
- **The industrial and economic growth and competitiveness were low**

Forces of Globalisation and Shift towards Outward-looking NIS

Industrial Policy – 1991:

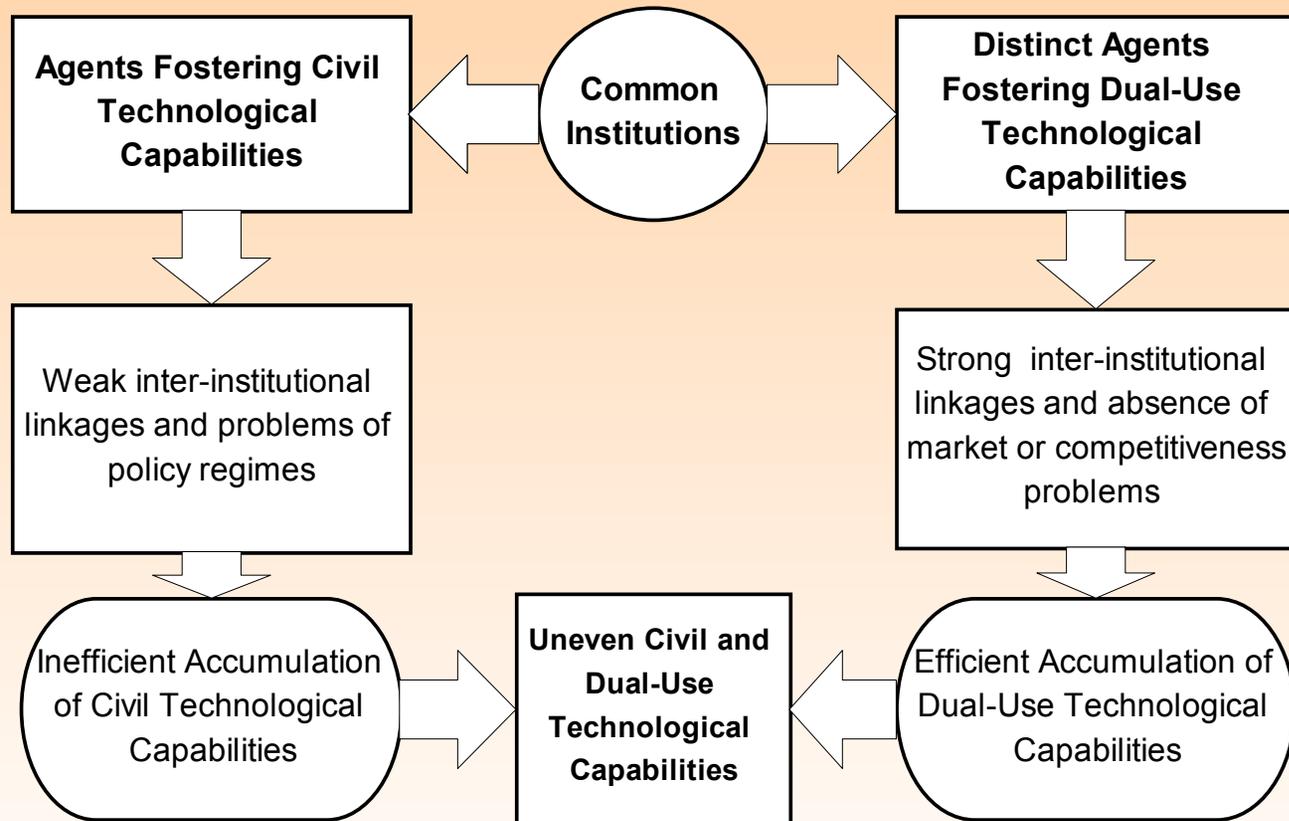
- **Shift from Import regulating activity to Export promotion activity**
- **The main change is the reforming policy regimes not the institutions themselves, though some efforts are made**

The Impact (though not fully clear):

- **Foreign technology imports and investment have increased**
- **Opening of R&D centres by some MNCs – Collaboration within Indian S&T institutions**
- **Outsourcing of operations by foreign companies, mainly in the service sector**
- **Small decline of R&D investment in domestic R&D by private firms**
- **Slow progress in export and competitiveness, except IT sector.**

Duality in the Indian NIS

Figure 3: Duality in Indian National Innovation System





Performance of NIS

- **Created a 'lopsided' innovation system**
- **Despite major weakness – low growth and poor export, led to significant achievements:**
 - **Significant R&D investment -- S & T infrastructure, expansion of higher education and strong basic research**
 - **Technological capabilities in many industrial sectors**
 - **Creation of scientific and industrial potential to become more competitive**
 - **Since early 1990s GDP growth higher than in the past, not consistent**

Table 1: Comparison of Major Economic Indicators and R&D Expenditure as Percentage of GNP between India and Selected Countries (World-wide)

Country	Year *	R&D Expenditure (% of GNP)	Gross National Product (GNP) in US\$ -billions (1999)	Per Capita GNP in US\$ (1999)	GNP— Average Annual % Growth 1998-99	GDP— Average Annual % Growth 1990-99
India	1998	0.82	442.2	480	6.9	6.1
Argentina	2000	0.45	277.9	7 600	- 2.9	4.9
Brazil	2000	0.77	742.8	4 420	- 2.0	2.9
Canada	2000	1.84	591.4	19 320	3.8	2.3
China	2000	1.00	980.2	780	7.2	10.7
Egypt	2000	0.19	87.5	1 400	5.7	4.4
France	2000	2.15	1 427.2	23 480	2.4	1.7
Germany	2000	2.48	2 079.2	25 350	1.2	1.5
Israel	1999	3.62	---	---	--	5.1
Japan	2000	2.98	4 078.9	32 230	1.0	1.4
Madagascar	1995	0.18	3.7	250	5.5	1.7
Nigeria	1987	0.09	37.9	310	3.0	2.4
Republic of Korea	2000	2.68	397.9	8 490	11.0	5.7
Russian Federation	2000	1.00	332.5	2 270	1.3	- 6.1
Senegal	1997	1.40	4.7	510	5.1	3.2
Singapore	2000	1.88	95.4	29 610	5.6	8.0
South Africa	1993	0.70	133.2	3 160	0.8	1.9
Spain	2000	0.94	551.6	14 000	3.7	2.2
Sweden	1999	3.80	221.8	25 040	3.9	1.5
Tunisia	2000	0.45	19.9	2 100	6.2	4.6
Uganda	1999	0.75	6.8	320	7.7	7.2
UK	1999	1.87	1 338.1	22 640	1.7	2.2
USA	2000	2.69	8 351	30 600	4.1	3.4

Source: UNESCO, *Statistical Year Book 1999 and Science and Technology: Selected R&D Indicators (1996-2000)*, November 2002; World Bank, *World Development Report 2000-2001*

* Year relates to R&D Expenditure (% of GNP) only

Table 3: Comparison of Number of Scientists, Engineers, and Technicians (SET) -- Between India and Selected Countries (World-wide)

Country	Year *	All R&D Personnel	Research Persons	Technicians	Support Staff	Year **	Research Persons / million	Technicians / million
India	1996	357 172	149 326	108 817	99 029	1994	149	108
Argentina	2000	37 515	26 420	5 707	5 228	1995	660	147
Brazil	2000	78 565	55 103	21 914	1 548	1995	168	59
Canada	1998	139 570	90 200	31 380	19 560	1993	2 648	1 070
China	2000	922 131	695 062	---	---	1995	347	200
Egypt	1991	102 296	26 419	19 607	56 274	1991	459	341
France	2000	314 452	160 424	---	---	1994	2 583	2 873
Germany	1999	480 415	255 260	110 364	114 415	1993	2 843	1 472
Israel	1997	13 110	9 161	3 023	926	1984	4 828	1 033
Japan	1999	919 132	658 910	84 527	175 695	1994	6 293	827
Madagascar	2000	985	240	730	15	1994	12	37
Nigeria	1984	18 345	1650	9 696	6 999	1987	15	76
Republic of Korea	1999	137 874	100 210	26 160	11 504	1994	2 637	318
Russian Federation	1999	989 291	497 030	80 498	411 76	1997	3 587	600
Senegal	1996	78	19	29	30	1996	3	4
Singapore	2000	19 365	16 633	---	---	1995	2 318	301
South Africa	1993	60 464	37 192	11 343	11 929	1993	1 031	315
Spain	1999	102 237	61 568	40 670	---	1994	1 211	343
Sweden	1999	66 674	39 921	---	---	1993	3 706	3 166
Tunisia	1999	5 363	3 149	292	1 922	1997	125	57
Uganda	2000	1 187	549	330	308	1997	21	14
UK	1998	---	157 662	---	---	1993	2 413	1 017
USA	1997	---	1 114 100	---	---	1993	3 676	---

Source: UNESCO, *Statistical Year Book 1999 and Science and Technology: Personnel Engaged in R&D (1996-2000)*, November 2002.

* Year relates to All R&D personnel, Researchers, Technicians and Support staff columns only.

** Year relates to Research persons / million and Technicians / million

Table 5: India – Trends of Major Macroeconomic Indicators (1990-91-- 2000-01)

<i>Country</i>	<i>1990-91</i>	<i>1991-92</i>	<i>1998-99</i>	<i>1999-2000</i>	<i>2000-01</i>
1. Growth Rate (%)					
GDP at constant factor cost	5.6	1.3	6.5	6.1*	4.0+
Industrial Production	8.2	0.6	4.1	6.7	5
Exports (BOP in US\$)	9	-1.1	-3.9	9.5	19.6
Imports (BOP in US\$)	14.4	-24.5	-7.1	16.5	7
2. As % of GDP at current market prices					
Total foreign investment net (BOP)	0.03	0.05	0.6	1.2	1
Foreign direct investment (FDI) net	0.03	0.05	0.6	0.5	0.4
3. Foreign Exchange Reserves (US\$ billion)	5.8	9.2	32.5	38	42.3
4. Debt Indicators					
External Debt/GDP ratio (%)	28.7	38.7	23.6	22.2	22.3
Debt service ratio (%)	35.3	30.2	18	16.2	17.1

Source: Government of India (Ministry of Finance), *Economic Survey 2001-2002*.

*Notes:** Provisional + Quick estimate

Table 6: Industrial Growth in India Between 1960 and 2000

<i>Year</i>	<i>Index</i>	<i>Growth rate</i>	<i>Year</i>	<i>Index</i>	<i>Growth rate</i>
<u>Base: 1970 = 100</u>			<u>Base: 1980-81 = 100</u>		
1960-61	55.8	---	1985-86	142.1	8.7
1963-64	72.3	9.3	1986-87	155.1	9.1
1964-65	78.6	8.8	1987-88	166.4	7.3
1965-66	84.8	5.3	1988-89	180.9	8.7
1966-67	83.3	0.6	1989-90	196.4	8.6
1967-68	82.8	1.2	1990-91	212.6	8.3
1968-69	89.9	6.7	1991-92	213.9	0.6
1969-70	96.8	7.6	1992-93	218.9	2.3
1970-71	100.7	4.1	1993-94	232.0	6.0
1971-72	106.4	5.6	<u>Base: 1993-94 = 100</u>		
1972-73	110.6	3.9	1994-95	109.1	9.1
1973-74	111.5	0.8	1995-96	123.3	13.0
1974-75	115.1	3.2	1996-97	130.8	6.1
1975-76	122.8	6.7	1997-98	139.5	6.7
1976-77	134.4	9.5	1998-99	145.2	4.1
1977-78	140.0	4.2	1999-2000	154.9	6.7
1978-79	150.7	7.6	2000-2001	162.7	5.0
1979-80	148.2	- 1.6			
1980-81	154.1	4.0			
1981-82	167.3	8.6			
1982-83	174.3	4.1			
1983-84	184.9	6.1			
1984-85	197.4	6.8			

Source: Government of India, Handbook of Industrial Policy and Statistics, 2001, p.303.

Summary:

- **Indian NIS is refining with more reforms of policy regimes and is likely to perform more efficiently**
- **But liberalisation of policy regimes may not be enough to realise its full potential**
- **Fundamental institutional and cultural changes are required**



Broad features that can describe African system of innovation in comparison to India:

- **Both technology and institutional dimensions are externally driven, India innovation system (lopsided and dualistic it may be) managed to internalise external knowledge.**
- **Africa's research environment including its science and technology system has been dominated by foreign sponsorship.**
- **R & D expenditure as share of GNP for the whole continent was a mere 0.28 per cent in 1980 and it dropped by 0.25 per cent by 1990, while India has made sustained investment.**

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- **In Africa the state support to R&D is yet to grow and supplant disproportionate donor funding. India funds its own science largely from its own resources.**
 - **Private sector contribution to innovations is largely from multinational companies. African centred R & D development and the link with production are yet to be developed. India's private sector is very active in innovative activity.**
 - **S&T human resources in Africa are below threshold to provide effective R&D leadership. India has trained skill labour which it is exporting.**

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- **Many African researchers are outside and those inside work for external actors and agencies. Indians work for both national and outside firms**
 - **No African research university comparable to major Western universities (except South Africa). India has a relatively functioning higher education system.**
 - **Indian system has stronger techno-economic networks relative to Africa, though it may still not be coherent enough in relation to the developed economies**

Table 7: R&D Expenditure and its Share in World Total by Continents (1980–1990)

<i>Continent</i>	R&D Expenditure (US\$ billion)			As % Share in World Total R&D Expenditure		
	<i>1980</i>	<i>1985</i>	<i>1990</i>	<i>1980</i>	<i>1985</i>	<i>1990</i>
Africa	1.1	0.9	1.1	0.5	0.3	0.2
America	70.4	118.9	196.6	33.8	43.7	43.4
Asia	31.7	47.2	91.2	15.2	17.4	20.2
Europe	70.7	65.6	105.0	33.9	24.1	23.2
Oceania	2.2	2.1	3.0	1.1	0.8	0.7
Former Soviet Union	32.3	37.2	55.7	15.5	13.7	12.3
World Total	208.4	271.9	452.6	100	100	100

Source: Government of India, *Handbook of Industrial Policy and Statistics*, 2001, p. 497

Table 2: Comparison of Major Economic Indicators and R&D Expenditure as Percentage of GNP between India and Selected African Countries

Country	Year *	R&D Expenditure (% of GNP)	Gross National Product (GNP) in US\$ -billions (1999)	Per Capita GNP in US\$ (1999)	GNP—Average Annual % Growth 1998-99	GDP—Average Annual % Growth 1990-99
<i>India</i>	<i>1998</i>	<i>0.82</i>	<i>442.2</i>	<i>480</i>	<i>6.9</i>	<i>6.1</i>
Benin	1989	—	2.3	380	5.1	4.7
Burkina Faso	1997	0.19	2.6	240	5.2	3.8
Burundi	1989	0.31	0.8	120	- 0.5	- 2.9
Central African Rep.	1984	0.25	1.0	290	3.7	1.8
Congo Rep.	1984	0.01	1.9	670	7.7	0.9
Egypt	2000	0.19	87.5	1 400	5.7	4.4
Madagascar	1995	0.18	3.7	250	5.5	1.7
Mauritius	1997	0.28	---	---	---	---
Nigeria	1987	0.09	37.9	310	3.0	2.4
Rwanda	1995	0.04	2.1	250	7.5	- 1.5
Senegal	1997	1.40	4.7	510	5.1	3.2
South Africa	1993	0.70	133.2	3 160	0.8	1.9
Togo	1994	0.48	1.5	320	2.1	2.5
Tunisia	2000	0.45	19.9	2 100	6.2	4.6
Uganda	1999	0.75	6.8	320	7.7	7.2

Source: UNESCO, Statistical Year Book 1999 and Science and Technology: Selected R&D Indicators (1996-2000), November 2002; World Bank, World Development Report 2000-2001

** Year relates to R&D Expenditure (% of GNP) only*

Table 4: Comparison of Number of Scientists, Engineers, and Technicians (SET) -- Between India and Selected Countries (Africa)

<i>Country</i>	<i>Year *</i>	<i>All R&D Personnel</i>	<i>Research Persons</i>	<i>Technicians</i>	<i>Support Staff</i>	<i>Year **</i>	<i>Research Persons / million</i>	<i>Technicians /million</i>
India	1996	357 172	149 326	108 817	99 029	1994	149	108
Benin	1989	2 687	794	242	1 651	1989	176	54
Burkina Faso	1997	780	176	165	439	1997	17	16
Burundi	1989	814	170	168	476	1989	33	32
Central African Rep.	1996	19 500	---	---	---	1990	56	32
Congo Rep.	2000	217	101	111	3	1984	462	789
Egypt	1991	102 296	26 419	19 607	56 274	1991	459	341
Madagascar	2000	985	240	730	15	1994	12	37
Mauritius	1992	1 162	389	170	603	1992	361	158
Nigeria	1984	18 345	1650	9 696	6 999	1987	15	76
Rwanda	1995	315	181	40	94	1995	35	8
Senegal	1996	78	19	29	30	1996	3	4
South Africa	1993	60 464	37 192	11 343	11 929	1993	1 031	315
Togo	1994	1 473	387	249	837	1994	98	63
Tunisia	1999	5 363	3 149	292	1 922	1997	125	57
Uganda	2000	1 187	549	330	308	1997	21	14

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