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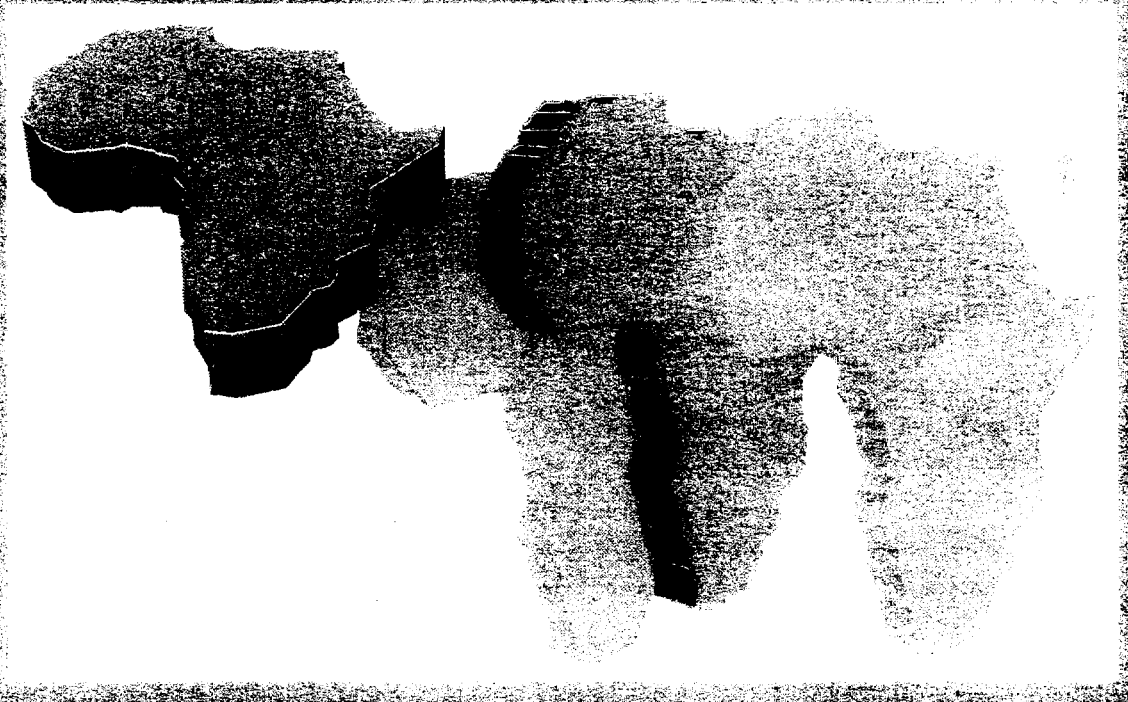
The Population, Agriculture and Environment Nexus in Sub-Saharan Africa (Revised)



Kevin Cleaver and Götz Schneider

Technical Department
Africa Region

The World Bank

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Kevin M. Cleaver and Götz A. Schreiber

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Foreword

Over the past 30 years, most of Sub-Saharan Africa has seen very rapid population growth, poor agricultural performance, and increasing environmental degradation. Why do these problems seem so intractable? Are they connected? Do they reinforce each other? If so, what are the critical links? These are questions that this study seeks to answer. The approach was to review the literature and available country data to test the hypothesis that there are strong inter-relationships between these phenomena. The findings suggest that this nexus is very much at work in Sub-Saharan Africa and that development efforts would be far more effective if their design reflected this.

Key links are found in traditional crop and livestock production methods, land tenure systems, women's responsibilities, traditional family planning mechanisms, and methods of forest resource utilization. The traditional systems and practices were well suited to people's survival needs when population densities were low. As populations grew slowly, they evolved in response. But with the acceleration of population growth in the 1950s, these traditional ways came under increasing strain -- eventually to the point of being overwhelmed. The results have been the triad of problems noted at the outset.

The solution to these problems are complex, which is why effective responses have not been forthcoming on a wide scale. The study suggests an action plan involving agricultural intensification, measures to increase demand by Africans for smaller families, land tenure reform, conservation efforts to address environmental problems, and actions to deal with the special problems of women. Important themes include the necessity for Africans themselves to lead this process. There is also an important need for incentives to create demand for agricultural intensification, for smaller families, and for conservation. The importance of relying on inter-relationships between these various parts of the solution in arriving at a significant impact on the problem is emphasized; hence the idea of a nexus of problems, and solutions.

Several country specific population, agriculture and environment nexus studies have been initiated to deepen this work, including in the Côte d'Ivoire, Malawi, Nigeria, Ethiopia, Rwanda, Kenya, Tanzania and the Sahel as a sub-region. Initial results have been summarized or incorporated into this study. Follow-up is ongoing in these countries largely in the context of environmental action plans, agricultural, forestry and human resource projects.

Acronyms and Abbreviations Used

ADB - African Development Bank
AIDS - Acquired Immune Deficiency Syndrome
CFCs - Chlorofluorocarbons
CMR - Child Mortality Rate
CNN - Cloud Condensation Nuclei
CPR - Contraceptive Prevalence Rate
DHS - Demographic and Health Survey
FAO - Food and Agriculture Organization of the United Nations
FHH - Female-Headed Household
FP - Family Planning
GEF - Global Environmental Facility
HYV - Higher-Yielding Variety
IARCs - International Agricultural Research Centers
IEC - Information, Education and Communication
IITA - International Institute of Tropical Agriculture
IMR - Infant Mortality Rate
IPM - Integrated Pest Management
ITTO - International Tropical Timber Organization
ITCZ - Inter-Tropical Convection Zone
IUCN - World Conservation Union (formerly International Union for Conservation of Nature)
LPG - Liquefied Petroleum Gas
MCH - Maternal and Child Health
NARS - National Agricultural Research System
NGO - Non-Governmental Organization
NRR - Net Reproduction Rate
SPAAR - Special Program for African Agricultural Research
SSA - Sub-Saharan Africa
STDs - Sexually Transmitted Diseases
TFR - Total Fertility Rate
UNDP - United Nations Development Programme
UNEP - United Nations Environment Programme
WFS - World Fertility Survey
WMO - World Meteorological Organization

Acknowledgments

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THE POPULATION, AGRICULTURE AND ENVIRONMENT NEXUS IN SUB-SAHARAN AFRICA

Executive Summary

A. The Three Basic Concerns

i. ***Population Growth.*** Sub-Saharan Africa (SSA) lags behind other regions in its demographic transition. The total fertility rate (TFR) -- the total number of children the average woman has in a lifetime -- for SSA as a whole has remained at about 6.5 for the past 25 years, while it has declined to about 4 in all developing countries taken together. As life expectancy in Sub-Saharan Africa has risen from an average of 43 years in 1965 to 51 years at present, population growth has accelerated from an average of 2.7 percent per annum for 1965-1980 to about 3.1 percent per year at present. Recent surveys appear to signal, however, that several countries -- notably Botswana, Zimbabwe, Kenya -- are at or near a critical demographic turning point.

ii. ***Agricultural Performance.*** Agricultural production in Sub-Saharan Africa increased at about 2.0 percent per annum between 1965 and 1980 and at about 2.1 percent annually during the 1980s. Average per capita food production has declined in many countries, per capita calorie consumption has stagnated at very low levels, and roughly 100 million people in Sub-Saharan Africa are food insecure. Food imports increased by about 185 percent between 1974 and 1990, food aid by 295 percent. But the food gap (requirements minus production) -- filled by food imports, or by many people going with less than what they need -- is widening. The average African consumes only about 87 percent of the calories needed for a healthy and productive life.

iii. ***Environmental Degradation.*** Sub-Saharan Africa's forest cover, estimated at about 679 million hectares in 1980, has been diminishing at a rate of about 3.7 million ha per annum, and the rate of deforestation has been increasing. As much as half of SSA's farm land is affected by soil degradation and erosion, and up to 80 percent of its pasture and range areas show signs of degradation. Degraded soils lose their fertility and water absorption and retention capacity, with adverse effects on vegetative growth. Deforestation has significant negative effects on local and regional rainfall and hydrological systems. The widespread destruction of vegetative cover has been a major factor in prolonging the period of below long-term average rainfall in the Sahel in the 1970s and 1980s. It also is a major cause of the rapid increase in the accumulation of carbon dioxide (CO_2) and nitrous oxide (N_2O), two greenhouse gases, in the atmosphere. Massive biomass burning in Sub-Saharan Africa (savanna burning and slash-and-burn farming) contributes vast quantities of CO_2 and other trace gases to the global atmosphere. Acid deposition is higher in the Congo Basin and in Côte d'Ivoire than in the Amazon or in the eastern United States and is largely caused by direct emissions from biomass burning and by subsequent photochemical reactions in the resulting smoke and gas plumes. Tropical forests are considerably more sensitive than temperate forests to foliar damage from acid rain. Soil fertility is reduced through progressive acidification. Acid deposition also poses a serious risk to amphibians and insects that have aquatic life cycle stages; this risk extends further to plants that depend on such insects for pollination.

B. The Nexus in Brief

iv. Sub-Saharan Africa's demographic, agricultural and environmental problems are closely linked in a nexus of mutually reinforcing causality chains. Key linkages are found in traditional crop production and livestock husbandry methods, traditional land tenure and land use practices, traditional

responsibilities of women in rural production and household maintenance, and traditional methods of utilizing woodland and forest resources. These systems and practices, well suited to people's survival needs on Africa's fragile resource endowment when population densities were low and populations stable or growing only slowly, came under increasing strain with the rapid acceleration of population growth that began when mortality rates declined sharply in the 1950s while birth rates remained high. The pace of evolution of these systems has been inadequate in the face of dramatically intensifying pressure of more people on finite stocks of natural resources.

v. Traditional land use and forest exploitation practices have become major direct causes of environmental degradation and resource depletion. This degradation reduces the productivity and resilience of natural resource systems. Despite considerable investment in yield-increasing technology, crop yields, especially of food crops, have stagnated or declined in many countries, retarding agricultural growth. Slow agricultural growth, contributing to slow aggregate economic growth, impedes the demographic transition from high to low birth rates. Rapidly growing poor rural populations increasingly degrade and mine the natural resources of the rural environment to ensure their own day-to-day survival. And continuing rapid population growth ties up scarce resources to meet current survival and consumption needs which could otherwise be used to create the base for less resource-intensive and more sustainable development.

vi. Many other factors also have a detrimental impact on agriculture and the environment. These include civil wars, poor rural infrastructure, lack of private investment in agricultural marketing and processing, and ineffective agricultural support services. Inappropriate price, exchange rate and fiscal policies pursued by many governments have reduced the profitability and increased the risk of market-oriented agriculture, prevented significant gains in agricultural productivity and contributed to the persistence of rural poverty. A necessary condition for overcoming the problems of agricultural stagnation and environmental degradation will be, therefore, appropriate policy improvements along the lines suggested in the 1989 World Bank report on Sub-Saharan Africa's longer-term development prospects (World Bank, 1989d). These policy changes will be instrumental in making intensive and market-oriented agriculture profitable -- thus facilitating the economic growth in rural areas necessary to create an economic surplus useable for environmental resource conservation and to provide the economic basis for the demographic transition to lower population fertility rates.

C. Key Elements of the Nexus

vii. ***Shifting Cultivation and Transhumant Pastoralism.*** Shifting or long-fallow cultivation and transhumant pastoralism have been appropriate under conditions of slow population growth, abundant land, limited capital and limited technical know-how. The ecological and economic systems were in equilibrium. The key to maintaining this equilibrium was mobility. People shifted to a different location when soil fertility declined or forage was depleted. This allowed the fertility of the land to be reconstituted through natural vegetative growth and decay. For field cropping, this typically involved farming a piece of land for two to four years, then leaving it fallow for as long as 15 to 25 years. Herders' mobility generally involved a far greater geographic range, but a far shorter temporal cycle, dictated by the seasonal availability of water and forage.

viii. As long as land was abundant, more land could be gradually brought into the farming cycle to accommodate the slowly growing populations. Where population density increased slowly, the traditional extensive agricultural production systems gradually evolved into more intensive, and eventually permanent, systems which included soil conservation, fertility management, various forms of agro-forestry and the integration of livestock into farming systems. This has happened, for instance, in the Eastern African highlands and in the more densely settled areas of northern Nigeria.

ix. But in most of Sub-Saharan Africa the scope for further expansion of crop land has drastically narrowed. Large areas of forests, wetlands, river valley bottoms and grassland savanna have already been converted to farmland. On average, per capita arable land actually cultivated declined from 0.5 ha per person in 1965 to slightly less than 0.3 ha/person in 1990 (it was 0.3 ha/person in India in 1990). In many areas, rural people are increasingly compelled to remain on the same parcel of land, yet they continue to use their traditional production techniques. Soil fertility and structure deteriorate rapidly where fallow periods are too short and traditional cultivation methods continue to be used. As a result, crop yields decline and soils erode. In most areas, population growth has been so rapid that the reduction of arable land per farmer and the associated soil degradation have greatly outpaced the countervailing innovation and adjustment by farmers. When farming is no longer viable, people migrate to establish new farms on land previously not used for farming -- in semi-arid areas and in tropical forests where soil and climatic conditions are poorly suited to annual cropping. Migrants bring with them the knowledge of only those farming techniques they practiced in the areas they left, and these are often detrimental to their new environment.

x. In some countries land still appears to be more abundant in relation to their current population. But much of this land is under tropical forests which need to be preserved. Yet even in these more land-abundant countries, rapid population growth is pushing settlers to extend farming and grazing into areas that are agro-ecologically unsuited to these forms of land use.

xi. One of the conditions which stimulated Asian farmers to adopt "green revolution" technology -- the abundance of labor relative to cultivable land -- is increasingly emerging in parts of SSA. But institutions and individuals have not been able to adapt quickly enough in the face of very rapid population growth. Slow technological innovation because of ineffective agricultural research and extension systems is only part of the reason. The poor transport infrastructure throughout most of SSA severely blunts farmers' incentives to switch from subsistence to market production and from extensive to intensive farming. Inappropriate agricultural marketing and pricing as well as fiscal and exchange rate policies have reduced the profitability of market-oriented agriculture, prevented significant gains in agricultural productivity and contributed to the persistence of rural poverty. Poorly conceived and implemented agricultural projects have not helped.

xii. ***Women's Time, and Their Role in Rural Production and Household Maintenance Systems.*** Women's responsibilities in rural Africa extend far beyond bearing and rearing children. Most women in Sub-Saharan Africa bear heavy responsibilities for foodcrop production, weeding and harvesting on men's fields, post-harvest processing, fuelwood and water provision, and household maintenance. In traditional settings this worked well, as both genders had clearly defined and complementary roles to ensure the present and future welfare of family, village, clan and tribe. But the burdens on rural women are increasing, as population growth outpaces the evolution of agricultural technology and growing numbers of men leave the farms for urban and industrial jobs. As forests and woodlands are cleared or severely degraded, it takes more time and effort for women to collect fuelwood. Deforestation and soil structure deterioration, combined with declining rainfall, reduce groundwater recharge and make water scarcer. Women must walk further to fetch water and fuelwood -- and get their daughters to help them. In most of rural SSA, women also are the primary "beasts of burden," spending substantial time headloading not only water and fuelwood, but also farm produce and other commodities to and from their homes. Producing the needed food on increasingly less fertile plots and with diminished time becomes more difficult. Women also face severe restrictions on access to extension advice, to institutional credit, and to improved production, processing and transport technology. These constraints, combined with increasing pressure on women's time, severely impede productivity improvements and the intensification of women's farming operations.

xiii. Many factors underlie the persistence of very high human fertility rates. The fundamental problem is low **demand** for fewer children. Environmental degradation, agricultural problems, food insecurity and poverty, and the heavy work burdens of women all play a part in this respect. Children provide social standing for their parents as well as some prospect of economic support in old age. In the short term, children also can produce more than they consume. Women's time constraints and reduced availability of water and fuelwood have implications for infant and child health and mortality and, hence, for fertility aspirations and attitudes towards family planning. High infant and child mortality rates are a major factor explaining the persistent high demand for large numbers of children in Africa. Where girls are kept out of school to help with domestic tasks, this negatively affects their fertility preferences and their ability to make informed decisions about family planning once they reach childbearing age. Polygamy and the widespread practice of women marrying at an early age and marrying considerably older men tend to increase women's eventual economic and social dependency on sons and, hence, their willingness to bear many children. The very young age at which women tend to marry increases the number of fecund years spent in union. In many traditional land tenure systems, as in open access systems, the amount of land allotted for farming is a function of the ability to clear and cultivate it -- in short, of family labor. The severe time pressure and the constraints faced by women in their farming and other income-earning activities may be preventing the emergence of women's demand for fewer children. There has been little progress in easing the constraints on women's productivity, their capacity to earn and control incomes, and their ability to assume greater control over their own fertility.

xiv. ***Land and Tree Tenure Systems.*** Traditional tenure systems in Sub-Saharan Africa, with communal land ownership, provide considerable tenurial security on land farmed by community members (although women's tenurial security is generally far less certain than that of men.) *Strangers* (i.e., non-members of the community) may obtain use rights, but usually with considerably less long-term security. As long as populations increased only slowly, traditional systems also were able to accommodate the emerging need to move towards *de facto* permanence of land rights assignation. However, in many countries, tenure systems have not been able to adjust rapidly enough to changing economic conditions. In many societies, for example, the individual land user's ability to transfer land use rights remains subject to significant constraints. Tree tenure arrangements are often distinctly separate from land use rights pertaining to the cultivation of annual crops, and this can result in serious conflict. Much common property land -- forests, wetlands, and range and pasture areas -- has become *de facto* open-access land and has been converted to farming, often with significant negative environmental consequences. In many areas where traditional land rights systems provided for overlapping and complementary uses by sedentary farmers and transhumant herders, the development of valley bottoms into permanent crop land has created major constraints on the mobility of herders, with negative implications for environmental integrity. Increasing population pressure and agro-environmental problems are inducing considerable rural-rural migration. Since migrants often come with conflicting traditions of land allocation and land use, *strangers'* tenurial rights and their implications for land resource conservation are of increasing concern. These various pressures are causing traditional land tenure systems to break down, reducing tenurial security.

xv. Most governments and development agencies have mistakenly believed that traditional tenure systems provide inadequate tenurial security and that these systems are not conducive to the introduction of modern agricultural technology and market-oriented agriculture. They also witnessed the erosion in customary laws and practices regulating land use which occurred as a result of significant rural-rural migration, changes in social values and customs, and ambiguities created by the overlaying of "modern" land administration systems over traditional ones. In many instances, this led to the emergence of *de facto* open-access systems which are not conducive to resource conservation or to private investment in soil fertility maintenance and land improvement.

xvi. Many governments have responded by nationalizing the ownership of land -- and then allowing customary rules to guide the use of some land, while allocating other land to private investors and public projects. Often, the well-connected have used their influence to wrest land from its customary owner-occupants. The result has been reduced, rather than improved, tenurial security. In most cases, this has accelerated the breakdown in customary land management and the creation of open-access conditions, especially in forest and range areas, where settlement and exploitation by anyone are permitted and environmental degradation is usually rapid. Where governments allocated individual land titles -- as in Kenya, Zimbabwe and Côte d'Ivoire -- this generally ignored the existence of customary tenure arrangements, and more often than not, the actual results have differed considerably from the stated intent. Local community and individual land resource management has been discouraged, while political and economic elites have succeeded in alienating the land from its traditional owners and users. This has skewed land distribution and intensified the exploitation of land resources for private short-term gain.

xvii. ***Forest and Woodland Exploitation.*** The heavy dependency on wood for fuel and building material has combined with rapid population growth to contribute to accelerating forest and woodland destruction. This is particularly severe around major urban centers where it has led to the appearance of concentric rings of deforestation. Fuelwood has generally been considered a free good, taken largely from land to which everyone has the right of access. This has impeded the development of efficient markets for fuelwood. Urban woodfuel prices reflect primarily transport costs, not the cost of producing trees, and there is no incentive to plant trees for fuelwood production until transport costs to urban markets become high enough to justify peri-urban planting. This is beginning to happen around some cities and in very densely populated areas, but the scale of such planting is very inadequate. Alternative fuels, such as kerosene or liquefied petroleum gas (LPG), are more costly to obtain and not available in open-access conditions, and are therefore not replacing woodfuels in significant quantities.

xviii. Commercial logging has significantly contributed to deforestation. Although directly responsible for no more than 20 percent of forest destruction in SSA as a whole, it has been considerably more destructive in some countries, such as Côte d'Ivoire. Moreover, logging usually leads to a second phase of forest destruction: logging roads provide access for settlers who accelerate and expand the process of deforestation that the loggers have begun. Logging concessions rarely take into account the traditional land and forest use rights of forest dwellers. These rights, once eroded, are disregarded by new settlers penetrating along the logging roads.

xix. The degradation and destruction of forests and woodlands accelerates soil degradation and erosion, eliminates wildlife habitat, leads to loss of biodiversity, and has severe implications for local and regional climates and hydrological regimes. Deteriorating climatic and hydrological conditions negatively affect agriculture. The worsening fuelwood situation forces women and children to walk further and spend more time to collect fuelwood. Closely related, and increasingly of concern, is the fact that animal dung and crop residues are being used as fuels. Under conditions of shortening fallows, characteristic of much of Sub-Saharan Africa, the economic utility of dung and crop residues is far greater when they are used to maintain soil fertility. People also must walk further and/or pay more for building materials and the many important non-wood forest products they depend upon for medicinal purposes, home consumption and traditional crafts and industries. For forest dwelling people, forest destruction threatens not merely their lifestyles and livelihood systems, but their very survival.

D. An Action Plan

xx. The appropriate policy response and action program to address these problems are not easily brought into compatible focus. Many of the most immediately attractive remedies have been tried and have failed. For example, individual land titling -- intended to clarify resource ownership, prevent

further degradation of common property regimes into de facto open-access situations, and improve tenurial security -- has been tried in several countries and has been beset by significant problems. Similarly, efforts to introduce "modern" agricultural technology in the form of higher-yielding varieties, chemical fertilizer and farm mechanization have not met with great response from farmers. Soil conservation and forest protection efforts have had little success outside relatively small areas. And efforts to slow population growth through programs based primarily on the supply of family planning services and the distribution of contraceptives have not been very successful in most SSA countries.

xxi. ***Some Basic Targets.*** Indicative aggregate targets regarding fertility rates, food availability, agricultural growth and environmental protection illustrate the magnitude of the effort required. Reaching these targets will be far more likely by focusing on the synergetic effects inherent in the linkages of the nexus. There are, of course, wide variations in what is necessary and attainable in each country, and country-specific targets will need to reflect this.

xxii. For Sub-Saharan Africa as a whole, agricultural production needs to grow at about 4 percent per annum during the period 1990-2020. Daily per capita calorie intake should be increased from the present average of 2,027 to about 2,400 by the year 2010. Although the share of the population that is food insecure should be reduced from the present 25 percent to zero as rapidly as possible, it is more realistic to aim for a reduction to 10 percent by the year 2010 and to 5 percent by 2020. The rate of deforestation needs to be slowed, and the area of forests and woodlands should be gradually stabilized. Loss of remaining wilderness areas should also be minimized: about 23 percent of SSA's total land area could be maintained as wilderness (compared with about 27 percent today). To preserve wilderness and forest areas, cropped land can only be increased from 7.0 percent of SSA's total land area at present to about 8.3 percent in 2020. The arithmetic of these indicative agricultural, food security and environmental objectives requires a reduction in population growth from the present average annual rate of over 3.1 percent to 2.3 percent per annum in the third decade of the next century. This will require lowering the average TFR by 50 percent between today and the year 2020.

xxiii. ***Reducing Fertility Rates.*** A key aspect will be to increase **demand** for fewer children. Raising girls' school enrollment rates is critical. Better health care services and access to safe water will improve child survival rates and, hence, lower the demand for children. Educational efforts, directed at both men and women, are needed to raise awareness of the benefits of fewer children. Women's work loads need to be eased to reduce the need for child labor. Dynamic agricultural development and improved food security will also reduce the demand for children. Kenya, Zimbabwe, Botswana and Mauritius, where the TFR is declining, provide strong evidence. These countries have relatively high population densities on cultivated land, relatively high female school enrollment rates, relatively low infant mortality, active family planning (FP) programs, and among the best agricultural performance records.

xxiv. As demand for reducing fertility rises, it must be effectively met with increased supply of FP services and contraceptives. But supply must follow demand -- it cannot lead it. Where AIDS is a problem, improved health care, FP services and education focused on preventing sexually transmitted diseases and increasing the use of condoms become even more important.

xxv. ***Promoting Environmentally Sustainable Agriculture.*** Farm productivity per unit area must be raised significantly to generate more output with little increase in the area farmed. To minimize negative impacts on the environment, much more emphasis is required on "environmentally benign and sustainable" technologies. Land-saving technology will allow forests and other fragile areas to be protected. Numerous environmentally benign and economically viable agricultural techniques have been developed and successfully applied, often through adaptation of traditional practices that have evolved

in response to local agro-ecological and socio-economic conditions. Examples include contour farming, minimum tillage, mulching, "managed" fallowing, numerous crop rotation and intercropping systems, vegetative and soil bunding, a variety of agro-forestry practices, integrated pest management, water harvesting and small-scale irrigation. Integrating livestock into farming systems and promoting animal traction will be important. Soil and moisture conservation need strong emphasis.

xxvi. Agricultural research and extension services need to focus less on mono-crop technologies and farm mechanization and much more on the above types of technologies, adapting them to local conditions and making them available to farmers in "menu" form for selective adoption. Women must become the target of such efforts to a much greater extent. Prescriptive approaches to agricultural intensification are far less suitable in the varied environments of Sub-Saharan Africa -- where conservation and management of natural resources, integrated production systems and risk management are critical -- than in more homogenous high-potential regions such as the Indo-Gangetic Plain.

xxvii. However, intensification with the above technologies alone is unlikely to be sufficient in most SSA countries to achieve agricultural growth rates of 4 percent per year and more. Improved variety/fertilizer/farm mechanization technologies will also be necessary. Increased use of fertilizers will be especially important to raise yields and maintain soil fertility. So will diversification of production into higher-value crops, for domestic and export markets, to increase rural incomes and to improve food security through income stabilization. It would also be unrealistic, and unnecessary, to preclude bringing more land under cultivation.

xxviii. There has been little incentive for farmers to abandon their traditional practices. Intensive and resource-conserving agriculture must be made less risky and more profitable. This requires appropriate marketing, price, tax and exchange rate policies as well as investments in rural infrastructure, health and education facilities. Creating parks, reserves and community-owned range land and protecting these against conversion into crop land will be important to conserve natural resources and biodiversity. So will reducing infrastructure development in forests and other fragile areas to discourage settlement in these areas. Since this will limit the scope for further expansion of cropped land and, potentially, the scope for agricultural production growth, there is a trade-off between conservation and agricultural growth. Creating additional protection areas will only be feasible and sustainable if agricultural production can be intensified at the rate suggested here (i.e., to about a 3.5 percent annual increase in farm output per unit of land farmed). In this sense, conservation and agricultural intensification are complementary. As African farmers have shown, land scarcity leads to agricultural intensification -- and if the necessary advice and inputs are available, intensification can be made sustainable and the rate of intensification greatly accelerated. Strengthening tenurial security will also stimulate greater concern for soil fertility management and conservation as well as tree planting. Some sustainable agricultural practices, such as soil conservation, may require initial subsidization to offset externalities.

xxix. ***Easing Women's Time Constraint and Improving Their Productivity.*** Initiatives in research, extension, infrastructure development, rural technology, and education are needed to ease women's time constraints and improve their productivity. Much can be learned in this regard from the experience of local and international NGOs in establishing rural water supply systems managed by women's groups, developing and popularizing locally appropriate fuel-efficient and time-saving stoves, providing improved farming and crop processing techniques and tools to women, facilitating women's access to land and institutional credit, improving village-level transport infrastructure, and providing intermediate means of transport. Such initiatives should be pursued through projects dealing with agricultural research and extension, rural water supply and transport, credit and land tenure, and in education and training policies which more effectively reach women.

xxx. ***Clarifying Resource Ownership.*** Urgent action is needed to eliminate open-access systems and to provide legal protection to traditional and private land owners. Local community or individual ownership and management responsibility of natural resources appear to be the only workable arrangement in most of Africa. Governments alone are not able to protect and conserve land, forest and pasture resources. State-ownership of farm land should be eliminated. Where traditional tenure systems still work and are evolving toward explicit recognition of individual ownership and transfer rights, they should be recognized and protected by law and supported by appropriate administrative arrangements. Land title, or at least legally secure user rights, should be provided to traditional communities, and community land can continue to be allocated according to customary practice. Where traditional mechanisms have completely broken down, individual land titling is likely to be necessary, but it should be provided only on demand and to the traditional or customary owners/occupants. Women need equal rights to land and tenurial security as men, especially in view of the increasing number of female heads of households in many rural areas. These actions will require effective mechanisms to assess land ownership and use rights and to ensure legal protection to holders of either traditional or modern titles.

xxxi. Wherever possible, state-owned pasture and forest lands should be returned to traditional owners and/or local communities, with clear and legally established utilization rights tied to the responsibility for conservation. This must be done with care, however, since many of these communities and their traditional land resource management systems have broken down under the pressure of logging, settler influx, and government ownership. Where this is the case, resource destruction may simply accelerate if people are given the opportunity. Communities will need appropriate technical assistance in managing these resources.

xxxii. ***Addressing the Fuelwood Problem.*** Efforts to promote agro-forestry need to be greatly expanded to have a significant impact on the agro-ecological environment, the rural energy economy and women's time. Investment in fuelwood production and tree farming, on a large scale, by farmers and by community groups and private enterprises will not occur unless it is profitable. The incentives are gradually emerging, particularly around major urban areas, as populations grow and forests and woodlands are depleted. But woodfuel markets are developing too slowly, impeded by inappropriate forest, land tenure and energy policies. The pace of market development will accelerate if open-access sources of fuelwood are eliminated, cutting in protected areas is stopped, farmers are not restricted in marketing wood from their own land, fees are levied on bringing fuelwood to urban centers so as to provide incentives for wood production near cities, and communities and farmers have uncontested ownership of local forests and woodlands. On the demand side, there is a great need for more fuel- and time-efficient wood and charcoal stoves which can be made by women themselves or by local artisans on a commercial basis.

xxxiii. ***Infrastructure Development and Settlement Policy.*** The importance of rural infrastructure and of rural towns and secondary cities for promoting agricultural and rural development is well established. Many services to rural communities are provided from secondary towns and cities. These also provide the major wholesale markets for agricultural products on their way to major cities and to the ports, as well as the assembly markets for agricultural inputs and consumer goods going to rural areas. The strong bias in urban and infrastructure investments favoring the few major cities needs to be abandoned. Adequate transport links to product markets are major factors associated with the intensification of farming -- even where population densities are comparatively low. The high physical barriers and economic costs of transporting goods to local markets sharply reduce farmers' incentives to switch from subsistence to market production and from extensive to intensive farming. Rural roads and improved tracks navigable for animal-drawn vehicles are crucial. Major efforts are also needed to promote the use of locally suitable and appropriate intermediate transport technology, especially animal-drawn implements, and of improved off-road transport.

xxxiv. Infrastructure development also has a major impact on the productivity of rural labor and on key determinants of fertility. Roads provide access to health facilities and schools. Better educated and healthier farmers are more productive and more likely to be innovators. Water supply and sanitation facilities have significant impact on health and labor productivity. Rural water supply, sanitation, health and education facilities and services are particularly important in terms of their impact on infant and child mortality and on female education -- both critical determinants of fertility preferences.

xxxv. Careful locational targeting of infrastructure and urban development can also be a powerful instrument to guide population movement into environmentally resilient areas with agricultural potential and to keep settlers out of fragile areas.

xxxvi. ***Natural Resource Management and Environmental Protection.*** Environmental resource protection and sustainable management are urgently needed to prevent further degradation and destruction. Establishing conservation areas and protecting forests is conducive to promoting agricultural growth, because they protect watersheds and stabilize local and regional climate and hydrological systems. If the rate of agricultural intensification can be increased as postulated here, the constraining impact of expanding conservation areas on crop land expansion can be offset and conservation will be fully consistent with agricultural growth. Protection of rural environments also ensures the sustainable provision of crucial forest products and environmental services. Particularly urgent are establishment and maintenance of conservation areas and effective regulation and taxing of logging. Environmental Action Plans are a suitable instrument to plan these and other actions in a coherent manner.

xxxvii. Land use planning is a useful tool for reconciling the objectives of natural resource management, settlement and population policy, agricultural and infrastructure development. These objectives come together in specific locations and can be effectively integrated in regional and local land use plans. These can be prepared within environmental action plans or as separate planning exercises. Land use plans should identify areas to be protected, areas to be farmed, areas to be utilized for sustainable logging, and so forth. Land allocation and use, land tenure systems, agricultural technology, infrastructure development, and conservation efforts must be tailored to the specifics of each region and location. Local communities and individuals need to be directly involved in the development and implementation of such plans, and they must have outright ownership of, or strong and legally recognized rights to, natural resources as an incentive to manage and conserve them. Mobilization of community and individual participation in natural resource management may be the most important step now waiting to be taken.

xxxviii. In the final analysis, however, successful agricultural intensification and much reduced fertility rates and population growth are the critical elements to preventing further degradation of the rural environment.

xxxix. ***Water.*** In large parts of Sub-Saharan Africa, water is the critical limiting resource, and conflicts over competing uses are becoming evident. Demand for water is rising rapidly, driven by population growth and economic development. With the major exceptions of the humid regions of Central and coastal West Africa, almost all of Sub-Saharan Africa will be facing water shortages or water scarcity early in the next century. In many of the arid regions, this is already the case -- particularly during the dry season. There is an urgent need for effective hydrological planning and for prudent demand management. Water must be recognized as the critical and limiting resource it is. It must be carefully allocated, and it must be protected against pollution. Planning for water use must be based on natural hydrological units such as river basins and integrated with planning for land use and other activities that affect, and are affected by, water development. Since water resources are frequently shared among countries, it is important to cooperate closely in planning for long-term water sharing.

E. Conclusion

xl. Past efforts have, on the whole, failed to reverse the direction of the downward spiral that is driven by the synergetic forces of this Nexus. Part of the explanation appears to be that past efforts have been pursued too narrowly along traditional sectoral lines -- matching established institutional arrangements and traditional academic disciplines -- while crucial cross-sectoral linkages and synergies have been ignored. At the same time, primary emphasis in most sectoral development efforts has generally been placed on the supply side, i.e., on efforts to develop and deliver technology and services. Far more emphasis needs to be given to promoting effective **demand** for environmentally benign technologies which intensity farming, for family planning services, and for resource conservation. The synergies inherent in the Nexus provide considerable potential in this regard. To address these issues requires appropriate cross-sectoral analysis and the development of action programs which address the linkages and synergies among sectors. These programs should focus on price incentives, trade and fiscal policies, public investments, and asset ownership (such as land) as tools to promote sustainable resource management. To facilitate efficient implementation, action should, however, be defined within single sectors.

Machakos District in Kenya

The experience of Machakos district in Kenya demonstrates that the right policy framework and investments of the kind recommended here will work (English *et al.*, 1992). Significant soil degradation and erosion was observed in Machakos as early as 1920. Substantial efforts have been undertaken over the past 60 years to combat these problems and to prevent further deterioration. By 1990, with nearly five times the population as in 1920, the district's agricultural production had increased more than five-fold -- yet land degradation had not merely been arrested, but reversed. Contributing to this has been a good economic policy environment which has made intensive, market-oriented farming profitable. Relatively good transport infrastructure facilitated the movement of farm inputs and output at affordable costs. Secure land tenure encouraged investment in land. Rural education and health services have also been relatively good. In this setting, farmers were receptive to good extension advice -- based on solid research -- regarding soil conservation and moisture retention, the intensification of farming, and tree planting. Efforts to slow population growth are only now beginning to show the desired impact, but the combined effect of these other measures has been so positive that photographs taken of the same locations in 1930 and again in 1989/90 suggest improvement of the rural environment simultaneous with greatly increased production.

xli. In analytical work that should precede the formulation of action plans and developmental interventions, far greater attention needs to be paid to the social organization of production and consumption, of decision-making and resource allocation, of access to resources and services. These systems and structures can be very complex and often differ substantially among communities. This implies the need to use relevant "units of analysis." The "household", the "family" and the "family farm" may not be appropriate if these terms are simply taken to convey concepts of social and economic arrangements familiar to 20th-century industrialized economies. Where societies are characterized by complex resource-allocation and -pooling arrangements for both production and consumption purposes, based on lineage, kinship, gender and age-groups, it is imperative to be cognizant of these, to analyze the impact of development interventions on individuals in this context, and to design development efforts such that traditional groups can implement and manage them. Gender issues are particularly critical, especially in terms of gender-specific divisions of responsibilities, tasks and budgets, as well as in terms of access to resources, information and markets. Interventions and incentives do not necessarily work in the same direction or with the same intensity for men and women.

xlii. Already, many countries of Sub-Saharan Africa have begun to implement various elements of this action plan. Over 20 national environmental action plans are in place or being prepared. Several country-specific population, agriculture and environment nexus studies have been initiated, including in Côte d'Ivoire, Ethiopia, Kenya, Malawi, Nigeria, Rwanda and in the Sahelian countries as a group.

Macroeconomic and agricultural policy reforms are underway in over half the African countries. Several countries have successful family planning programs, and others are developing promising programs. Agricultural research and extension systems are beginning to place more weight on "sustainable" technology and responsiveness to varying farmer demand. A few countries have brought much of this together and obtained positive synergies between agricultural growth, environmental protection and reduction in fertility rates. Kenya, Zimbabwe, Botswana and Mauritius are examples. Others, such as Ghana and Tanzania, are moving in the right direction. Major deficiencies remain in rural health care and education (particularly female education), rural infrastructure, participation of local communities in development efforts, forest and conservation policy, land tenure reform, urbanization policy, and family planning programs.

I. INTRODUCTION AND HYPOTHESES

A. Objectives of the Study

1.1 Over the past thirty years, most of Sub-Saharan Africa (SSA) has experienced very rapid population growth, slow agricultural growth and increasingly severe environmental degradation. Why this has occurred, and what might be done about it, are the questions addressed in this study. It is based on a review of available research findings and operational experience. Its objective is not to compile and address all of the demographic, agricultural and environmental issues facing the countries and people of Sub-Saharan Africa. It is, rather, to gain a better understanding of the linkages and mutually reinforcing causes of these three sets of problems. The demographic, agricultural and environmental problems of Sub-Saharan Africa are closely interlinked in a "nexus" of multiple and mutually reinforcing causality chains.

1.2 The need to survive -- individually and as a species -- affects human fertility decisions. It also determines people's interactions with their environment, because they derive their livelihood and ensure their survival from the natural resources available and accessible to them. Rural livelihood systems in Sub-Saharan Africa are essentially agricultural, and agriculture is the main link between people and their natural resource environment. Through their agricultural activities, people seek to husband the available soil, water and biotic resources so as to "harvest" a livelihood for themselves. Such harvesting should be limited to the yield sustainable from the available stock of resources in perpetuity so as to ensure human survival over successive generations. Improvements in technology can make the use of these resources more efficient -- increase the sustainable yields and/or reduce the resource stock required. Population growth should, thus, be matched or surpassed by productivity increases so as to safeguard the dynamic equilibrium between the available/required stock of resources and the human population that depends on it for survival. Over the past thirty years, this has not been the case in Sub-Saharan Africa. The rate of population growth has considerably exceeded the rate of productivity increase in agriculture, and this has resulted in the "mining" of natural resources as well as in stagnating per capita agricultural production and incomes.

B. The Nexus: An Hypothesis

1.3 This study's hypothesis is that strong synergies and causality chains link rapid population growth, degradation of the environmental resource base, and poor agricultural production performance -- the "nexus". Key linkages are likely to be found in traditional African crop production and livestock husbandry methods, traditional land tenure systems and land use practices, traditional responsibilities of women in rural production and household maintenance systems, and traditional methods of utilizing woodland and forest resources. These systems and practices were well suited to people's survival needs on Africa's fragile resource endowment when population densities were low and populations stable or growing only slowly.

1.4 As Boserup pointed out, farmers are unlikely to intensify their mode of production (i.e., to produce more output per unit of land) unless there is a constraint on the amount of land available for farming with low labor and low capital inputs (Boserup, 1965). Technological innovation at the farm level comes about at least in part because of farmers' inability to carry on with traditional technologies and still ensure an adequate livelihood. Extensive agricultural production systems -- shifting and long-fallow cultivation and transhumant pastoralism -- are the appropriate responses to abundant land, limited capital and limited technical know-how. They have predominated in most of Sub-Saharan Africa where,

into the recent past, they been the optimal modes of production for farmers and herders.[1] Where population density gradually increased over time, traditional systems of cultivation, land tenure, women's responsibilities, and forest resource use evolved in response. This evolution was slow -- matching the rate of population growth and, hence, the pace of adjustments required.

1.5 These well balanced and slowly evolving traditional systems came under increasing strain with the rapid acceleration of population growth that began when mortality rates started to decline sharply in the 1950s while birth rates remained high. The traditional arrangements and practices, so well suited to an Africa of low population densities, failed to evolve fast enough. The unprecedented rate of population growth in the past few decades has placed a severe strain on the traditional rural production and livelihood systems in Sub-Saharan Africa. The pace of evolution in key elements of these systems -- farming practices and technology, land tenure and management arrangements, women's responsibilities, forest resource utilization -- has been inadequate in the face of the dramatically intensifying pressure of more people on finite stocks of natural resources. Traditional land use and wood provision practices have become major direct causes of environmental degradation and resource depletion. This degradation reduces the productivity and resilience of natural resource systems, contributing to soil erosion and changing weather patterns, which then contributes to agricultural stagnation and, in turn, impedes the onset of the demographic transition.

1.6 Chapter II documents key consequences of this process. These include rapid and accelerating deforestation, widespread problems of soil erosion and fertility loss, and rising population growth rates. The growth of agricultural production, on the other hand, remains at its approximate long-term average of about 2 percent per annum, falling well short of population growth. The results include widespread food insecurity, poor export earnings, and little stimulus from the agricultural sector for overall economic development and growth.

1.7 Sub-Saharan Africa's forest cover has been diminishing at a rate of more than 0.5 percent per year in the 1980s. Forests provide many products and serve many functions, and these are diminished or lost with deforestation. Vast areas of farmland are affected by soil erosion, and vast portions of Sub-Saharan Africa's pasture and range areas show signs of degradation. Degraded soils lose their fertility and water absorption and retention capacity, with drastic effects on vegetative growth. Significant declines in rainfall recorded in many countries are at least partly attributable to the rapid destruction of forests. This environmental degradation has a negative impact on crop and livestock production and on water availability for human and livestock use. Since 1965, the increase in agricultural production in Sub-Saharan Africa has averaged only about 2 percent per year, while the total population has grown at about 2.8 percent annually. In the 1980s, agricultural growth has been only slightly above the longer-term average, but the rate of population growth accelerated to about 3.1 percent per year. Nowhere and at no time in history has any significant human population grown at such a rate. Per capita food production has declined in many countries, and roughly 100 million people in Sub-Saharan Africa are food insecure. Average per capita calorie consumption has stagnated at very low levels and declined in some countries. The average African consumes only about 87 percent of the calories needed for a healthy and productive life. Poor agricultural performance is due in large part to the poor policy environment for agriculture, but much of the explanation also lies in environmental degradation, in the continuous expansion of farming into areas only marginally suited to crop farming, and in the lack of adaptation of various improved agricultural technologies to the locally prevailing agro-ecologic and socio-economic conditions.

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[1] See, for instance, Pingali, Bigot and Binswanger, 1987; Lele and Stone, 1989.

1.8 The human costs associated with this forest and land degradation are high. As forests and woodlands are destroyed, people must walk further or pay more for fuelwood, building materials and the many important non-wood forest products they depend upon. Woodfuels are the staple source of household energy in Sub-Saharan Africa, and the demand for woodfuels is rising at about the rate of population growth. As fuelwood becomes scarce, women and children must spend more time collecting it from more distant sources. Since forests recycle vast quantities of water locally, deforestation also has negative effects on local and regional rainfall and hydrological systems. Combined with deteriorating soil structure, which reduces the water absorption and retention capacity of the soil and, thus, groundwater recharge, this leads to declining plant growth and worsening rural water supply for both humans and animals. Women have to go further, especially during the dry season, to fetch water for household use as well as for watering livestock and home gardens. And forest destruction threatens not merely the traditional lifestyles and livelihood systems, but the very survival of forest dwelling peoples.

C. Critical Linkages

(i) Shifting Cultivation and Transhumant Pastoralism

1.9 Chapter IV deals with the most important linkage in the process hypothesized here. For centuries, shifting cultivation and transhumant pastoralism have been, under the prevailing agro-ecological conditions and factor endowments, appropriate systems for people throughout most of Sub-Saharan Africa to derive their livelihood in a sustainable manner from the natural resource endowment of their environment. The ecological and economic systems were in equilibrium. The key to maintaining this equilibrium was mobility. People shifted to a different location when soil fertility declined or forage was depleted, allowing the fertility of the land to be reconstituted through natural vegetative growth and decay. For field cropping, this typically involved cultivation periods of two to four years, land then being left fallow for as long as 15 to 25 years. Herders' mobility generally involved a far greater geographic range, but a far shorter temporal cycle. They would move their herds on extended migratory patterns as dictated by the seasonal availability of water and forage and in most cases repeat the same cycle in one or sometimes two years. Adjustments to these traditional systems, including gradual intensification of farming practices, took place as and when they became necessary, but the pace of the adjustment required was slow.

1.10 As long as population growth was slow and land remained available, the additional people could be accommodated by gradually bringing more land into the farming cycle. But new land for cultivation has become increasingly scarce in most regions of Sub-Saharan Africa. Large areas of forests, wetlands, river valley bottoms and savanna have been converted to farmland. The scope for further expansion has drastically narrowed. There is considerable diversity among countries -- but everywhere fallow periods are becoming shorter as populations increase and the land frontier recedes. In many areas, such as Mauritania, parts of coastal West Africa, Rwanda, Burundi, Lesotho and Liberia, fallow periods are no longer sufficient to restore soil fertility. Increasingly, rural people are compelled to remain on the same parcel of land, due to the lack of availability of unoccupied land -- yet they retain their traditional farming methods.

1.11 These people face a critical dilemma. The most central element of their traditional farming system -- the ability to shift around on the land -- is being eliminated by population pressure, yet they continue to use the other elements of this traditional production system. Soil fertility is not restored and soils are not conserved where fallow periods are too short, or non-existent, and where traditional cultivation techniques continue to be used. As a result, crop yields decline and soils erode. When farming is no longer viable, people migrate to establish new farms on land previously not used for farming -- in semi-arid areas and in tropical forests where soil and climatic conditions are poorly suited

to annual cropping. Indigenous adjustment has been too slow in the 1970s and 1980s to keep pace with the unprecedented rate of population growth. The result has been low growth, and in some cases decline, in crop yields. Population pressure is inducing farmers to intensify production, but for the most part this is occurring much too slowly to offset the negative impact on crop fertility.

(ii) Land and Tree Tenure Systems

1.12 A second link, also discussed in Chapter IV, involves land tenure systems. Traditional systems provide considerable security of tenure on land brought into the farming cycle (clearing, cropping, fallowing, reclearing) through customary rules of communal land ownership and allocation of use rights to members of the community. In most cases, the tenurial security enjoyed by members of the community is sufficient to induce investment in land. Outsiders, or *strangers* (i.e., non-members of the community) may obtain use rights of various types, but in many cases with considerably less long-term security. As long as populations increased only slowly and the demand for land use rights by migrants from other communities remained modest, traditional systems also were able to accommodate the emerging need to move towards *de facto* permanence of land rights assignation to community members.

1.13 With increasing rural-rural migration and settlement in previously less densely populated areas, *strangers'* tenurial rights and their implications for land resource conservation are of increasing concern (migrants in most cases being *strangers* in the areas to which they move). Tree tenure arrangements are often distinctly separate from land use rights pertaining to the cultivation of annual crops and can result in serious conflict. And traditional norms have increasingly failed to provide adequate protection to land that is not already in the farming cycle and, hence, not under individual or family management. On the contrary, with rapidly growing populations and associated demand for bringing new land into cultivation, common property land -- such as forests, wetlands and range lands -- has often become *de facto* open-access land. Finally, in many areas where traditional land use rights provided for overlapping and complementary uses by sedentary farmers and transhumant herders, rapid population growth and the conversion of valley bottoms into permanent farm land has created major constraints on the mobility of herders, with serious implications for environmental integrity.

1.14 Most governments and donors have believed that traditional community ownership of land is totally inconsistent with individualized tenurial security. Traditional tenure systems did not seem to adjust rapidly enough to changing demographic realities, agricultural technology developments and market forces. Governments and donors also witnessed the erosion in customary laws and practices, including those regulating land use. This erosion occurred partly as a result of significant migration within and between many countries, partly as a result of changes in social values and customs, and partly as a result of ambiguities created by the overlaying of "modern" land administration systems over traditional ones. The result, in many instances, has been the emergence of *de facto* open-access systems which are not conducive to resource conservation or to investments in soil fertility maintenance and land improvement. Such open access systems, found especially in forest and pasture areas, result in rapid environmental degradation -- following the script of the "tragedy of the commons". Each user has an incentive to exploit the land and the associated resources as much as possible for private advantage, moving on when the resources are exhausted or too depleted to provide a livelihood. Moreover, in open access systems the size of land holdings is partly a function of the amount of family labor available; this may be an important element contributing to the high fertility preferences observed.

(iii) Women's Time and Their Role in Agriculture and Rural Production Systems

1.15 A third critical link is the important role of women in rural production systems, dealt with in Chapter V. The widespread prevalence of gender-specific (gender-sequential and/or gender-segregated)

roles and responsibilities in rural production systems may be a major factor contributing to agricultural stagnation and environmental degradation as well as to the persistence of high fertility rates. In many areas, women have primary or sole responsibility for food crop production, and they usually manage separate fields for this purpose. Women also tend to have significant obligations concerning labor to be performed on men's fields and with post-harvest processing activities.

1.16 Given women's triple roles -- child bearing and rearing, family and household maintenance, and production and income-earning activities -- the pressures on their time continue to intensify. With increasing deforestation, yet growing populations requiring more fuel, fuelwood has become scarcer, and women must walk further to fetch it -- or reduce the number of hot meals prepared. Increasing populations put greater pressure on available water resources, while environmental degradation reduces the availability and accessibility of water. Women must walk further to fetch water, and get their daughters to help them. Throughout much of rural Sub-Saharan Africa, women also are the primary providers of transport services. In the absence of adequate rural transport infrastructure and of means of transport other than human porterage, women spend substantial time headloading water and fuelwood, farm produce and other commodities.

1.17 As growing numbers of working-age men leave the farms to work in towns and cities, women are increasingly taking on primary responsibility for farm operations -- while their access to adult male labor for critical tasks is diminishing. Moreover, the expansion of higher-input cash cropping under male control tends to increase demands on female labor for traditional female activities such as weeding and harvesting. At the same time, women in most societies are confronted with severe restrictions on access to land, to extension advice, to institutional credit, and to improved production, processing and transport technology. These constraints, combined with the intensifying pressures on women's time, severely impede productivity improvements and the intensification of women's farming operations. As a result, most women farmers have little choice but to continue practicing traditional low-input, low-productivity farming which, with sharply shortened fallow periods, is neither environmentally sustainable nor viable in terms of longer-term agricultural productivity. Women's time constraints also retard the growth of cash crop production controlled by men, since this depends on substantial female labor input at critical times.

1.18 The constraints on women's time have implications also for infant and child welfare and, hence, infant and child mortality -- with significant repercussions on fertility aspirations and attitudes toward family planning. More contentious is the hypothesis that the multiple work burdens and the heavy time pressure on women, by raising demand for child labor, may contribute to the persistence of high fertility rates. Additional labor may be the only factor of production which women can easily augment, or are permitted or even compelled to augment, in order to meet their production and household management responsibilities. The traditional role of women may thus contribute to maintaining the very high fertility rate in most of Sub-Saharan Africa. The total fertility rate (TFR) -- the total number of children the average woman has in her lifetime -- currently stands at about 6.5 for SSA as a whole (compared with an average of 4 in all developing countries taken together).

(iv) The Rural Energy Economy and Traditional Fuelwood Provision

1.19 Fuelwood provision and use are important issues in terms of women's time and productivity as well as in terms of environmental degradation. Closely related is the fact that animal dung and crop residues are increasingly being used as fuel, although not yet to the degree found in South Asia. The economic utility of using such organic matter to maintain soil fertility under conditions of shortening fallows and the gradual shift to permanent cultivation is very high, and its declining availability for this purpose has a high cost in terms of reduced agricultural productivity.

1.20 The heavy dependency on wood for fuel and building material has combined with rapid population growth to contribute to accelerating forest and woodland destruction. This is particularly severe around major urban centers where it has led to the appearance of concentric rings of deforestation. Wood is generally regarded as a free good, taken largely from land to which everyone has the right of access. As a result, efficient markets for fuelwood have not developed in most countries -- despite its increasing scarcity. Consumer prices reflect primarily the cost of transporting the wood, not the cost of tree planting and maintenance. Even where extreme scarcity has led to the emergence of an efficient market, the price of fuelwood has been below the cost of replanting because most supplies come from open-access sources. Alternative fuels, such as kerosene or LPG, are more costly to obtain. Despite dwindling supplies of wood for fuel and building material, other fuels are therefore not replacing woodfuels (and other biomass such as dung and crop byproducts) in significant quantities.

1.21 The degradation and destruction of forests and woodlands through unsustainable woodfuel extraction accelerates soil degradation and erosion, causes destruction of wildlife habitat, leads to loss of biodiversity, and has severe negative implications for local and regional climates and hydrological conditions. Deteriorating climatic, soil and hydrological conditions negatively affect agriculture. There is further feedback to the Nexus through the increasing burden on women who must walk further and spend more time to meet household fuelwood needs or, in situations of extreme scarcity, are forced to cook with dung or crop residues or even to reduce the number of cooked meals.

(v) Logging, Forest Management, and Settler Influx into Forest Areas

1.22 In forested regions, logging has contributed to rapid reductions in the area under forest cover, with similar negative impact on climatic patterns and soil fertility as excessive and unsustainable woodfuel extraction. Although directly responsible for no more than 20 percent of forest destruction in Sub-Saharan Africa as a whole, commercial logging been considerably more destructive in some countries, such as Côte d'Ivoire. Moreover, logging usually leads to a second -- and in most cases far more damaging -- phase of forest destruction. Logging roads provide access for land-hungry settlers into areas previously difficult to enter, and these settlers accelerate and expand the deforestation begun by the loggers.

1.23 Forest people are usually especially victimized by the invasion of loggers and subsequent settlers. Loggers ordinarily acquire logging rights from governments, without regard to the traditional rights of forest dwellers. These rights, once eroded, are not respected by new settlers penetrating along the logging roads.

(vi) Interaction With Policy Constraints and Other Structural Problems

1.24 Many other factors also have a detrimental impact on agriculture and the environment. These include civil wars, inappropriate price, exchange rate and fiscal policies, poor rural infrastructure, lack of private investment in agricultural marketing and processing, and ineffective agricultural support services. These were discussed in the World Bank's recent report on Sub-Saharan Africa's development perspectives (World Bank, 1989d). These factors prevent significant gains in agricultural productivity and contribute to the persistence of rural poverty, and thereby compel growing populations, as a survival strategy, to exploit ever more extensively the natural resources available and accessible to them. The predominance of long-fallow cultivation and of traditional farming methods, traditional separation of farming activities into male and female spheres, and unsustainable methods of forest resource exploitation will continue in these circumstances. A necessary condition for overcoming the problems of agricultural stagnation and environmental degradation will be, therefore, policy improvements along the lines suggested in the above World Bank report.

D. Population Growth Revisited: Feedback from the Nexus

1.25 Agricultural stagnation and environmental degradation probably inhibit the demographic transition because they retard economic development which is the driving force behind this transition. The extraordinarily high fertility rates prevailing in Sub-Saharan Africa are the result of many factors. The fundamental problem is low **demand** for smaller families. In many societies, becoming a parent is a precondition for becoming a socially recognized adult. Fertility enhances female and male status, while infertility results in severe anxiety and, particularly for women, can be socially and economically devastating. Such widespread phenomena as polygamy and women marrying considerably older men tend to increase women's eventual economic and social dependency on sons and, hence, their willingness to bear many children. The very young age at which women tend to marry increases the number of fecund years spent in union.

1.26 Infant and child nutrition and mortality are affected by the availability of safe potable water and by the number of nutritious and warm meals provided. Where environmental degradation reduces the availability and accessibility of water and fuelwood, this has negative impact on infant and child mortality and, hence, positive impact on parental demand for more children. Where girls are kept out of school to help with domestic tasks, including water and fuelwood fetching, this has strong negative repercussions for their fertility preferences and their ability to make knowledgeable decisions about family planning once they reach childbearing age. Where food security is low, demand for children remains high -- so as to provide labor to help produce more food ("each mouth comes with two hands attached to it") and to ensure the survival of some children for providing support in one's old age.

1.27 The preference for many children is also linked to economic considerations. In many communal land tenure systems, the amount of land allotted for farming to a family by the community (through its chief or its *chef de terre*) is a function of its ability to clear and cultivate land -- i.e., of family size or, more correctly, family labor (hired labor in most settings being rare, although labor pooling for certain tasks is not uncommon). This is also true in open-access systems where the size of holdings equals land cleared and cultivated. This counteracts efforts to stimulate demand for fewer children. Moreover, as long as there is (or is perceived to be) as yet unfarmed and unclaimed land available, there is no incentive for individuals to manage their land more intensively nor to limit their family size so as to be able to bequeath a viable farm to their offspring.

E. The Evidence

1.28 This study presents the evidence for the complicated inter-actions identified above. Chapters VI to X outline an action program to deal with these problems in a manner which exploits the positive synergies between agricultural intensification, reduced population growth and environmental resource conservation. The action program involves elements that are relatively new. It also presents much that is well known, such as the need for far greater attention to gender issues, from a new perspective. The evidence on which the analysis and recommendations are based is largely from site-specific studies. Given data limitations, statistical analysis, though attempted and presented, does not provide definitive confirmation. Statistical analysis and country-specific studies are therefore continuing.

II. AGRICULTURAL STAGNATION AND ENVIRONMENTAL DEGRADATION

A. Agricultural Stagnation, Population Growth and Food Security

2.1 Over the past 25 years, agricultural production in Sub-Saharan Africa rose by only about 2 percent a year, while aggregate population growth averaged about 2.7 percent per year (Tables 2 and 9).[1] Per capita food production has declined in most SSA countries (Table 10). Cereal imports increased by 3.9 percent per annum between 1974 and 1990, food aid by 7 percent per annum. But the food gap (requirements minus production) -- filled by imports, or by many people going with less than what they need -- is widening. In the early 1980s, about 100 million people in Sub-Saharan Africa were unable to secure sufficient food to ensure an adequate level of nutrition for themselves, and average food consumption per capita has declined during the 1970s and 1980s in 17 of the 36 SSA countries for which data are available (Table 10).[2] In years of poor harvests the numbers affected have been much larger. Severe food shortages were exceptional in the 1960s, but are no longer so. Famines in several countries in the 1980s have been graphic indications of natural calamity, as well as of civil disruption, in the region. On average, officially estimated per capita food intake in Sub-Saharan Africa in the late 1980s, at 2,027 calories per day, was actually below the 1965 level and significantly lower than in other parts of the developing world. The average in India, for example, is 2,238 calories daily per person. The average African consumes only about 87 percent of the calories needed for a healthy and productive life.

2.2 The available data show no acceleration of aggregate agricultural growth in the 1980s. It has only slightly risen above the longer-term average for the past three decades of 2 percent per annum (Table 9). (It was higher than 2 percent in the 1960s and much lower in the 1970s.) This poor performance is also evident in the decline of agricultural export earnings. Export volumes and values have declined for almost all SSA countries (Table 13), with volume declining at 2.7% per annum on average, from 1980 to 1990. There are notable exceptions. Exports of tea and horticultural products from Kenya, cocoa from Côte d'Ivoire and cotton from several West African countries have grown substantially in volume. But the success stories are few.

2.3 Projections, based on present trends, are disturbing. Aggregate population growth has accelerated to over 3.1 percent per annum (Table 2). Projections based on current trends in fertility and mortality rates (including the impact of AIDS) indicate only a slight deceleration in aggregate population growth through the year 2000. The total fertility rate (TFR) -- i.e., the average number of children born to a woman in her childbearing years -- for Sub-Saharan Africa as a whole has remained at about 6.5 or 6.6 from 1965 to the present (Table 2). By contrast, the average TFR for all the world's low-income countries declined from 6.3 in 1965 to 4.0 in 1987. During the same period, the crude death rate in Sub-Saharan Africa fell from 23 to 16 (Table 3). In countries with a high incidence of AIDS, death rates will rise, but nowhere is population growth expected to fall below 2 percent per annum by the year 2000,

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[1] Statistical information on agricultural performance, as on most other aspects of social and economic development, is difficult to obtain and tends to be of poor quality. This study draws on what is generally assumed to be the best available statistical information (see the Statistical Appendix for data and sources).

[2] The data on which estimates of food availability and consumption are based (e.g., crop acreage, yields, livestock production, processing and storage losses, etc.) are of poor quality in most African countries. Increasingly, it is also recognized that non-cultivated plants and "bushmeat" contribute far more to many Africans' diets, particularly in poor crop years, than has been captured in official statistics. Nevertheless, few observers are as skeptical of the general picture of serious food deficits as Svedberg (1991).

even under worst-case AIDS scenarios currently considered plausible.[3] Unless efforts to reduce TFRs succeed (or mortality rates rise dramatically due to currently unanticipated AIDS developments), population growth rates will decline very little.

2.4 Table VI.I (pg. 63) shows the implications of these trends for Sub-Saharan Africa's future food gap. In 1990, Sub-Saharan Africa's 494 million people produced about 90 million metric tons of maize equivalent of food. With 100 million tons of aggregate consumption, there was a gap of 10 million tons met by imports. At currently projected growth rates, Sub-Saharan Africa's population will total about 1,200 million and its food production will reach about 163 million tons of maize equivalent in 2020. Aggregate requirements will be about 243 million tons, assuming there is no change in average per capita consumption. The 80 million ton food gap would be eight times today's gap and equivalent to about one fourth of the present annual production of cereals in the United States. Food aid varied between 4 and 7 million tons of cereals per year in the 1980s and could not conceivably increase sufficiently to fill this gap. Without significant per capita growth in agricultural production it is difficult to imagine sufficient overall economic growth that would generate the resources needed to finance food imports of this magnitude -- nor, for that matter, to maintain educational and health services and infrastructure facilities.

2.5 These disturbing trends will, of course, not continue indefinitely. What is at issue is how they will eventually be overcome. Will the strong synergies and the dynamics of these trends lead to human and environmental degradation and ultimately to widespread starvation? Or will these trends be overcome through voluntary, but determined action to reduce population growth and promote sustainable agricultural development and growth?

B. The Deteriorating Natural Resource Base and Ecological Environment

2.6 Much of Sub-Saharan Africa's natural resource base and ecological environment is deteriorating. If present trends continue, this will deteriorate even more rapidly in the future. The most pressing problem is the high rate of loss of vegetative cover -- mainly due to deforestation and conversion of savanna to crop land -- which in turn leads to loss of soil fertility and soil erosion. Global and regional climatic changes and/or deviations from longer-term average conditions are also causal factors -- but human impact on the environment in Sub-Saharan Africa may itself be an important element contributing to these climatic changes.

(i) Deforestation

2.7 In much of Sub-Saharan Africa, deforestation is a major problem -- with significant local, national and global consequences. Forests provide a multitude of products and serve many functions, including essential environmental ones. With deforestation, these are lost. Forests and woodlands are cleared for farming and logged for fuelwood, logs and pulp wood. Data on forest resources and rates of extraction and clearing are imperfect, as are data on most of Africa's environmental resources, but information is continually improving and reliable enough to suggest the scale of the problem. In 1980, there were about 679 million ha of forests and woodlands in Sub-Saharan Africa. A 1980 FAO/UNEP study estimated that 3.7 million ha of tropical Africa's forests and open woodlands were being cleared each year by farmers and loggers (Lanly, 1982). More recent estimates suggest that close to 3.8 million

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[3] Demographic modeling of the potential impact of AIDS is extremely difficult. Some simulations suggest that AIDS may reduce the population growth rate of SSA as a whole by as much as 0.5 to 1.0 percentage points in the early decades of the 21st century -- through drastically higher mortality rates. But higher mortality rates may delay fertility declines.

ha have been lost each year during the 1980s (Table 18), mainly through conversion to farm land, and the rate of deforestation may be accelerating. Reforestation amounted to only 229,000 ha per year during the 1980s, only about 6 percent of the area lost each year to deforestation (Table 18).

2.8 Aggregate data obviously obscure important differences among regions and countries. Deforestation has been particularly rapid in West Africa, with Eastern and Southern Africa also suffering substantial losses in forest cover.[4] Large tracts of tropical forest still remain, especially in Zaïre, Gabon, Congo, the Central African Republic and Cameroon. It would take many years for Central Africa's forests to be completely destroyed, but the process has started. In most of Eastern and Southern Africa, as well as in the West African coastal countries, the process is far advanced.

2.9 Degradation and destruction of forests have a severe impact on wildlife habitat and biodiversity, with potentially irreversible losses of animal and plant life. The World Conservation Union (IUCN) and the World Resources Institute (WRI) estimate that 64 percent of original wildlife habitat in Sub-Saharan Africa has already been lost (Table 20). This is directly due to deforestation, conversion of wildlands to agricultural uses and other human activity. Uncontrolled harvesting, poaching and illegal trade also take a heavy toll on many species. Degradation of tropical moist forests has a particularly negative impact on biodiversity by destroying plant and animal life which may exist nowhere else in the world.

The Threat to African Wildlife

WRI has compiled estimates of the number of threatened species in Africa (WRI, 1992, pp. 304-309). Examples include the following:

- 18 of the 226 known species of mammals in Côte d'Ivoire are threatened with extinction, and 70 of the 3,660 known plant species are rare and threatened;
- Zaire has the largest number of known species of mammals in Africa, and 22 of these 409 are threatened;
- 53 of Madagascar's 105 known mammal species and 28 of its 250 known species of birds are threatened;
- in Chad, 18 of the 131 known species of mammals are threatened;
- in Kenya, 15 of the 314 known mammal species are threatened, and 144 of the 6,500 known species of plants are rare and threatened; and
- 1,145 of South Africa's roughly 23,000 plant species are listed as rare and threatened.

2.10 As forests and woodlands are destroyed, people must walk further or pay more for fuelwood, construction materials and other essential forest products. Woodfuels are the staple source of household energy in Africa, with 90 percent of all households using them for cooking -- the main end-use of energy in Sub-Saharan Africa.[5] Various agro-processing and rural artisanal and semi-industrial activities also use woodfuels (e.g., fish smoking, shea nut processing, tobacco drying, distilleries, pottery making, smithies, brick making). Fuelwood deficits are severe in the Sahel, in the savanna regions of West, Central and East Africa and in the arid areas of southeastern and southwestern Africa (Table 19). They impose particular hardships on women who are usually responsible for household fuel provision. As fuelwood becomes scarce, women (and children) have to spend more time collecting it from more distant sources and eventually begin to substitute crop residues and manure which would otherwise be used to maintain soil fertility.[6]

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[4] FAO/UNEP estimates for the late 1970s indicated that of West Africa's undisturbed, productive closed forests, almost 8 percent were logged annually, compared with only about 1.6 percent in East Africa and 0.4 percent in Central Africa (FAO and UNEP, 1981).

[5] UNDP/World Bank, African Development Indicators (1992), Tables 14-8 through 14-14, provides country-specific data on energy consumption, including consumption of fuelwood.

[6] The fuelwood problem and its impacts on rural households, family welfare, women's time and women's production activities have been investigated by many researchers; a number of such studies are listed in the bibliography.

2.11 The loss of future wood for the forest industry will be another important cost of continuing deforestation. In the period 1985-87, the six largest African timber exporters (Cameroon, Congo, Côte d'Ivoire, Gabon, Ghana and Liberia) exported US$500-600 million worth of timber annually. Without significant afforestation, the potential for future export earnings will be lost as forests disappear.

2.12 Forests also provide a wide variety of non-wood products for local populations. Many are used particularly by women to meet subsistence needs or to generate cash income, and various wild plant and animal food sources are especially important in times of stress (FAO, 1989; 1990). A recent FAO publication lists 94 different forest and farm tree foods as being commonly used in West Africa (FAO, 1990a, pp. 102-103); 30 forest species are listed as being commonly used for fodder (*ibid.*, p. 113). Women often possess much specialized knowledge in this regard (Molnar and Schreiber, 1989); in Sierra Leone, women listed 31 different products they gather from bushes and trees near their villages (Hoskins, 1989, p. 43). Traditional medicine throughout Sub-Saharan Africa is highly dependent on a variety of forest plants.[7] As forest are degraded and destroyed, these resources are no longer available and/or accessible to the local populations.

Non-Wood Forest Products Gathered by Women in the Arid Region of Brakna, Mauritania

Foods & fodder: gums, fruits, leaves and grasses, chemicals from plants for preserving butter, *couscous* seasonings, a wild grain (*aze*) used as animal feed; Medicines, cosmetics, dyes, etc.: medicinal plants, henna and pods for cosmetic purposes, incense plants; Utensils, handicrafts, etc.: fronds, grasses, dyes, leather tannins, floor mats (Smale, 1985).

2.13 Deforestation also has a particularly severe impact on forest dwellers, such as the pygmies, threatening not merely their traditional lifestyles, but their very survival (Bailey, Bahuchet and Hewlett, 1992; Dyson, 1992; Peterson, 1992; Winterbottom, 1992).

(ii) Soil Degradation and Erosion

2.14 Much of Sub-Saharan Africa is highly vulnerable to soil degradation and erosion -- because of factors such as soil characteristics, intense soil drying in the dry seasons, heavily erosive seasonal rainfall in many areas, wind erosion in drier areas, and low-resource farming with inadequate soil conservation measures. The United Nations Environment Programme estimates that more than 80 percent of Sub-Saharan Africa's productive drylands and rangelands, some 660 million ha, are affected by "desertification" -- the process of sustained deterioration of the biological productivity of land (Table 23).[8] Most of this is in the West African Sahelo-Sudanian Zone, in Sudan, Ethiopia, Somalia and Kenya, as well as in southern Africa, but parts of many other countries (such as the northern areas of many West African coastal countries) are also affected. The Soil Reference and Information Centre in Wageningen, Netherlands, has recently published more conservative estimates of the extent and severity of soil degradation in Africa. Its data indicate that about 321 million ha (14.4 percent of the total vegetated land surface) are moderately, severely or extremely degraded and an additional 174 million ha (7.8 percent of the vegetated area) are lightly degraded (Oldeman *et al.*, 1990).

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[7] The Inter-African Committee on Medicinal Plants and African Tropical Medicine and the Scientific, Technical and Research Commission of the OAU have published a pharmacopeia of African medicinal plants of proven efficacy, African Pharmacopeia (1985), and several African countries have established research institutes focussing on traditional medicine and the sources and effects of the active ingredients in medicines administered by traditional healers (DeJong, 1991).

[8] The term "desertification" is often used without precision: it denotes a process of gradual loss of soil fertility and the consequent loss of the ability of soils to produce significant vegetative matter -- trees, pasture or crops. Desertification is manifested in such phenomena as soil erosion, soil structure deterioration, compaction, reduction in organic matter and nutrient content, salinization, etc. "Land degradation" is a more appropriate term, with less alarmist connotations.

2.15 Sizeable areas used for cropping in low-rainfall regions are subject to soil degradation and soil fertility loss. Topsoil losses even on gently sloping cropland have been reported to range from 25 to 250 tons per hectare annually from Niger to Madagascar and from Ethiopia to Zimbabwe (Table 22). These rates translate into losses of between 2 mm and 2 cm of topsoil annually.[9] The agronomic relevance of such data is difficult to assess, however, without information on new soil formation and total topsoil remaining:[10] topsoil depth should be at least 15 cm to provide an adequate root zone for annual crops (but optimal rooting depth differs among crops). Nevertheless, given the poor fertility characteristics of most African soils and the prevailing low-input farming practices, topsoil losses in the middle and upper ranges of the magnitudes reported will cause rapid productivity declines.

Soil Erosion and Degradation: The Data Problem

Despite their pervasiveness, the extent and impact of the degradation, erosion and desertification of Africa's soils are not easy to assess. Reliable data on which to base national, regional and continental estimates are scarce. Soil erosion rates are difficult to calculate, and published data on degradation and erosion are highly location-specific and often of doubtful reliability, due to poor measurement techniques. They are also subject to considerable misinterpretation, especially when field data are extrapolated to develop aggregate estimates for entire watersheds, regions or countries. Moreover, most research on the relationship between soil degradation and erosion and soil productivity has been carried out in temperate zones (notably the United States), but there are vast differences in this relationship throughout the world as also in the resilience of land systems and the rate of new soil formation (Seckler, 1987; Stocking, 1987).

2.16 Soil erosion is usually accompanied by other aspects of soil degradation, such as deteriorating soil structure, reduced moisture retention capacity, soil nutrient depletion, and reduction in soil fauna and flora. A major study undertaken in the late 1970s estimated that, with unchecked soil degradation and erosion and no change in farming technology, the productivity of land in Africa would decline at an average rate of 1 percent per annum between 1975 and 2000 (Higgins *et al.*, 1982, pp. 23-25). In Zimbabwe, nitrogen and phosphorus losses attributable to soil erosion on arable land were estimated to be about three times the amount of fertilizer applied in the 1984/85 crop year; fully compensating for this nutrient loss through the application of chemical fertilizers would have cost about US$ 1.5 billion -- or US$ 35 per hectare of arable land (FAO, 1990b).

Extent and Economic Cost of Soil Erosion in Mali

Soil erosion on cultivated land in Mali has been estimated to range from a low of 1 t/ha/year in the arid north to a high of 31 t/ha/year in parts of the more densely settled and intensively cultivated south of the country. Given the enormous difficulties involved in quantifying the effect of soil degradation and soil loss on farm productivity, the researchers had to work with a range of values for the critical parameters that define this link. The associated crop yield reductions were estimated to range between 2 and 10 percent per year for the country as a whole. The present value (using conservative parameters of a 10-year time horizon and a 10 percent discount rate) of current and future net farm income foregone as a result of one year's soil loss was estimated to fall between 4 and 16 percent of agricultural GDP (Bishop and Allen, 1989).

(iii) Rangeland Degradation and Desertification

2.17 About 25 million of the world's estimated 40 million nomadic and transhumant pastoralists live in Africa (Bass, 1990). Between 1963 and 1983, according to FAO estimates, the number of cattle

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[9] There is location-specific evidence that erosion is accelerating. A study of Tanzania's Shinyanga region, utilizing the fact that trees and bushes can be dated to determine changes in ground surface height over time, found that soil erosion during the first 60 years of the current century averaged about 1.4 t/ha/year; 20-30 years ago, it was 10.5 t/ha/year; and during the past two decades it has averaged 22.4 t/ha/year (Stocking, 1987, pp. 56-57).

[10] The natural rate of soil formation on non-agricultural land in temperate climates is about 0.8 mm per annum; it may be three times this much in the humid tropics (Seckler, 1987, p. 91). These rates are likely to be higher on well managed and lower on poorly managed farm land.

increased by 74 percent in Sudano-Sahelian Africa, by 65 percent in humid and sub-humid West Africa, and by 61 percent in southern Africa (FAO, 1986). At the same time, the extent and quality of the rangeland declined. Cultivators moved into the best grazing areas and converted them to crop land; the traditional use rights of pastoralists, and particularly of transhumant herders, were ignored or overridden, and their herds were increasingly forced to more marginal land which is rapidly degraded by overgrazing. The increasing cultivation of valley bottoms has further compounded the problem:[11] it restricts pastoralists' ability to move their herds there and to use these lands as migration routes during the dry season, thus forcing them to remain on degrading rangelands and around permanent waterpoints. Restrictions on the movement of pastoralists across national boundaries have had similar effects.

2.18 The issue is not simply one of too many animals relative to the available grazing areas. Long periods of below-normal rainfall and severe droughts have accelerated the degradation of rangelands, and past efforts to address the problem of water supplies for pastoralists have often compounded, rather than ameliorated, the problems. Deep wells have been sunk to ensure water supplies during the dry season, but with free access to these wells, the number of animals congregating around them far exceeds the carrying capacity of the surrounding rangeland, causing rapid deterioration. Desertification has tended to spread outward from these areas of excessive and prolonged animal concentration.

(iv) Water Resource Depletion and Degradation

2.19 In large parts of Sub-Saharan Africa, water is the critical limiting resource.[12] Unfortunately, many countries do not yet have adequate basic data to assess their water availability,[13] but conflicts over competing demands on scarce resources are becoming increasingly evident. The potential for such conflicts rises rapidly with population growth and economic development. At the rates of population growth currently projected, water availability per capita will decline to half of its present levels in almost all SSA countries within 25 years. A recent macro-level assessment suggests that ten countries in Sub-Saharan Africa will face severe water stress situations by the turn of the century: Mauritania, Niger, Somalia, Kenya, Burundi, Rwanda, Malawi, Zimbabwe, Namibia and Lesotho. By the year 2025, eleven more will have joined this list: Mauritania, Senegal, The Gambia, Burkina Faso, Togo, Benin, Nigeria, Ethiopia, Uganda, Tanzania and Mozambique (Falkenmark, 1991, pp. 83-85).

2.20 Rivers, streams, lakes, swamps and coastal waters are important resources. They provide critical economic goods and services and perform vital ecological functions and need to be protected and prudently utilized. But many are seriously affected by sedimentation, siltation, agro-chemical runoff, industrial pollution, and inefficient utilization. Pollution from domestic sources has become a concern around many large cities and in countless rural areas where lack of safe potable water is a major health issue. Such problems are increasingly serious in many parts of Sub-Saharan Africa, although quantitative information is particularly poor in this respect. The causes include soil erosion, deforestation, destruction of protective shoreline vegetation, indiscriminate drainage, encroachment for farming, poorly conceived

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[11] Much soil eroded from uplands and slopes is deposited in the bottomlands along river courses. But these deposits are deficient in organic material and poorly structured, require good tillage and are too heavy for hoe cultivation or traditional ploughs. Access to more efficient agricultural technology (for land preparation, drainage to prevent waterlogging, etc.) has made it increasingly possible for land-hungry farmers to extend cultivation into these areas.

[12] The critical importance of the water issue for Africa's population is reflected in this observation: "Accelerating water scarcity may well influence the time of population stabilization -- for example, by significantly influencing birth rates, death rates, migration patterns, or all of these variables" (Falkenmark, 1991, p. 81).

[13] The *Sub-Saharan Africa Hydrological Assessment* is attempting to meet this need by assisting countries to develop a reliable hydrological data base (see para. 10.30, fn. 5).

irrigation development, and lack of environmental regulations and enforcement on industrial activities. Many irrigation and hydropower schemes which involve damming and diverting rivers have adversely affected the flora and fauna of the downstream floodplains, the wildlife and livestock carrying capacity of the floodplain grasslands, the extent and productivity of wetlands and riverine forests, and the productivity and sustainability of downstream fishing and of farming based on traditional recession irrigation. Large impoundments also imply large evaporation losses. Other problems include coastal erosion, saltwater intrusion into aquifers in coastal areas, and destruction of coastal wetlands critical for birds and marine life. Problems have also been encountered with the spread of water-related diseases around water impoundments and irrigation schemes where water remains standing in fields and canals.

2.21 Groundwater resources have also come under pressure, especially in the arid and semi-arid regions. In some areas, groundwater reserves are being drawn down for irrigation much faster than they can be replenished. Deforestation, soil degradation and erosion, and poor on-farm soil and water management all increase surface runoff (causing erosion) and reduce the amount of rainfall that infiltrates the soil and eventually percolates into underground aquifers. Prolonged periods of below-average rainfall and unusually frequent and severe droughts have, of course, greatly exacerbated this problem (Table 21).

2.22 Drinking water in rural areas is the most pressing concern, but water scarcity is also a severe constraint on livestock and home garden production in many parts of arid and semi-arid Africa and even in many sub-humid regions. During the dry season, rivers, steams and springs in many areas of Sub-Saharan Africa run dry, and women often have to go very far to obtain meager quantities of water, often of very poor quality. As groundwater tables recede due to reduced rainfall and reduced rain infiltration into the soil and into subsurface aquifers, wells dry up and must be dug deeper or abandoned.

(v) Environmental Degradation and Climatic Change

2.23 The consequences of environmental degradation are profound. Most alarming is the possible negative impact on rainfall, although direct causality is difficult to establish. The Sahel region has been the object of extensive meteorological monitoring and research; it suggests increasing aridity during the past two decades. The graph on page 15 showing rainfall deviation from the 1900-1987 average is telling. It shows that the Sahel has always experienced wide variations in annual rainfall, but also that rainfall has been consistently and significantly below the long-term average every year since 1970 (Tucker *et al.*, 1991, based on Nicholson, 1989).[14] There have also been significant declines in average rainfall in the coastal countries along the Gulf of Guinea and in eastern Africa.[15]

2.24 Climatologists' hypotheses to explain rainfall decline in the continent's drier regions include long-term climatic cycles and changes in ocean surface temperatures and in wind patterns over Africa brought on by changes in global atmospheric temperatures. The causes of Sahelian drought remain

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[14] Satellite imagery now allows scientists to monitor the latitudinal movement of the southern edges of the Sahara (and of the other North African deserts contiguous with it) running from southern Mauritania to mid-Sudan. These data are available only since 1980, so that longer-term trends cannot be inferred from them. The Sahara expanded southward in the first four years for which these data are available (1980 to 1984) when there was a serious drought. As a result, it was about 1.3 million km^2 (or 15 percent) larger in 1984, when the drought was most severe, than in 1980. Although rainfall since 1984 has remained significantly below the mean for 1900-1987, it has not again been as low as in 1984. The Sahara has therefore receded in size from its 1984 peak, but not back to what it covered in 1980 (Tucker *et al.*, 1991).

[15] In Côte d'Ivoire, where deforestation has been the most rapid (Table 18), mean annual rainfall has declined significantly during the 1970s and 1980s (World Bank, 1989a). Rainfall in Senegal has decreased by 2.2 percent per annum over the past two decades, and there has been a sharp decrease in rainfall in northern Nigeria and Cameroon (Lele, 1989c; Lele and Stone, 1989). Rainfall also declined precipitously throughout Ethiopia during that period (World Bank, 1987a).

poorly understood, but a broad consensus is emerging that they are related to large-scale patterns of atmospheric circulation -- specifically the reduced northward extension over Africa of the Inter-Tropical Convergence Zone (ITCZ), the band of wet weather that surrounds the earth where the trade winds from the southern and northern hemispheres converge (Odhiambo, 1991, p. 79). These ITCZ extensions, in turn, are affected by cyclical changes in ocean surface temperatures.

Departures in Rainfall from the Long-Term Average for the Sahel Zone, 1900-1987 (in %)

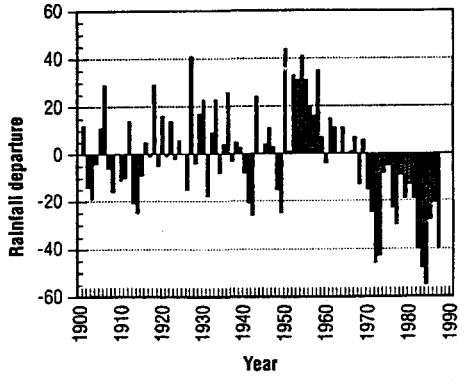

Fig. 1. Rainfall departures for the Sahel zone of Africa from 1900 to 1987 from Nicholson

Source: Tucker *et al.*, 1991.

2.25 There also is increasing agreement that land surface changes -- which include changes in albedo, evapotranspiration, soil moisture, surface temperature and roughness, and the amount of dust generation -- can prolong and intensify Sahelian drought by reinforcing the atmospheric conditions which initially reduce rainfall (Nicholson, 1989, pp. 53-54). Evidence is accumulating which strongly suggests that the widespread and severe changes in land surface characteristics in West and Central Africa caused by human activity have disrupted the normal cycle of the ITCZ extension over Sahelian Africa, causing the prolonged decline in rainfall from the long-term average. Changes in the land surface are partly caused by reduced rainfall itself, but human activity, notably deforestation and removal of vegetative cover on range and crop land, has a considerable impact. If the massive generation of smoke and atmospheric gases caused by biomass burning is considered, as it should, as an additional change in "surface" conditions over much of Western Africa (see paras. 2.29-2.30), it is difficult to avoid concluding that growing human populations have an impact on climatic change. Indeed, the effect of biomass burning of the enormous scale represented by African forest and grassland fires on the behavior and property of clouds is of increasing concern.[16]

2.26 Tropical forests are extremely important for recycling water between the Earth's surface and the atmosphere, and their disappearance has serious consequences for regional and global climate. They are highly efficient in returning rainwater to the atmosphere in the form of water vapor which forms new clouds and leads to subsequent rainfall. Rainforest regions thus store enormous quantities of water not only on the soil and biomass, but also in the atmosphere above them. When tropical forests disappear, water runs off quickly and much of it flows into the sea. This not only affects local and regional hydrological cycles, but also has potentially serious effects on climate. An important mechanism for the redistribution of heat is the atmosphere's ability to store energy in the form of water vapor and to release this energy again when vapor condenses into cloud droplets. If less water is available for this process, heat absorbed at the ground has to be removed by other means such as radiation and dry convection, leading to higher surface temperatures and to changes in the vertical distribution of heat (Andreae and Goldammer, 1992, p. 88).

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[16] Cloud droplets form around aerosol particles, called cloud condensation nuclei (CCN). Biomass burning generates and releases into the atmosphere vast amounts of pyrogenic aerosol particles which are very effective as CNN. The more CNN in the atmosphere, the more droplets form, resulting in smaller droplet size with a given amount of available water. Clouds composed of smaller droplets are lighter in color, reflect more sunlight back into space, and are less likely to produce rain. Since clouds are a major regulatory and control mechanism for the Earth's heat balance, large-scale modifications in cloud properties have a strong impact on global climate. The increasing abundance of CNN is, therefore, likely to have potentially critical impact on precipitation efficiency -- compounding the changes in hydrological cycles in the tropics caused by land surface changes such as deforestation (Andreae and Goldammer, 1992, pp. 87-88).

2.27 Deforestation also is a major cause of the rapid increase in the accumulation in the atmosphere of carbon dioxide (CO_2) and nitrous oxide (N_2O), two of the heat-trapping "greenhouse gases" that cause global warming (MacNeill *et al.*, 1991, pp. 11-13). Deforestation has been estimated to account for about one quarter of worldwide net CO_2 emissions into the atmosphere, the remainder coming from the combustion of fossil fuels (Andreae, 1991, p. 276).[17]

2.28 Burning of forests and grasslands causes enormous atmospheric pollution with both regional and global implications. Burning of biomass (forests, grasslands, agricultural wastes, fuelwood, etc.) world-wide is responsible for about one third of global emissions of carbon aerosols into the atmosphere. Africa accounts for over 42 percent of tropical and almost 37 percent of global biomass burning annually and contributes more to gas and smoke emissions from biomass burning than any other region of the world (Andreae, 1991, p. 272; Andreae and Goldammer, 1992, p. 82). The destruction of tropical rainforests through burning directly contributes to the greenhouse effect, because the CO_2 released (up to 600 tons of dry matter per hectare) is not recaptured rapidly enough by regrowth on the same site of grasses or crops (ranging from 5 to 50 tons of dry matter per hectare). About 31 percent of annual burning of tropical forest biomass worldwide occurs in Africa, 46 percent in South and Central America and 22 percent in Asia (Andreae, 1991, p. 272-273).

2.29 About 90 percent of biomass burning in Africa is accounted for by the annual dry-season burning of savanna and grasslands -- to clear them for farming, to stimulate grass growth and control pests and shrub growth, or to facilitate hunting. About one third of total worldwide emissions from biomass burning is due, thus, to savanna burning in Africa. Unlike deforestation, however, savanna burning does not contribute significantly to the greenhouse effect, because the CO_2 released by the burning is recaptured into new savanna vegetation during the next annual growth cycle. But due to its geographic and temporal concentration, African biomass burning results in regional atmospheric pollution levels that are comparable to, and at times exceed, those in industrialized countries. Acid deposition is higher in the Congo Basin and in Côte d'Ivoire than in the Amazon Region or in the eastern United States and is largely caused by direct emissions from biomass burning and by subsequent photochemical reactions in the resulting smoke and gas plumes. High levels of acid deposition have a negative effect on plant health and on fish and other aquatic organisms. Due to the longer average leaf life in the tropics, tropical forests are considerably more sensitive to foliar damage than temperate forests. Acid deposition also poses a serious risk to amphibians and insects that have aquatic life cycle stages and depend on rain water collected in plants and mosses and between dead leaves. This risk extends further to the many plants that depend on such insects for pollination. There is also an effect of soil degradation through progressive acidification and associated problems such as leaching of aluminum, manganese and other cations, interference with nitrogen cycling, and the disturbance of microbial processes in the soil (Andreae and Goldammer, 1992, pp. 88-89).

(vi) Environmental Degradation and Agricultural Stagnation

2.30 Soil degradation and erosion (excepting the often dramatic gully erosion that occurs where surface runoff is concentrated) are insidious processes, not readily apparent to farmers until the effects are severe and irreversible with the means traditionally available. They deplete the soil of nutrients, diminish its moisture retention capacity and reduce the depth of the rooting zone for annual crops. These effects exacerbate the impact of drought. Farmers and pastoralists in the semi-arid regions of Sub-Saharan Africa have always had to cope with drought, and they relied on effective adjustment

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[17] Most of the burning of fossil fuels occurs in the industrialized countries of the northern hemisphere, in the countries of the former Soviet Union and in China.

mechanisms. But when drought extends over several successive years, as has been the case in the 1970s and early 1980s, the problems become extremely serious.

2.31 The problems were compounded by the fact that the main traditional coping and adjustment mechanisms -- shifting cultivation with long-duration fallows, and pastoralists' mobility -- had become severely constrained. In the Sahel, for instance, rainfall during the 1950s and 1960s, when populations began to grow rapidly, was well above the long-term average almost every year. As a result, cultivation had been expanded into traditional rangelands, making both cultivators and pastoralists more vulnerable to drought. Range and pasture areas were reduced in size and the mobility of transhumant pastoralists was increasingly restricted. At the same time, a growing share of total crop land was in marginal areas, and changes in farming practices (for example, shorter fallows, reduction of multi-variety seeding and intercropping, displacement of traditional drought-tolerant varieties) rendered farmers increasingly more vulnerable to climatic risk (as well as to plant pests and diseases).

2.32 As vegetative degradation and desertification proceed, the livestock carrying capacity of pastures and rangelands declines. Crop yields decline as the result of soil degradation and erosion on cropland. Available data on average cereal and root crop yields show decreases in many countries -- despite significant investments in agriculture (Tables 10 and 12). Site-specific information confirms the problem in many countries.[18] The data suggest that environmental degradation, accelerated by population pressures, is part of the cause of Sub-Saharan Africa's slow rate of agricultural and economic development -- through its negative impact on soil fertility, rainfall, water availability, fuelwood supply and other forest products. Exacerbating this are a frequently poor agricultural policy environment, low use of productivity-enhancing agricultural inputs, and the generally low productivity of rural labor -- attributable in large measure to low health and nutritional status and low educational attainment levels of the rural population.

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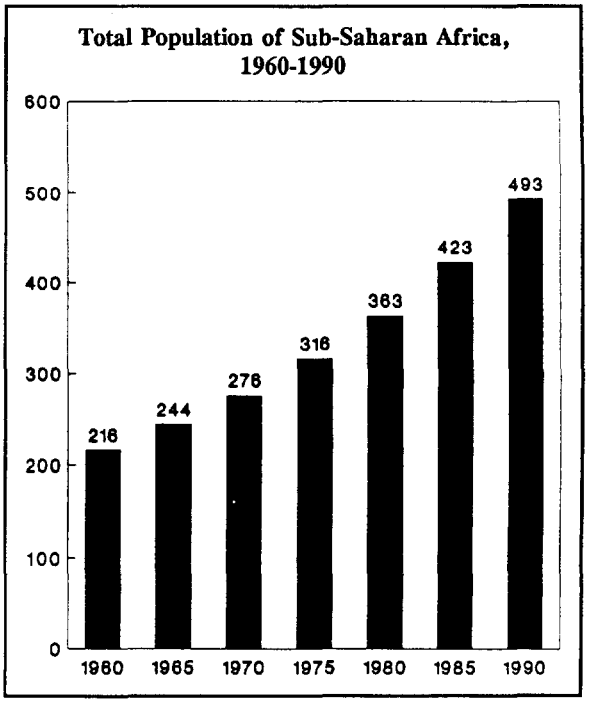
[18] See, for example, Barnes, 1990a and 1990b; Bishop and Allen, 1989; Elliot, 1986; Falloux and Mukendi, 1988; Gorse and Steeds, 1987; FAO/IBRD Cooperative Programme, 1991; Lal and Okigbo, 1990; Matlon, 1990; de Montalembert and Clement, 1983; Mortimore, 1989a and 1989b; Nelson, 1988; Stocking, 1987.

III. POPULATION GROWTH

A. The Lagging Demographic Transition

3.1 Sub-Saharan Africa lags behind other regions in its demographic transition. The total fertility rate (TFR) for SSA as a whole has remained virtually unchanged at about 6.5 to 6.6 for the past 25 years (Table 2). This is significantly higher than in other countries with similar levels of income, life expectancy, female education and contraceptive prevalence. In a number of countries of Sub-Saharan Africa fertility has in fact has risen (in large part due to significant success in treating diseases that cause infertility), while it has declined elsewhere.

3.2 Recent statistics, collected through nationally representative sample surveys carried out between 1986 and 1989 under the Demographic and Health Surveys (DHS) Program,[1] appear to signal, however, that several countries of continental Sub-Saharan Africa are at or near a critical demographic turning point (Table 8).[2] In Botswana, the TFR has fallen from 6.9 in the mid-1960s to 4.7 in 1989, and in Zimbabwe it has dropped from 8.0 to 5.3 over the same period. In Kenya, the TFR has declined from 8.2 in 1977/78 to 7.7 in 1984 and to 6.5 in 1989 (Kelley and Nobbe, 1990, p. 33.). Encouraging, too, are the data from Nigeria which indicate a TFR of 5.7 in 1990, compared with 6.9 in 1965. In Côte d'Ivoire, Ghana, Mozambique and Sudan, fertility also appears to have begun to decline (Table 2).[3]



3.3 Life expectancy in Sub-Saharan Africa has risen from an average of 43 years in 1965 to 51 years in 1990 (Table 1). In 18 countries, average life expectancy today is 53 years or more. Mainly due to the decline in mortality rates, population growth has accelerated from an average of 2.7 percent per annum for 1965-80 to about 3.1 percent per year at present (Table 2). And, given the age structure of SSA populations, the momentum for continued growth is already built in. Even if the TFR were to drop immediately to the replacement level of 2.2 births per woman, it would take almost a hundred years before the population would cease growing. By then it would be 80 to 100 percent larger than it is today.

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1 The DHS Program, a follow-up to the World Fertility Survey (WFS), is a nine-year program to assist developing countries in implementing 59 demographic and health surveys.

2 The TFR has declined most dramatically in Mauritius, falling from 4.8 in the mid-1960s to 1.9 by 1990 (Table 2).

3 Detailed analysis of the DHS data is still in progress, and this study could therefore not yet draw fully on the information collected under the DHS Program.-- Note also that the data in Table 2, which represent the "best estimates" currently available in the World Bank's demographic statistical data base, do not yet in all cases fully reflect the most recent survey findings obtained under the DHS Program.

3.4 The high fertility rates, and the marriage, reproductive and contraceptive behavior patterns that underlie these, arise in part from the fact that most women live in rural areas and have little or no eduction, few opportunities outside their traditional roles, and limited legal rights. Childbearing enhances their status, and most women marry and begin having children early and continue to have them throughout their fecund years. But the comparative lack of urbanization and education does not explain everything: data available from the World Fertility Survey (WFS) for 1978-1982 indicate that urban and rural, educated and uneducated women in Sub-Saharan Africa have and want more children than their counterparts elsewhere.[4]

Population Projections for Sub-Saharan Africa

Recent Bank projections assume that the TFR for SSA (including South Africa) will decline from 6.5 percent in 1985-90 to about 3.25 percent by 2030. This implies average annual population growth rates of just over 3 percent in the 1990s, 2.9 percent in the following decade and close to 2.6 percent in the decade thereafter. In this scenario, the SSA population would exceed 1 billion by the year 2012. By the turn of the present century, SSA would be second only to Asia in terms of total population. Aggregate population growth will remain above 2 percent p.a. at least until 2025, by which time the population of Sub-Saharan Africa, at 1,378 million, would be 2.6 times that of today. The net reproduction rate (NRR) will decline to 1 only by 2060. And Sub-Saharan Africa would reach a hypothetical stationary population of over 3.1 billion only some time after the year 2150 (Stephens *et al.*, 1991).

3.5 Women in Sub-Saharan Africa marry early: WFS data for the early 1980s show that, on average, 40 percent of all women aged 15-19 and 75 percent of those aged 20-24 were or already had been married (Cochrane and Farid, 1989). Early female marriage increases the number of fecund years a women spends in union and therefore tends to exert upward pressure on the TFR. Even urban women in Sub-Saharan Africa marry earlier than rural women in North Africa and Asia (*ibid.*).

3.6 Contraceptive use is far below that in other regions (Tables 5 and 6). It is associated primarily with the desire for child spacing and only secondarily with the wish to limit family size (Table 6). Use of efficient contraceptive methods generally increases with urbanization.[5] Low contraceptive use is due in part to poor knowledge. There are wide differences among countries, but on average, only about half of all women in Sub-Saharan Africa had, by the early 1980s, heard of a way (either efficient or inefficient) to prevent pregnancy. This compared with rates of 85-95 percent in other regions (Cochrane and Farid, 1989). By the late 1980s, the DHS surveys showed measurable increases in the percentage of women who had knowledge of modern contraceptive methods: in 10 of the 12 SSA countries surveyed and for which data are available so far, between 64 and 98 percent of currently married women aged 15-49 knew of at least one modern contraceptive method (the exceptions were Mali and Nigeria, with only 29 percent and 41 percent, respectively). The DHS data on contraceptive prevalence rates (CPRs) indicate, however, the difficult task ahead: only between 1 and 6 percent of these married women were currently using a modern contraceptive method, and the percentage of married women using any contraceptive method ranged only between 3 and 13 percent. The exceptions, with significantly higher CPRs, are Botswana, Kenya and Zimbabwe (Table 8).

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[4] Under the WFS, national surveys were undertaken in the late 1970s and early 1980s. Using these data, Cochrane and Farid (1989) carried out a comparative analysis to ascertain similarities and differences in fertility and underlying causal factors between Sub-Saharan Africa and other regions; WFS data were available for ten SSA countries at the time they undertook their study.

[5] Interestingly, when efficient and inefficient methods were considered together, urban use was higher than rural use in only three of the ten countries for which WFS data were available (Lesotho, Nigeria, Sudan). Traditional practices of fertility control, such as breastfeeding, might have been abandoned in the course of modernization, while modern methods were not yet adopted widely enough to offset this. This explanation is frequently given for the small differentials in fertility across socio-economic groups, but the available data on breastfeeding practices in Sub-Saharan Africa do not support this conjecture. Breastfeeding does not decline rapidly with increasing education (Cochrane and Farid, 1989).

3.7 Among all groups of women, desired fertility is far higher in Sub-Saharan Africa than elsewhere. However, the WFS data analyzed by Cochrane and Farid also showed that: (a) younger women desire fewer children than do older women; (b) urban women want fewer children than do rural women;[6] and (c) educated women want far fewer children than do uneducated ones.

3.8 In Sub-Saharan Africa, as elsewhere, women's education affects fertility preferences, use of modern contraceptive methods, and fertility. Cochrane and Farid found that:

- there are considerable differences in desired family size among countries (see also Table 8), but with increasing maternal education there is both a decline and a clear convergence across countries;

- current use of any contraceptive method was only 4 percent among the least educated (compared with 19 to 34 percent in other regions of the developing world), but 19 percent among the most educated (compared with 43 to 56 percent in the other regions);

- although current use of contraceptive practices among the most educated women in Sub-Saharan Africa was only about the same as among the least educated in North Africa and well below the least educated in Asia and Latin America, even this comparatively low rate was sufficient to lower the TFR of women with 7 years or more of schooling to about 5; and

- fertility rises with a few years of primary schooling, but then declines (as elsewhere); but the effect of maternal education on fertility has been less pronounced -- to date -- in Sub-Saharan Africa than elsewhere.

Contraceptive Prevalence among Women: Sub-Saharan Africa vs. Other Regions

Data for the early 1980s indicate that the percentage of women who had ever used any contraceptive methods varied widely -- from 2 percent in Mauritania to 74 percent in Côte d'Ivoire. The average for the ten SSA countries covered in the WFS was 26 percent, compared with 40 percent in both North Africa and Asia and 62 percent in Latin America. The regional comparison was far worse when only "efficient" methods were considered: an average of 6 percent of SSA women had ever used these, compared with 32 to 50 percent in other regions.

Based on reported current users, contraceptive prevalence in SSA was very low indeed, of both efficient and inefficient methods. In six of the ten SSA countries surveyed, fewer than 1 percent of all women were current users of modern methods. The difference between "current use" and "ever used" was much greater in SSA than elsewhere, probably reflecting the much greater use of contraceptive practices for birth spacing in SSA (Cochrane and Farid, 1989).

3.9 The very high levels of infant and child mortality (Table 3) prevent achieving desired, or target, fertility levels -- and this helps explain the low CPRs (Tables 5 and 6). Contraceptive use increases as the number of living children increases. Although infant and child mortality have declined over the past two decades (in some countries substantially), they remain much higher than in other regions (albeit with considerable differences among countries).[7] Higher rates of child survival reduce the need to replace children who have died or to have more children to insure against the possibility of

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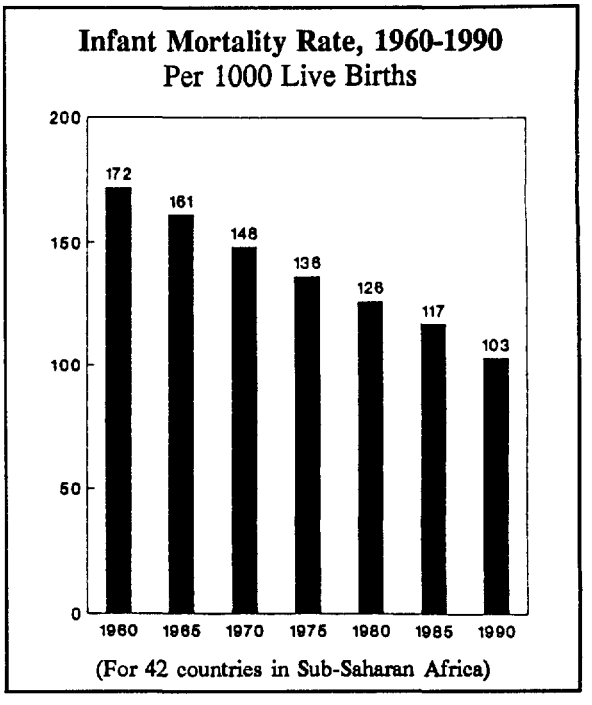
[6] However, urban residence has not yet become a strong fertility depressant -- the rural-urban differentials being smaller in Sub-Saharan Africa than in other regions.

[7] Infant and child mortality are both higher in Sub-Saharan Africa than in other regions. The differential is higher in the case of child mortality, due to high mortality in the second and third years of life following weaning. Toddler and child mortality rates are two to three times greater in SSA than in Latin America and Asia. Toddler and child mortality at all levels of mother's education are higher than in other regions (Cochrane and Farid, 1989). See also Table 3.

future deaths. Infant mortality rates are well below the SSA average of 103 in Botswana (37), Kenya (60), Zimbabwe (53) and Nigeria's Ondo state (56). The same is true for child mortality rates where the SSA average is 154: Botswana (53), Kenya (69), Zimbabwe (75) and Ondo state (108). In each of these cases, the TFR has begun to show a decline, signalling the onset of the demographic transition (Table 8).



3.10 Infant mortality is highest in rural areas, and children born to young mothers are at greater risk. Infant mortality is also higher for first-born children and for those born seventh or later. Children's survival chances are greater if the interval from the previous pregnancy is longer (maternal attrition, lower risk of low-birth weight babies, maternal attention). Infant and child mortality decrease consistently with the mother's education. Urban-rural differences in infant and child mortality are significant and somewhat larger in Sub-Saharan Africa than in other regions.

3.11 Prolonged and near universal breastfeeding has been the main factor keeping fertility below a biological maximum in most SSA countries. Although the duration of breastfeeding is generally shorter in urban than in rural areas, it does not decline as rapidly with mother's educational levels as in other regions. The most educated women in SSA breastfeed considerably longer than those in Latin America and Asia. Breastfeeding has important positive effects on child health -- and, indirectly, via reduced infant mortality, on fertility decisions. It also affects birth spacing -- and thereby maternal health, infant health, and fertility. In this respect, post-partem infecundity is far more important in Sub-Saharan Africa than elsewhere, accounting for 59 percent of the reduction in fertility from the biological maximum. On average, fertility in SSA is only 67 percent of what it would be in the absence of breastfeeding.[8]

B. Fertility and Agriculture: Part of the Nexus?

3.12 Fertility is highest in rural areas -- reflecting economic and socio-cultural factors which affect fertility aspirations. Traditional lineage and kinship systems, gender roles and relations between generations contain strong pro-natalist forces, and in most communities women's fertility is a major determinant of their status. Extended families, where the costs of high fertility are widely shared and only partly internalized by the couple making the fertility decision, tend to encourage high fertility. In most of rural SSA, labor is not readily available for hire; it must be mobilized instead from within the "household" or through social, communal or kinship arrangements specific to the area and community. For men, polygamy (or polygyny) is one widely practiced way of securing additional labor -- of women and their children (but even women may welcome co-wives as co-workers to help share the burden).[9]

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[8] Nevertheless, fertility patterns do not seem to be fully explained by the proximate determinants of marriage, post-partem infecundity (breastfeeding) and contraceptive use. Abortion, sterility, sub-fecundity and/or spousal separation appear to suppress the "maximum" fertility below that observed in other regions. This suggests the need for more research on other determinants of fertility to understand current levels and probable future trends (Cochrane and Farid, 1989).

[9] Polygamous men generally have more children than monogamous men -- while women in polygamous marriages tend to have fewer children than those in monogamous marriages (Bongaarts *et al.*, 1990, pp. 135-136).

3.13 Women may recognize far more readily than men the costs of high fertility to their own and their children's health. This may be particularly prevalent in polygamous unions where each women is responsible for her own children. The costs of children are lower to men than to women, yet the value of child labor may be higher to the mothers than to the fathers -- except in communities where fathers have and assert priority rights to their children's labor. For women, the labor of their own children is often the only means of securing adequate labor to cope with their many responsibilities.[10] As water and fuel resources become more scarce and the time required to obtain them increases, the need increases for children to help with the mothers' increasing work load associated with these survival activities. Child labor is also increasingly needed to compensate for declining male labor in foodcrop production, particularly in poor families which cannot hire wage labor. This may contribute to the maintenance of high fertility rates.[11] In much of Sub-Saharan Africa, men and women cultivate different crops on separate plots, and women's farming systems depend very heavily on female and child labor. Most women marry at an early age and usually considerably older men. Coupled with the high rates of divorce/separation and the fact that in most African societies women can obtain access to critical assets (such as land) and public services only through male relatives, this may increase women's willingness to bear many children so as to have sons to turn to when husbands leave or die. The desired number of children is considerably higher among rural women in Sub-Saharan Africa than among their counterparts in any other region of the world. And in no other region of the world do women play as significant as role in agriculture as in Sub-Saharan Africa.

3.14 The characteristics of most traditional land tenure systems may also bear upon fertility decisions -- but more research is needed to establish this link. Where access to land for farming is granted to all members of a community, this may be a disincentive to fertility control. Where the amount of land allocated is based on the ability to cultivate it, this ability -- under the low-resource farming conditions prevailing in most of Sub-Saharan Africa -- is primarily determined by the ability to mobilize labor. In most cases, this means family labor -- more specifically, female and child labor. Indeed, a number of field studies report this to be an important incentive to increase family size through such means as polygamy and pressure on women to have many children.

3.15 Among groups with matrilineal descent and inheritance traditions, further complications may arise because land use rights are not passed on from fathers to their children, but to uterine relatives (in most cases males). This weakens the link between land availability and land resource management on the one hand and demand for fewer children on the other. It also weakens men's incentives to invest in maintaining the fertility of the land they farm.[12] Fathers may see little point in preserving farm land in good condition beyond their own lifetime or in having few children so as to pass on a viable farm unit to each of them. Women, conversely, may face social pressure to bear many children so as to increase the number of future claimants to land resources who belong to their lineage.

3.16 The implication derived from the above is that most rural Africans attach high economic value to having large numbers of children. Larger families appear to fare better economically than small families. Children contribute labor in cropping, livestock tending, water and fuelwood fetching, and child

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[10] In a number of communities, women try to ease their peak labor constraints by participating in various forms of kinship- or community-based work group and labor exchange arrangements.

[11] This is suggested, though not necessarily proved, by the statistical analysis summarized in the box on page 25.

[12] Among the matrilineal Akan in Ghana, it is frequently observed that a son employed in urban areas is extremely reluctant to have remittances he sends to his father invested in improving the father's farm ventures because these investments will, upon the father's death, benefit his maternal uncles or cousins, rather than himselves.

rearing. The available evidence, although imperfect, suggests that high demand for children may be partly the result of the historic abundance of land and the shortage of labor, combined with high infant, child and overall mortality rates and high food insecurity. Maintaining high fertility is the rational response of people who seek to ensure adequate family labor and the survival of children to provide support to them in old age. For men in particular, polygyny makes good sense in this situation because it increases the supply of female and child labor and improves the prospects for security in old age. The widespread practice of payment of a bride price for a women (instead of the woman's family providing a dowry) reflects this reality where women are wanted for their labor and their ability to bear many children. Early female marriage, common in Africa, also increases the prospects for multiple childbirths.

3.17 Various other trends also tend to keep the TFRs high. As forest resources, water availability and soil fertility decline, farmers and pastoralists obtain less product per hectare. The main resource available to them to increase production is family labor which permits increasing the extent of the land farmed. It also makes it easier to diversify the sources of family income by taking up more seasonal or full-time off-farm employment. Hence, agricultural stagnation and environmental degradation, in resource-poor situations characteristic of most of Sub-Saharan Africa, provide an economic incentive -- and often a survival strategy -- to maintain large families. These factors also provide an incentive to keep children out of school to work on the parental farm or with the family's livestock.

3.18 This situation is exacerbated by the specific and important responsibilities placed on women in most farming systems of Sub-Saharan Africa. Women are often responsible for food cropping, and almost always for fuelwood and water provision (see Chapter V). As soil fertility declines and distances to fuelwood and water sources increase, many rural women are faced with the situation that the only resource that can be increased to meet the increasing need for labor is child labor. More labor substitutes for reduced soil fertility and compensates for the greater difficulty in obtaining fuel and water. This then completes a vicious circle in which population growth, combined with traditional farming practices, contributes to environmental degradation, in turn contributing to further agricultural stagnation and to the persistence of high rates of population growth.

3.19 These hypotheses are consistent with statistical tests (see the box on page 25) which show that, *ceteris paribus*, TFRs are highest in those SSA countries which have the most cultivated land per capita. Similarly, TFRs are highest in countries with the highest infant mortality rates, lowest level of female education, lowest urbanization and greatest degree of land degradation, all other things being equal. This suggests that demand for children as well as TFRs will decline over time as population density on cultivated land increases, and if female school enrollment rates rise, infant mortality declines, urbanization increases and environmental degradation is minimized.

3.20 However, changes in these determinants of demand for children are coming about only slowly. Analysis of available cross-country data suggests a considerable degree of inertia in fertility rates as well as the presence of many other factors that influence fertility rates but for which data are not available. Cultural factors appear to be very important.[13] They are likely to change only slowly, even though the factors which help shape culture are changing. Fertility rates will decline, therefore, even without an active population policy -- but only slowly, and only if infant mortality declines and environmental degradation is arrested. But these changes are occurring too slowly to compensate for the enormous difference between the rates of growth of population and of agricultural production.

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[13] Commenting on the findings obtained from the analysis of the WFS data collected in the late 1970s and early 1980s, one of the program leaders stated that the onset of the demographic transition "appears to be determined more by ill-understood cultural factors than by any objectively ascertainable development indicators" (Gille, 1985, p. 279).

3.21 Nonetheless, rising population pressure on cultivated land, declining infant mortality rates and improvements in female education are stimulating demand for family planning services. Much of this demand remains, at present, unmet (Table 6).

Statistical Analysis to Explain Inter-Country Variations in Total Fertility Rates (TFRs)

1. The available data were used to test several of the findings from the country-level analysis about the determinants of high TFRs in Sub-Saharan Africa. Data were available for 38 countries. A first set of statistical tests was undertaken using cross-country data only, looking at statistical relationships in the variation of variables across countries. The results were consistent with the analysis presented in this chapter, but there were questions concerning the robustness of the results and the weak statistical fit. A new set of tests was therefore carried out on much a larger set of data which included both time series and cross-country data. The results are reported here, along with any differences with the fuindings from the initial set of tests. The results of both sets of tests are highly consistent. (The data and a discussion of the methodology are presented in the Annex.)

2. For the statistical test, TFRs are hypothesized to be related to the independent variables as follows: positively to infant mortality (the higher the expected loss of infants, the more births are desired to assure a sufficient number of survivors); negatively to food security (the greater the food security, the lower the need for children to provide family labor for food production since sufficient other factors of production are available); negatively to female school enrollment (better educated women want fewer children); positively to cultivable land per person (the more cultivated land per person, the greater the need for family labor to help cultivate it); positively to the rate of deforestation (the higher the rate of deforestation, the greater the need for child labor to help with wood gathering and water fetching); and negatively to urbanization (the higher the degree of urbanization, the lower the total fertility rate).

3. This hypothesis is tested by means of statistical regression in which the TFR is the dependent variable. The independent variables are all lagged one year. The lag structure is arbitrary; several were tried, but the statistical fit did not improve. The annex presents the results of the several tests on combinations of different countries and different data. Only the sign of the coefficient, the range of T-statistics and the range of significance levels in the various tests are reported below. Since the methodology used does not permit the value of the coefficient to be readily interpreted, it is not reported.

Independent Variables	Coefficient	T-statistic	2-Tail Significance Test
Female school enrollment rate	negative	2.3-2.8	0.6%-2.2%
Hectares cultivated per person	positive	2.0-4.7	0.0%-4.5%
Infant mortality rate	positive	4.6-4.9	0.0%
Calorie supply as % of requirement	positive	0.9-1.4	17%-38%
Rate of deforestation	positive	0.2-1.3	21%-82%
Degree of urbanization	negative	1.9-2.9	0.4%-6.4%

Adjusted R squared = 0.44 to 0.46

4. The coefficients for female school enrollment, hectares cultivated per person, infant mortality, and the degree of urbanization are statistically significant at above the 90% level (i.e., with a 2-tail significance test of 10% or less). The 2-tail significance test indicates the probability of the coefficient actually being zero. Hence, a 2-tail test of 2.2% for the rate of female school enrollment indicates a 2.2% probability that the coefficient is zero -- or a 97.8% probability that it is not zero. Although the relationship between deforestation and the TFR is positive as hypothesized, the statistical tests do not suggest significance. The coefficient for calorie supply has the wrong sign and is insignificant.

5. In the tests using only single-year cross-country data, the results were the same, except that deforestation was also significantly related to the TFR, and the coefficient for calorie supply was positive as hypothesized, but insignificant.

6. These findings, combined with the site-specific evidence cited in the text, suggest that the TFR is lower as female primary school enrollment is higher. The greater the area cultivated per person, the higher the TFR. The higher the infant mortality rate, the higher the TFR. The greater the rate of urbanization, the lower the TFR. The positive association between the rate of deforestation and the TFR has ambiguous significance. The ambiguity may be due to the fact that the rate of deforestation is a poor proxy for the rate of degradation of the rural environment which includes soil and water degradation. Or the hypothesis itself may be incorrect. If further analysis establishes the significance of this relationship, it suggests that greater demand for child labor is associated with deterioration of the environment (more labor required to obtain fuelwood and water and to produce sufficient food as the productivity of farm land deteriorates due to deforestation). The relationship between nutrition and the TFR is even more ambiguous, and the hypothesis could not be supported statistically. It may be that at very low levels of nutrition, improving calorie intake increases fertility and, hence, the TFR (as the above equation hints). Or there may be no relationship. Better data are needed to resolve this.

IV. THE NEXUS BETWEEN POPULATION GROWTH, AGRICULTURAL STAGNATION AND ENVIRONMENTAL DEGRADATION

A. The Main Linkages

4.1 The preceding chapter cited some evidence suggesting that stagnating agriculture and environmental degradation, combined with traditional land tenure systems and the traditional roles of rural women, may contribute to maintaining high fertility rates. These systems and practices appear to create a demand for child labor as a family survival strategy. The complexity of this analysis is created by the multiplicity of factors which affect the rate of population growth, environmental degradation and slow agricultural development in Sub-Saharan Africa. In addition, there are important variations across countries. This chapter pursues the analysis of synergetic links between rapid population growth, poor agricultural performance and environmental degradation. The role of women in rural production systems, a major link in the nexus, is discussed separately in Chapter V.

4.2 The complexity of these linkages and the ambiguity of the analysis result primarily from Boserup's finding that agricultural intensification occurs as population density on agricultural land increases (Boserup, 1965). Others have published more recent material confirming the applicability of the "Boserup hypothesis" to many developing country situations, including in Sub-Saharan Africa.[1] It should not be surprising that this phenomenon has been observed so widely. Farmers are unlikely to have an incentive to intensify their agricultural production (i.e., to generate more output per unit land area) unless there is a constraint on land. If there is no land constraint, and land is free or very cheap, it makes sense from the farmer's perspective to extend the use of land and minimize the use of other inputs, including capital and labor. Shifting cultivation and pastoral livestock raising are perhaps the best illustrations of this situation. They have predominated in most of Sub-Saharan Africa.

Ukara Island, Lake Victoria (Tanzania): Agricultural Intensification under Population Pressure

An extreme example of agricultural intensification under population pressure is that of Ukara island in Lake Victoria. Faced with considerable population pressure and soils of low fertility, the island's inhabitants, the Kara (or Wakara), had developed, prior to European contact, a highly refined intensive farming system which included erosion control, crop rotation with intercropping and green manuring with legumes, fodder cultivation, stabling of cattle, and fertilizing of fields (farm-yard manure, leaf manure, household ash). The tenure system was based on private property, with inheritance and sale of land. The system has, however, reached its limits. The island's population has numbered about 16,000 since the beginning of the century; population density is about 500 per km^2, and the average family holding amounts to 1 ha of arable land. There has been little, if any population growth, whereas there has been substantial population growth in the rest of the Lake area where shifting cultivation is still practiced. Excess population moves to the mainland, where labor-intensive techniques are quickly abandoned because the returns to labor are far higher with the extensive systems still possible on the mainland (Kocher, 1973; Ruthenberg, 1980, pp. 158-160).

4.3 Consistent with Boserup's findings, these traditional extensive farming and livestock systems change, even in traditional society, when populations become more dense. This can be seen in the Kenya highlands, Burundi, Rwanda, the Kivu Plateau in eastern Zaïre and in parts of Nigeria. In Rwanda in particular, intensive traditional agricultural systems exist, brought about by the scarcity of land relative to the population dependent on it. In most of Sub-Saharan Africa however, land has been abundant until recently, and in some countries it still is.

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[1] See, for example, Binswanger and Pingali, 1984, 1988; Pingali, Bigot and Binswanger, 1987; Lele and Stone, 1989.

4.4 Traditional crop production and animal husbandry methods, traditional land tenure systems and land use practices, traditional methods of obtaining woodfuels and building materials, and traditional responsibilities of women in rural production and household maintenance worked well and could evolve slowly when population densities were low and populations were growing only slowly. The hypothesis is that rapidly increasing population pressure in the past 20-30 years has overwhelmed only the slowly evolving rural African traditions of farming, livestock raising, fuelwood provision, land allocation and utilization, and gender-specific responsibilities in household maintenance and rural production systems. This has led to an accelerated degradation of natural resources. This in turn has contributed to the low rate of growth of agriculture.

The Kofyar in Nigeria:
Extensive Farming When the Land Frontier Opens

The Kofyar initially lived as subsistence farmers on the Jos Plateau in north-central Nigeria. As population density on the escarpment increased, they intensified their farming system, with increasing reliance on agro-forestry, terracing and manuring. When population growth on the Plateau outpaced the ability of their farming system to sustain the increased numbers, the Kofyar obtained permission from tribes in the Benue plains to clear low-land forests and farm there. The migrants abandoned the intensive farming techniques they had practiced on the Plateau and adopted instead an extensive forest-fallow farming system focused on cash cropping and market-oriented animal production. The subsistence farms on the Jos Plateau had averaged about 1.5 acres, while the new farms in the cleared forests averaged 7.8 acres (Stone, 1984).

4.5 The complexity is further increased by interaction with the economic policy environment characterizing many African countries since the mid 1960s. Agricultural price, trade, exchange rate and tax policies in many African countries have often combined to render agriculture unprofitable (World Bank, 1989d). The mechanisms for developing and transmitting improved agricultural technology are severely inadequate throughout Sub-Saharan Africa. And excessive government control of agricultural marketing and processing has either squeezed out the private sector or forced it to operate clandestinely. Yet public-sector marketing and processing enterprises have performed poorly. Farmers have not usually been permitted to associate freely in farmer-managed cooperatives, nor to freely market their products. Throughout Sub-Saharan Africa, this lack of empowerment of farmers has discouraged them from investing. To break out of the trap of rapid population growth, low agricultural growth, and environmental degradation, these policy constraints must be overcome. The World Bank's 1989 long-term perspective study on Sub-Saharan Africa suggested how this might be done (World Bank, 1989d). This study contends that measures will also be needed to overcome the constraints imposed by increasing population pressure on traditional cultivation, fuel provision and tenure systems, and by the roles traditionally assigned to women in rural societies. Appropriate policy reforms will make the more rapid evolution of these traditional systems easier.

B. Traditional Crop Cultivation and Livestock Husbandry Methods

4.6 For centuries, shifting cultivation and transhumant pastoralism have been, under the prevailing agro-ecological conditions and factor endowments, appropriate systems for people throughout most of Sub-Saharan Africa to derive their livelihood, in a sustainable manner, from the natural resource endowment of their environment. The ecological and economic systems were in equilibrium. The key to maintaining this equilibrium was mobility. People shifted to a different location when soil fertility declined or forage was depleted, allowing the fertility of the land to be reconstituted through the natural processes of vegetative growth and decay. For field cropping in forest- and bush-fallow systems, this typically involved cultivation periods of two to four years, land then being left fallow for as long as 15 to 25 years. Transhumant herders' mobility generally involved a far greater geographic range, but a far shorter temporal cycle. They would move their herds on extended migratory patterns as dictated by the seasonal availability of water and forage and in most cases repeat the same cycle in one or sometimes two years.

4.7 These mobile systems of shifting and long-fallow cultivation and pastoral transhumance were suitable because of low population density, abundant land, limited capital and technology and frequently difficult agro-climatic conditions. As long as population growth was slow and land was available, the additional people could be accommodated by gradually bringing more land into the farming cycle and by establishing new settlements on previously uncropped land. Adjustments, including gradual intensification of farming, were made as and when they became necessary, but the pace of adjustment required was slow because population growth was slow. Inter-cropping in Rwanda, for example, was a traditional adaptation of thgis type, necessitated because shifting cultivation became increasingly constrained by rising population density.

Land Requirements for *Chitemene* Cultivation

The suitability of land for *chitemene* cultivation in Zambia depends, *inter alia*, on the density of woody vegetation available for cutting and on the land's regeneration capability. A person completely dependent on *chitemene* requires one hectare under cultivation each year for survival (Stølen, 1983, pp. 31-32; Vedeld, 1983, pp. 98-100). If 50 percent of the land in an area is suitable for *chitemene* and the regeneration cycle is 25 years, the aggregate land requirement for long-term ecological sustainability of the system is 50 ha per person. In a village of 200 people, requiring a total area of 100 km^2 to sustain *chitemene* farming, individual fields would therefore be as far as 5.1 km away from the village -- assuming the village land forms a circle and the village is located in the center of this circle.

This simple arithmetic also shows that traditional farming and land use practices, combined with limitations on the time people can afford to spend walking to and from their fields each day, limits the size of farm settlements. Some people eventually migrate to establish satellite villages in virgin forest land once the situation in their home village becomes too difficult.

4.8 In the absence of sufficiently rapid and widespread technological change, population growth has led to the expansion of the area under cultivation. This has involved mainly the conversion of large areas of forests, wetlands, river valley bottoms and grassland savanna to crop land. Since 1965, the area farmed has increased by over 21 million hectares (Table 16). Much of this has taken place on ecologically fragile and agriculturally marginal land which is not suitable for sustained farming and eventually abandoned in an advanced state of degradation. Forested land has declined by about 65 million ha since 1965 (Table 16). But land available to expand cultivation has become increasingly scarce in most of Sub-Saharan Africa, drastically narrowing the scope for further expansion. Most farming systems in Sub-Saharan Africa are, in fact, not "land surplus" systems, but land-extensive systems (Eicher, 1984a, p. 455). Over the past 25 years, crop acreage expanded by only 0.7 percent annually, and the population pressure on cropped land has increased sharply. On average, per capita arable land in Sub-Saharan Africa declined from 0.5 ha per person in 1965 to 0.4 ha/person in 1980 and to less than 0.3 ha/person in 1990 (Table 17).[2]

4.9 Because of agro-climatic and soil characteristics, the potential productive land endowment per capita in most of Sub-Saharan Africa is even poorer than these simple acreage statistics suggest. Niger, for example, is even more densely populated than India or Bangladesh if account is taken of the extremely poor quality of its agricultural resource endowment. Nigeria and Senegal are more densely populated than the Philippines. And Mali, Burkina Faso and The Gambia are twice as densely settled as Indonesia (Binswanger and Pingali, 1986; Matlon, 1990).

4.10 There is considerable diversity among countries, but everywhere fallow periods are shortening as populations increase and the land frontier recedes. In many areas, from Mauritania to Lesotho, fallow periods are not sufficiently long any more to restore soil fertility. Increasingly, farmers are compelled to remain on the same parcel of land -- yet they change their farming methods only very slowly.

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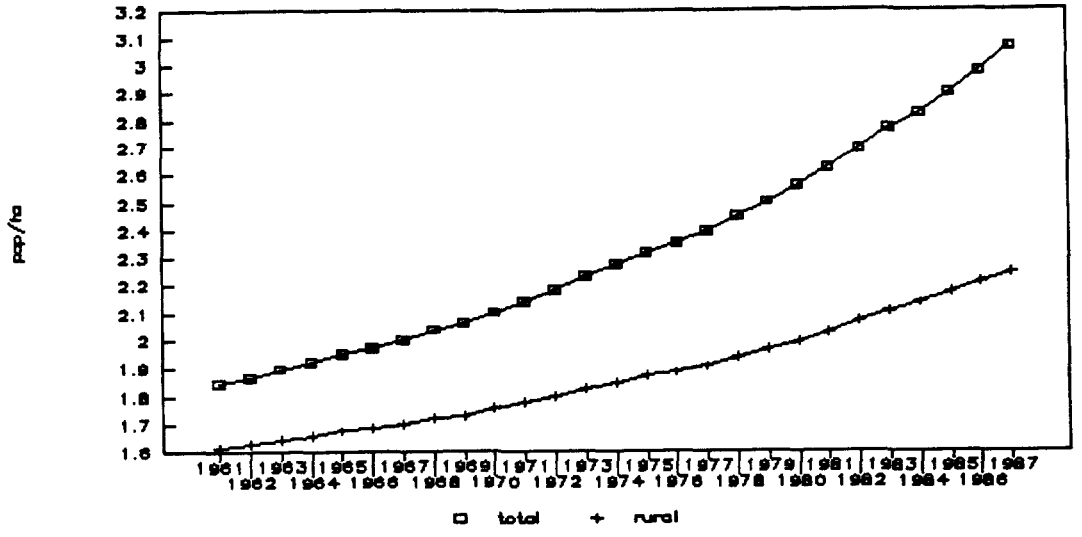
[2] For comparison, crop acreage in China declined from 0.6 ha/person in 1965 to 0.4 ha/person in 1987. In India, it declined from 0.3 ha/person in 1965 to 0.2 ha/person in 1987 (Table 17).

Population Pressure on Crop Land in Sub-Saharan Africa, 1961-1987
(total and rural population per hectare of crop land)



4.11 These people face a critical dilemma: a central element of their traditional farming system -- the ability to shift around on the land -- is being eliminated by population pressure, yet they continue to use the other elements of their traditional production systems. Where fallow periods are too short, or non-existent, and where traditional cultivation techniques continue to be used, soil fertility deteriorates and soils are not conserved. Wind and water erosion, soil nutrient depletion, acidity, and deteriorating soil structure become common and increasingly severe. As a result, crop yields decline, forcing farmers to expand production along the already receding land frontier. This expansion occurs firstly within the vicinity of their settlements -- on more steeply sloping land and in nearby forest, wetland and range areas. As this option becomes increasingly limited, people migrate to establish new farms, often in semi-arid areas and in tropical forests where soil and climatic conditions are poorly suited to the cultivation of annual crops and yields are therefore low. The migrants bring with them the knowledge of those techniques they practiced in the areas they abandoned, and these techniques are often detrimental to their new environment. Although they soon begin to experiment with simple modifications in farming techniques, this indigenous adjustment has been too slow in the 1970s and 1980s to keep pace with population growth.

4.12 Good pasture land is diminishing as the most productive tracts are converted to cultivation. The mobility of pasturalists' herds is further reduced as settlers increasingly cultivate bottom lands previously available to herders during their dry season migration. The concentration of increasing numbers of livestock on smaller areas destroys pasture vegetation, further reducing their carrying capacity and contributing to range degradation and eventual desertification (Gorse and Steeds, 1987; Falloux and Mukendi, 1988; Nelson, 1988).

4.13 Diminishing forest and woodland resources provide less fuelwood and other forest products, many of which are of considerable importance for rural livelihood and survival systems. Similarly, surface and groundwater resources are increasingly affected by the drastic alterations in land uses and vegetative cover. The effects of the worsening fuelwood and water scarcity are most directly felt by some of the most vulnerable: women and children. More time and effort are required to obtain these vital

commodities. Or people must manage with less of them. One consequence of reduced woodfuel availability is the increasing use of dung and crop by-products as fuels (see para. 4.40). This reduces their availability as farming system inputs to maintain soil fertility. Similar effects result from diminished availability of, and access to, water for household and home garden use: health and sanitation standards deteriorate, and home garden productivity declines.

4.14 These problems are gravest in parts of the Sahel and of mountainous East Africa and in the dry belt stretching from the coast of Angola through southern Mozambique. There are other countries where it appears that land is more abundant in relation to their current population. These countries lie in Central Africa, humid West Africa and Southern Africa. However, much of the potentially arable land in Central and humid West Africa is under tropical forest. To preserve biodiversity, maintain rainfall, and preserve the humid climate on which its tropical agriculture is based, much of this area should not be cultivated. Instead, the humid forests need to be preserved. This land has not been cultivated so far because it is poorly suited to cultivation (except possibly of certain tree crops). Soils in Africa's rain forest zones are typically low in nutrients and of high acidity. Even in these more land-abundant countries, the problem which is the focus of this paper can already be observed. An expanding population depending on agriculture and livestock is moving into the tropical forest areas, extending crop production and grazing into areas that are agro-ecologically unsuited to these forms of land use.

4.15 No analysis is available that quantifies the impact of environmental degradation caused by more people practicing traditional shifting cultivation and transhumant and pastoral livestock raising. It has therefore not been possible to separate the contribution of this phenomenon to poor agricultural performance in Sub-Saharan Africa from that of the policy problems identified in para. 4.5. There appears to be little doubt, however, that these policy deficiencies have slowed the evolution of traditional systems into systems more sustainable with higher population density. (A statistical test of this hypothesis is summarized in the box on pages 41-43.)

C. Land and Tree Tenure Systems and the Nexus

4.16 Critics of traditional tenure systems in Sub-Saharan Africa argue that these constrain agricultural productivity and cause environmental degradation -- because land resources are not privately owned, but are either common property of a community, clan or ethnic group, or open-access resources owned by no-one. They further argue that users of such resources have no incentive to limit their consumption thereof because they cannot be certain that other users will similarly limit theirs. Lacking secure property rights, individuals are dissuaded from adopting long-term conservation, investment and production strategies. There are two possible solutions, it is argued, to this problem: (a) establishing firm rules, with enforceable sanctions, which limit individual use of the resource for the common good, or (b) individualization/privatization of resource ownership and tenure, and registration of individual titles. In the critics' view, rapidly rising population pressure makes effective common ownership regulation increasingly more difficult. Based on the "tragedy of the commons" argument, they urge that land be placed in individual private ownership.

4.17 Opponents of tenure individualization focus on its alleged negative impact on land distribution and social equity. Evaluations of tenure reform in Kenya and Botswana are cited as showing that individualization of land tenure has led to land-grabbing, concentration of land ownership, *de facto* expropriation of women, landlessness and increasing marginalization.

4.18 Reality is far more complex. There is a wide diversity of farming systems in Sub-Saharan Africa, determined by differences in population density, agro-ecological conditions, socio-political organization, lineage and descent definitions, inheritance and residence patterns, agricultural technology,

and degree of commercialization. The correspondingly wide range of seemingly different land tenure systems is therefore not surprising. There are, however, important similarities among most of them. Most define land rights, particularly ownership rights, for groups. Individual or family use rights rest on customs recognized by the group. The group, not the individual, owns the land -- although there is no formal recording or land titling. An individual's entitlement to the land is transitory, although in most cases lineages enjoy continuous use rights over specific parcels. As fallow periods become shorter and cultivation of plots becomes more continuous, land is increasingly retained by families, households or individuals and transferred or bequeathed under prevailing customary rules (Migot-Adholla *et al.*, 1991). There is, thus, gradual institutional change in response to rising population pressure and this change accompanies and facilitates the evolution and intensification of agricultural production.

4.19 Customary tenure systems involve important intricacies. Ownership, management responsibility and use rights are often not identical. Use rights to different products from the same piece

Examples of Indigenous Land Tenure Systems

In **The Gambia**, each village has an identifiable land area that is administered by the village headman. Any compound can clear unclaimed land outside the village jurisdiction and claim it for the village. Land is passed on through the male lineage. Women obtain land mainly from their husbands, but also receive some from their parents. Men grow groundnut, millet and sorghum, women grow rice and vegetables. Maize is grown by both men and women. Women help with millet and sorghum harvesting and are beginning to grow some groundnut. Seasonal migrants from other parts of the country or from Senegal (*strange farmers*) can obtain land for cropping in return for working several days each week on the fields of the compound head; they return to their own villages at the end of the cropping season (Norem *et al.*, 1988, pp. 303-304).

Among the Fula and Mandinga in **Guinea-Bissau**, land is collectively owned by the resident clans of the village and allocated by the male elders to individual compounds; the male compound head allocates it to the individuals within the compound. Usufract rights can be granted on a collective or individual basis. Both men and women, married or not, can obtain use rights to individual plots and the right to dispose of the harvest from these. Collective fields remain under the control of the compound head who is responsible for maintaining the collective granary, and work on collective fields has priority over work on individual plots. Grasslands around the settlements are cropped exclusively by men, in a grass-fallow rotation of 4-8 year cycles, with sorghum, millet, fonio, cassava, peanuts and cotton. Male collective fields must be planted with subsistence crops (millet, sorghum) to be consumed, rather than sold. Male cash crops (groundnuts, cotton, cassava) are grown only on males' individual plots. Upland forest areas are used, with men and women working together, in long-cycle slash-and-burn shifting cultivation to grow upland rice, millet, maize and tubers. River valley land with sufficient moisture is utilized and controlled exclusively by women; they make all planting decisions and have the right to distribute and/or sell the product from their individual fields. Female collective and individual fields are always located in the valley bottoms and used for rice cultivation. The clans' senior women allocate this land to the compounds, and the senior woman of each compound is responsible for the compound's collective fields and allocates the individual fields to the compound's women. The senior women also have the rights to the oil palms in the valley bottoms. All women receive from the village elders rights to water and land for their gardens where they grow vegetables; they have the right to dispose of the produce of their garden. Some men produce cassava, cocoyam (taro), maize, sweet potato, and beans in their own gardens (Lifton, 1991, pp. 1-19)

In **Tanzania**, land was traditionally controlled and allocated by patriarchal clan leaders to heads of households or extended families. Today, all land is owned by the state, and the "Village Act" requires that each member of the village, male or female, be assigned separate plots to cultivate specific crops that are designated in the village by-laws. It is reported to be widespread practice for land to be allocated to male household heads who in turn assign plots to wives, sons and daughters. Often, vestiges of the traditional system remain, and the original users, usually males, retain some right over land even if it is currently lying fallow (Mtoi, 1988, p. 346).

Among the Bemba in **Zambia**, land holdings are semi-permanent. Local chiefs allocate land according to farmers' ability to cultivate (notably availability of draft power). Tenure is based, thus, on customary rights allocated by local chiefs and secured through clearing and continuous use. Land use rights are passed on through the matrilineal kinship system. Farm sizes are large, averaging close to 100 ha, but only about 5 percent of the farm is actually cultivated at any given time (Hudgens, 1988, pp. 373-387; Sutherland, 1988, pp. 389-406).

of land may be vested with different individuals or groups. Pastoralists and sedentary farmers may coexist on the same land, with farmers having cultivation rights and pastoralists grazing rights after crops are harvested. On the same plot of land, the right to the products of trees and the right to plant crops may be quite distinct and vested in different individuals or groups (see para. 4.23).

4.20 Where, under traditional tenure systems, usufruct rights are acquired simply by clearing and cultivating land, the incentive has been strong for settlers to move into previously uncultivated forest or savanna areas and to clear the land quickly in order to strengthen their claims and weaken those of other potential (even current) users.[3] This extends cultivation to marginal lands and imposes costs on the previous users -- often pastoralists or traditional forest dwellers. As fallow periods shorten or valley bottoms are taken under cultivation, land rights of farmers tend to take precedence over those of herders who are then forced to remain on more marginal and more rapidly degrading rangeland. Where sedentary farmers and transhumant herders have coexisted in symbiotic land use systems, the incorporation of livestock activities into settlers' farming systems also tends to cause difficulties for the pastoralists who are then increasingly compelled to keep their herds on pasture land alone. As a result, soil fertility declines more rapidly on such range land (Gorse and Steeds, 1987; Stocking, 1987; Falloux and Mukendi, 1988; Nelson, 1988; Mortimore, 1989a and 1989b).

4.21 In many traditional tenure systems, land for farming is assigned to eligible claimants on the basis of their ability to clear it and to establish field crops. In others, bush or forest fallows tend to revert to communal authority and can be reassigned to another claimant. The shortening of fallows may therefore also be the result of the cultivator's attempt to safeguard his/her rights to the plot. Because land is becoming scarce, it may also be caused by someone else moving in too soon after the previous cultivator has left the plot to natural regeneration.

4.22 Understanding the complexities of traditional local tenure systems is especially important for understanding the incentive system that applies to agro-forestry interventions. It also often helps explain deforestation. Tree tenure may be distinctly different from land tenure.[4] One person or group may have rights to the land, while others have rights to the trees on it, or to certain products from certain trees at certain times. In northern Sudan, for instance, a tree and its fruits may belong in shares to the owner of the land, the person who provided the seedling, and the owner of the waterwheel that irrigates the land (Gregersen *et al.*, 1989, p. 156). In some systems, tree clearing may be the only way to establish uncontested usufruct rights for cultivation. Elsewhere, tree planting may be regarded as laying claim to land. In many areas, diverse arrangements concerning rights in trees are common and of considerable relevance to those deciding whether or not to plant trees -- and which trees. Tree tenure issues are particularly critical where deforestation is severe and the fuelwood crisis pressing, but also where tree crops have potential for environmentally sustainable and at the same time profitable agricultural development. In some countries, because all forest land is owned by the state, people fear that if they

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[3] In Mali, farmers plough more land than they actually intend to crop in order to establish and protect their land use rights for the future. Ploughing without establishing crops renders the land even more vulnerable to erosion than if it were actually cropped. In Nigeria, large tracts of land for which members of the political and economic elite have obtained occupancy certificates under the provisions of the 1978 Land Use Act are rapidly cleared of vegetation with motorized equipment so as to preclude any possibility of smallholders remaining or becoming active in this area. This is an effective way of eliminating potential contestants to the land claimed under the provisions of the Act, but it also is extremely abusive of the environment. Even under government-sponsored land development schemes, the ability to clear, rather than to develop, the land is often a key determinant of eligibility. In Sudan, for example, the parastatal Mechanized Farming Corporation has been awarding 15-year leases only to people who clear 85 percent of their assigned holdings in three years (Southgate, 1990).

[4] See Raintree, 1987, for a number of detailed tree tenure studies in Sub-Saharan Africa.

plant trees their land will revert to the government. In parts of the Sahel, people have been unwilling to plant certain trees because they are on the forest department's protected list, and to crop or prune them would require going through tedious procedures to prove they own the land and planted the trees and to obtain a cutting permit (Timberlake, 1986).

Tree Tenure Rights

Tenure rights in trees comprise a variety of specific rights, primarily those of creation (i.e., planting), use and disposal. Use rights include: (a) gathering rights -- e.g., the right to gather or lop dead branches for fuelwood, to gather things growing on a tree (such as fungus or insects), or to gather tree products from under the tree, such as fallen leaves or fruit; (b) use of the standing tree -- such as hanging honey barrels in it; (c) cutting parts or all of a living tree -- e.g., for livestock fodder or building material; (d) harvesting produce. The disposal right comprises: (a) the right to destroy (by uprooting or felling individual trees) or the right to clear a section of forest; (b) the right to lend; (c) the right to lease, mortgage, or pledge; (d) the right to bequeath; (e) the right to sell (Gregersen *et al.*, 1989, pp. 155-157).

4.23 A recent in-depth study in Ghana, Kenya and Rwanda found that traditional land tenure systems do not appear to be insecure (Migot-Adholla *et al.*, 1991). Many farmers enjoy transfer rights on their lands -- although these rights may be subject to approval by family or lineage members. To the extent that the social system sanctions transactions in land, such transactions are sufficiently recognized. Traditional tenure systems continue to evolve, and many have over time accommodated increasing degrees of individual ownership and management control. Rapid population growth and growing commercialization of agriculture increasingly necessitate investing in land management and improvement, hastening the individualization of land rights (Migot-Adholla *et al.*, 1989).[5] In many cases, private rights to land have become virtually exclusive, although they fall short of outright ownership.[6] Other members of the community may have secondary concurrent or sequential rights that permit, for instance, fuelwood collection or livestock grazing. Inheritance has emerged as the most significant form of acquisition of agricultural land in traditional rural society, and rights to such land are very secure; nevertheless, security of tenure is strengthened by continuous occupation and cultivation. Restrictions on the sale of inheritable land may still apply in some systems (as in the northern Mossi Plateau in Burkina Faso), but in others land has been sold for half a century or more and can be mortgaged and leased (as in the Hausa areas of southern Niger). Purchases are becoming an increasingly important means of acquiring land. This is occurring in Kenya, with its history of land registration and government intervention in land matters, but also in Ghana and Rwanda, where governments have been less active in providing and enforcing a well defined legal framework for land transactions (Migot-Adholla *et al.*, 1989).

4.24 Problems arise as traditional tenure systems begin to impose constraints on evolving agricultural production systems and on the adoption of technological change. Unfortunately, most African governments and most donors have mistakenly believed that traditional community ownership of land did not provide adequate tenurial security, and that it discouraged investment in the land. This perception arose largely from failure to understand fully the intricacies of traditional tenure systems and the often subtle, but important differences among different communities' arrangements. A particularly important aspect of most, if not all, traditional African land tenure systems -- the concept of the inalienability of land -- has been widely regarded as an obstacle to agricultural development. As a result, land markets did not readily develop, and land ownership was difficult to establish as collateral for institutional credit.

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[5] There are exceptions -- still found, for example, in south-eastern Nigeria or western Sudan -- where individuals and families may be given access to an amount of land but not a specific plot. In such systems, where use rights for cultivation of seasonal crops rotate each year or after several years, individuals may not be keen on making long-term investments in land improvement (Migot-Adholla *et al.*, 1989).

[6] Women's tenurial security is generally far less certain than that of men (see Chapter V) -- although the opposite may be the case in some matrilineal-matrilocal societies.

4.25 There has also been an erosion and breakdown in customary laws and rules governing sustainable use and management of land and other common property resources. This has occurred under the pressure of rapid population growth and has been exacerbated by large-scale migration in many countries as well as by changes in social values and customs. Increasing commercialization of agriculture has induced changes in land use, farming systems and cropping patterns. Inappropriate pricing signals arising from government interference in input and output markets have often hastened such changes into unsustainable directions. And central political authorities have frequently undermined the capability of local decision-making bodies to manage their natural resource environment by imposing tight controls over local organizations, removing authority to central agencies, and creating new organizations that compete or conflict with traditional ones (Blaikie and Brookfield, 1987; Gorse and Steeds, 1987). In many areas, resources that were under effective communal management have, as a result, been converted into *de facto* open-access resources.[7]

Common Property vs. Open-Access Regimes

There is much misunderstanding of the difference between common property and open access regimes. Open access resources are at great risk of over-exploitation, since they lack clearly defined ownership and use rights assignations as well as effective management. Common property systems, by contrast, are well-structured arrangements in which group size is known and enforced, management rules are developed, incentives exist for co-owners to adhere to the accepted arrangements, and sanctions work to ensure compliance. There is a set of agreements within the community over the rights to use of communal land resources by various members and/or sub-groups of the community and by *strangers*, even in sparsely settled areas. Communal land really means not so much communally managed land, but land to which members of the community have rights, while outsiders do not or only under specific and tightly prescribed conditions (Repetto and Holmes, 1983; Blaikie and Brookfield, 1987; Bromley and Cernea, 1989; Barnes, 1990a).

4.26 The response of many governments has been to nationalize land ownership, but then to allow customary law to guide the use of some land, while allocating other land to private investors, political elites and public projects. This has reduced, not increased, tenurial security. Investing in the land becomes risky for farmers, since governments can and do reallocate land to serve "national purposes". In many cases this accelerates the breakdown of customary land management systems and emergence of open-access conditions in which exploitation by anyone is permitted. Open-access systems, found especially in forest and range areas,[8] result in rapid environmental destruction -- a repetition of the process widely observed before the agricultural transformation in Europe and usually (albeit mistakenly) labeled "the tragedy of the commons." Open-access systems are not conducive to resource conservation or to investment in land. This problem was resolved in Europe largely by the allocation of land to individual owners who then had an incentive to invest in it, develop it and conserve it.

4.27 As noted earlier, there may be a further problem in open-access systems, which may also be a problem of traditional tenure systems. Granting access to land for cultivation to members of a community on the basis of ability to cultivate it may be a disincentive to control human fertility, because the ability to cultivate is generally determined by the ability to mobilize family labor (e.g., Amankwah,

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[7] Nekby (1990) describes this situation in dryland areas.

[8] In much of the West African Sahelo-Sudanian Zone, pasture and even crop lands are often treated as a free good under current policies. Wells have been sunk to permit access to ostensibly un- or under-exploited rangeland, and settlers in less densely populated areas are not subject to any land-use guidelines. In both cases, legal incentives would help by offering land rights in exchange for management responsibilities (Gorse and Steeds, 1987). In most countries, forest land has been taken over by governments, overriding the rights of indigenous populations. Though nominally controlled, these "protected" or "reserved" forests have become virtually open-access resources for large- and small-scale exploitation, because the responsible agencies have not been able to provide effective management.

1989, p. 21).[9] Field studies report this to be an important incentive to increase family size through polygamy and pressure on women to bear many children.

4.28 The "solution" often proposed to solve these problems is the allocation of individual land titles, through large-scale titling programs. But the experience with such programs has been poor. Individualized land titling in Kenya and Botswana has facilitated land-grabbing, concentration of ownership and concomitant landlessness. Such land-grabbing had been practiced by European colonists, and some of the new elites have used the same methods. However, the problems in Kenya and Botswana may be associated more with the problem of transition from traditional to modern tenure systems. The rights of traditional land and tree owners were largely not respected in Kenya and Botswana, and members of the political and economic elite too easily manipulated the legal and administrative systems to wrest land from its traditional owners. However, once obtained, individual land ownership does provide an incentive to develop and maintain the land. This can be witnessed, for instance, in the intensive sustainable farming practiced by smallholders in the Kenya highlands, by private landowners in Zimbabwe and Botswana, and on tree crop plantations in Côte d'Ivoire.

4.29 To avoid the problems associated with an excessively rapid move to private individual land titles, or the even greater problems of nationalization of land ownership, it will be prudent to establish legal protection of traditional tenure systems, combined with a mechanism to provide individual or group titles on demand and only with the agreement of the traditional land owners and users (such as pastoralists). Only a demand-driven process of individual land titling will be possible and advisable in Sub-Saharan Africa. However, as traditional land tenure systems break down, and to resolve existing problems in open access systems, land titling will be necessary for agricultural growth, soil conservation and forest protection.

D. Deforestation, Fuelwood, and the Nexus

4.30 In arid and semi-arid areas, the need for woodfuel is a major cause of the reduction in tree cover. Excessive lopping and felling, combined with poor regeneration capability, have set in motion a downward trend that has been sharply accelerated by prolonged periods of drought and increasing livestock pressure on young regrowth. Woodfuel extraction considerably exceeds natural regrowth in many areas. Fuelwood shortages in fact limit the "carrying capacity" of arid and semi-arid West Africa more than do low crop and livestock yields (Gorse and Steeds, 1987, pp. 13 & 28).

4.31 Woodfuels are the staple source of household energy, with 90 percent of all households using them for cooking, the main end-use of energy in Sub-Saharan Africa (Barnes, 1990a). Some agro-processing and rural artisanal and semi-industrial activities (such as fish smoking, shea nut processing, pottery, brick making, smithies, beer brewing) also use considerable quantities of woodfuels.[10] In many countries, woodfuels are used in industrial production as well (tanneries, cigarette and match production, breweries, tea factories). In the early 1980s, wood accounted for over three fourths of total energy supply in 13 of Sub-Saharan Africa's 16 least developed countries (de Montalembert and Clement, 1983). In urban areas, charcoal is partly replacing wood.

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[9] Access to non-family labor is limited in most of rural SSA. Hiring wage labor is rarely an option, simply because there is, as yet, no class of landless laborers, although population pressure is leading to the emergence of seasonal and migrant wage labor in many countries. More common in many communities is the traditional practice of pooling labor for certain tasks, sometimes among gender and age mates within a village, more often among members of a larger kinship group.

[10] In Malawi, 100 kg of firewood are used to cure 3-12 kg of tobacco; in Côte d'Ivoire, 100 kg of wood are used to smoke 66 kg of fish (Dankelman and Davidson, 1988).

4.32 The fuelwood problem is a function primarily of population density and of agro-climatic and vegetation zone and is, therefore, very region- and location-specific. A 1983 FAO study (de Montalembert and Clement, 1983) identified the regions where people faced acute fuelwood scarcity or deficits.[11] The most vulnerable areas include the arid and semi-arid zones south of the Sahara as well as eastern and southeastern Africa and the islands and mountainous regions. Fuelwood deficits were identified in the savanna regions of West, Central and East Africa. The number of people affected by fuelwood shortages, already large, is expected to increase steadily:

- The arid regions face the most severe problem -- where the woodfuel scarcity is a more severe limit on the land's carrying capacity than food production capability.

- In the more densely populated savanna zone, only 25 to 50 percent of total fuelwood needs can be met from annual regrowth; conditions for tree regrowth are generally favorable, but rapid population growth is causing problems.

- In the less densely populated savanna, supply is still adequate for the resident population, but needs could rapidly outstrip supply in the absence of appropriate interventions.

- In Central Africa, with tropical forests and low population densities, woodfuel supplies are likely to be adequate well into the next century. However, increasing rates of cutting are contributing to deforestation and the resulting environmental problems.

- The coastal strip along the Gulf of Guinea has excellent conditions for tree growth, and tree plantations are widespread. Fuelwood supply is adequate, but this will change in the near future, especially around the large and rapidly growing urban concentrations.

- The densely populated highlands of Eastern Africa already face woodfuel deficits. Reforestation efforts in Burundi and Rwanda have been rather successful, but unable to keep pace with demand growth.

4.33 In 1980, eleven countries faced negative fuelwood supply-demand balances: Burkina Faso, Burundi, Chad, The Gambia, Kenya, Malawi, Niger, Rwanda, Swaziland, Tanzania and Uganda (Table 19). By the end of the century Ethiopia, Madagascar, Mali, Nigeria, Senegal, Sierra Leone, Sudan and Zimbabwe are expected to join this list. Since a significant switch to other fuels is not likely or possible in the short to medium term, population growth translates almost directly into a growth in demand for woodfuels (except to the extent that fuel use efficiency is improved). Yet continued reliance on woodfuels is clearly threatened in many regions by unsustainable exploitation.

4.34 Over time, urbanization will facilitate a switch to non-wood fuels, but urban Africa still depends very heavily on wood. Woodfuels are the fuel of the poor, including the urban poor. In many cities, as much as 90 percent of all households use woodfuels for cooking. Fuelwood prices in urban areas are high and rising. In some cities spending on fuelwood now claims up to 20 percent of the income of poor households. Urban demand for woodfuels has been far more destructive of forest resources than rural fuelwood gathering, mainly because of inappropriate policies. Rapid urban growth has led to intense cutting of wood on a large scale around cities and along major roads. Wood is brought

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[11] Populations facing "acute scarcity" were defined as those in areas where energy requirements could not be met even by taking wood on a non-sustainable basis or by making use of animal waste. Populations facing a fuelwood "deficit" are those in areas where fuel needs were met by taking wood on a non-sustainable basis.

from considerable distances, charcoal from even farther, and there are steadily widening rings of deforestation around cities such as Ouagadougou, Dakar and Niamey. Woodfuels are supplied to major cities in eastern Africa such as Mogadishu from as far as 500 km away. Since the wood itself is virtually cost-free to commercial suppliers, the cost of trucking woodfuels to urban markets is the main determinant of the distance from which woodfuels are brought. Where motor fuels are priced well below world market levels, such as in Nigeria, the effect is to extend drastically the distances over which trucking of woodfuels to urban centers is profitable, and the impact even on distant forest resources is particularly severe. The commercialization of the urban fuelwood and charcoal economy has increased the utility of rural fuelwood sources: under subsistence conditions, local fuelwood resources were used only to meet local demand, but these resources can now also be exploited for sale outside.[12]

Woodfuel Prices

Woodfuel prices to "producers" (usually collectors or exploiters of forest resources, rather than actual producers) tend to be extremely low (often as low as 5-6 percent of the urban consumer price) – providing no incentive to produce fuelwood commercially. Transport costs and profit margins account for most of the cost to urban consumers. Given the wide spread between the stumpage price and the consumer price, higher stumpage fees, providing incentives for more efficient harvesting and for fuelwood production, would have little impact on urban consumer prices (Barnes, 1990a).

4.35 As studies in Botswana, Malawi, Nigeria and Tanzania have confirmed, woodfuel demand first increases with rising income and later declines with increasing substitution of kerosene, liquefied petroleum gas (LPG) and electricity. The potential for such interfuel substitution depends heavily on economic growth and on income distribution in cities where economies of scale can be realized in meeting demand for fuel from such alternative sources. It also depends on pricing policies and supply security at the consumer level (Barnes, 1990a). To the extent that slow economic growth and rapid population growth prevent significant increases in average per capita incomes, demand for woodfuels will continue to increase about as rapidly as population growth. Moreover, even if aggregate economic growth can be accelerated, but is inequitable and leads to widening disparities in income distribution, this will impede the switch to non-wood fuels.

4.36 The brunt of the fuelwood crisis falls on women: they must manage household energy needs through fuel collection, preparation and use.[13] Children increasingly have to help with this task. Girls in particular have to help in fuelwood fetching, fuel preparation, cooking and tending the fire. In Tanzania, girls help their mothers as soon as they can walk. In many parts of Africa it is not uncommon for mothers to take their daughters from school to help them gather fuel. Women (and children) have to walk increasingly further and take more time to collect fuelwood.[14] This time is diverted from other pressing tasks -- including timely crop planting and weeding (thus depressing crop yields) and child care (which is increasingly entrusted to school-age girls kept at home). When fuelwood sources were more abundant, fuel gathering could often be combined with other activities, such as walking home from school or from the market or field. With increasing scarcity, fewer sources and longer distances, the loads

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[12] Limited and inelastic subsistence demand is replaced by limitless and elastic export demand (from the standpoint of the local economy), leading to much more rapid rates of exploitation than would be implied by local population growth alone (Repetto and Holmes, 1983). The collection of fuelwood and its sale in urban/peri-urban areas by poor rural women, on their own account or under wage contract to commercial traders, is an obvious example.

[13] Men do not usually involve themselves in fuel provision for the household under subsistence conditions, but there are exceptions (as among the Muslim Hausa in northern Nigeria). They usually take over only when the fuel economy becomes commercialized.

[14] In parts of Sudan, the time needed to fetch fuelwood increased more than fourfold between the mid-1970s and the mid-1980s (Agarwal, 1986).

carried become larger and heavier,[15] more time is required, and the opportunity to combine wood fetching with other tasks is reduced.

4.37 Fuel scarcity leads to changes in nutritional patterns, especially to fewer meals being cooked or meals being cooked less well (Timberlake, 1986, p. 34). This has nutritional and health implications. In parts of the Sahel, many families have gone from two to only one cooked meal per day (Agarwal, 1986); others mix uncooked millet with water for a midday meal (Tinker, 1987). A study in Rwanda found 62 percent of families cooking only once a day and 33 percent cooking even less often (Dankelman and Davidson, 1988, p. 71). Fuel shortages also induce shifts to foods which require less energy to cook, but may be nutritionally inferior. Women in Burkina Faso refused to use soybeans because of the long cooking time and greater fuel requirement compared with the traditional cowpeas (Hoskins, 1979) -- until they were taught to ferment the beans into soybean cake which reduced the heating time from as much as 12 hours to one (Tinker, 1987). Switching to raw or partially cooked food or to cold leftovers is becoming more common (Dankelman and Davidson, 1988, p. 71). The shortages of fuelwood, of food and of women's time combine into a serious nutritional and health problem. Partial cooking can cause significant health problems. Water purification also requires boiling -- not possible without fuel and time. Hot water to wash dishes, utensils, laundry and children may be out of the question (Dankelman and Davidson, 1988, pp. 71-72). The impact of nutritional and health problems on labor availability and productivity for farming and other income-generating activities is, of course, negative.

4.38 The intensifying fuelwood shortage has another important negative effect on rural women. Many of their non-farm income-earning activities require fuelwood: food processing, beer brewing, fish smoking, pottery, etc. Fuelwood scarcity therefore severely limits their opportunities to supplement their income through such activities. This is an increasingly critical issue in view of the widespread gender-separation of budgets and women's almost exclusive responsibility for child rearing (see Chapter V).

4.39 Eventually, women have little choice but to switch to other fuels. Interfuel substitution in rural Sub-Saharan Africa usually means a switch to less efficient fuels -- most commonly to crop byproducts and residues and dung which are far more valuable if recycled as inputs into the farming system to help maintain soil fertility. Many such fuels are less convenient than firewood or charcoal, requiring more tending and fire-feeding, generating more smoke and less heat, etc. Cooking may take longer and require even more fuel than before. Using crop byproducts and dung as fuel also has significant negative effects on soil fertility, water retention, crop yields, and soil degradation and erosion. This is increasingly happening, for example, in areas such as the Ethiopian highlands and the northern part of the Sahelo-Sudanian Zone.[16] The importance of agricultural wastes and dung for fertility management in farming systems is particularly critical as fallows are shortened and recycling of crop waste and dung is essential in the move towards agricultural intensification. Under the agro-ecological conditions of much of Sub-Saharan Africa, this is extremely important: organic matter is quickly mineralized in the absence of shading tree canopies, and nutrients are leached rapidly from most soils.

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[15] Women very rarely have access to any labor-saving technology for their task -- transport aids or efficient cutting tools for cutting or felling. They carry heavy loads to reduce the number of trips required to provide fuel for their household (and often their non-farm income-earning activity as well). They may headload as much as 35 kg (even though in many countries 20 kg is the maximum legally permissible headload for women) over distances of up to 10 km, often over difficult terrain. Carrying such heavy loads damages the spine, causing difficulties during pregnancy and childbirth, uses up substantial energy, and is a cause of frequent accidents.

[16] In Ethiopia, an active urban market for animal dung has developed where fuelwood resources have become depleted (Anderson and Fishwick, 1984). One study estimated that dung used as fuel in Ethiopia in 1983 would have increased the country's cereal output by 1-1.5 million tons if it had been used as fertilizer instead (Newcombe, 1989, p. 132).

4.40 There are many causes for the fuelwood problem, including the traditions of its use and the absence of alternative fuels. The major reason for the lack of success in introducing alternative fuels is that wood has been regarded in most of Sub-Saharan Africa as a free good, taken largely from land to which everyone has the right of access ("open access" land). As a result, a market for fuelwood has not developed in many countries despite its increasing scarcity. Even where fuelwood scarcity and high transport costs have created a market, the "producer price" of wood has remained below its replacement value because most supplies come from open-access forests. Market prices do not include the environmental costs of heavy fuelwood extraction. Alternative energy sources, such as kerosene, liquefied petroleum gas (LPG) and electricity are costly; their cost more closely reflects their scarcity value since they are not obtainable in "open-access" form. Despite dwindling forests and wood supplies, other fuels are not substituted in significant quantities, because the price of fuelwood is lower than that of alternative fuels. Investments in kerosene, LPG and electricity supply systems must be made more efficient to make them more price competitive with fuelwood. Fuelwood prices, conversely, need to be increased. Chapter VIII suggests how this may be done.

E. Logging

4.41 Commercial logging also takes a heavy toll -- in large part because of inappropriate logging policies and practices. It is, in fact, probably not so much the quantity logged but rather the procedures used that is the chief cause of forest destruction.[17] Logging concessions are often awarded as a form of political patronage. Logging practices are rarely monitored or controlled, and abusive logging practices are so common that they have become the norm (Repetto, 1988a; Spears, 1988). Stumpage fees tend to be very low, further encouraging extensive and destructive logging (Grut, Gray and Egli, 1991). Replanting is rare, because there is neither an incentive nor a requirement to do it. Concession agreements usually require neither replanting nor maintenance of concession areas as a forest. Most are also too short in duration to provide any inducement to the concessionaires to manage the concession areas for sustainable long-term multi-cycle production. Concessions are often abandoned once mined. In some cases, governments subsidize logging through tax and duty exemptions and through governmental financing of roads and infrastructure in forests. Subsidies provided to wood processing industries have the same effect. Areas closer to ports appear to be most abused, with high transport costs being probably the most important factor protecting inland forests against logging in parts of Central Africa.

4.42 There is widespread agreement that logging in tropical forests, as now practiced, is not consistent with the sustainability of rainforest ecosystems. It has been argued that logging itself, if properly undertaken, need not necessarily destroy the forests. However, recent surveys suggest that there are no sustained-yield forest management systems practiced on any sizeable scale in Western and Central Africa (Goodland, 1991, p. 14; Besong and Wencélius, 1992). Even selective logging for certain species and/or trees of certain size disrupts these fragile ecosystems with their multitude of highly specialized life-forms and of intricate multiple symbiotic relationships so severely that they will not survive intact. Although less directly linked to the Nexus, population growth will stimulate more logging, with its significantly negative impact on the environment. Through the environmental impact may come declines in rainfall, increases in water run-off and, hence, declines in agricultural yields (see Chapter II).

4.43 Logging almost invariably leads to a second -- and more damaging -- phase of forest destruction. Logging roads provide access for land-hungry settlers into areas previously difficult to enter. Moving along and spreading out from the logging roads, landless or shifting cultivators rapidly take over

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[17] Commercial logging by itself is responsible for only about 10 to 20 percent of forest destruction in Sub-Saharan Africa, but it has been considerably more destructive in some countries, such as Côte d'Ivoire.

logged-over forest areas, clear the remaining vegetation and convert the land to agricultural uses -- usually at very low levels of productivity. This accelerates and expands the process of deforestation begun by the logging companies. Logging concessionaires ordinarily acquire rights to log from governments, ignoring the traditional land and forest rights of forest dwellers. These rights, once eroded, are not respected by new settlers penetrating along the logging roads.

4.44 In virtually all countries of Sub-Saharan Africa, the institutions charged with managing and protecting national forest resources tend to be very weak. Forest guards and rangers often have neither the operating resources nor the training to monitor what is happening in the forest. They are even less equipped and prepared to regulate logging companies, deal with poachers, assist forest dwellers, and prevent encroachment by land-hungry settlers. These institutional weaknesses are so grave that farmer encroachment and logging occur on a significant scale even in many national parks. Forest services have little capacity to plan, to levy taxes, to undertake land use surveys, to deal with land disputes in forests (Besong and Wencélius, 1992).

4.45 The causes of the logging problem are related to those of the fuelwood problem. Forests have been widely regarded as reservoirs of free goods to be mined. Governments have shared in the bounty with private loggers through stumpage fees and taxes. However, once the forest disappears, the environmental services it provides disappear with it. It is disappearing fast.

Statistical Analysis to Explain Inter-Country Variations in Crop Yields

1. As in the case of the analysis of total fertility rates, two independent statistical investigations were undertaken to explain the cause of variation in yields per hectare of various crops, between countries and over time. Unfortunately, some of the relationships discussed in Chapter IV could not be investigated due to lack of suitable data. However, limited testing may establish the plausibility of the hypotheses:

- Incidence of drought will significantly affect crop yields.
- Crop yields should be higher where population is growing most rapidly relative to cultivated land. People begin to intensify agriculture as cultivable area per person declines. Hence, statistical analysis should show an inverse relationship between area cultivated per person and crop yields (all other things equal). However, the rate of growth in yields stimulated by declining availability of cultivable land per person will be significantly lower than the rate of population growth.
- Efforts to stimulate intensification, through the use of fertilizer, for example, will significantly accelerate the increase in crop yields beyond the growth rate stimulated by rising population density alone. This should be observed as higher yields in countries using more fertilizer (all other things equal).
- Primary school education, of men and women, should facilitate farmer adoption of intensive farming techniques and therefore be associated with higher crop yields.
- *Ceteris paribus*, countries with more rapid degradation of their natural resource endowment, as reflected in higher rates of deforestation, should have lower crop yields.
- Countries with a policy environment more accommodating for profitable market-oriented farming should have higher crop yields than countries with less conducive policies.

A. Pooled Cross-Country Time Series Analysis

2. The pooled cross-country time series analysis (described more fully in the Annex) investigated the determinants of crop yields for cereals as a whole, as well as separately for rice, maize, sorghum, wheat, and cassava. The independent variables were drought, nominal protection coefficient (representing the adequacy of agricultural policy), primary education, and cultivated area per capita. The higher the nominal protection coefficient, the higher is the farmgate price of the commodity relative to the world price. This is a proxy for the quality of the agricultural policy environment.

3. In summary, the following results were obtained (see the Annex for the equation):

(a) The coefficient on drought is negative for all crops and in all cases except for rice significant at the 10% level (this is the 2-tail test, meaning that there is a 90% probability that the coefficient is different from zero).

(b) The coefficient on the nominal protection coefficient is positive and in the case of cereals and sorghum significant at the 10% level. It has no impact on cassava, however; this makes sense because cassava is a subsistence crop which is least affected by price policy.

(c) The coefficient on primary education is positive, except for cassava and maize where it is highly insignificant. In the cases of rice and sorghum, it is significant at the 10% level.

(d) As hypothesized, the coefficient on per capita land under annual and permanent crops is negative, except for cassava where it is highly insignificant. In the cases of rice and maize, it is significant at the 10% level. This means that for the crops which are most commercialized, the smaller the land holdings, the higher the yield, all other things being equal.

(e) The results for cassava are strikingly different from those for the cereal crops. Neither the nominal protection coefficient, nor primary education, nor per capita farm size affect cassava yields. Cassava is a subsistence crop and rarely traded on international markets.

B. Single-Observation Cross-Country Analysis

4. A separate analysis was undertaken of the causes for variations in crop yields using a different data set with single observations for each country. This is less satisfactory since it eliminates the time dimension from the analysis and there are fewer observations. On the other hand, it allows a larger number of independent variables to be included. This analysis tested the statistical relationship between cereal yields (averages for 1984-1986) as the dependent variable, using as independent variables: cultivated area per person (average 1965-1987), fertilizer use per ha in 1987/88 (fertilizer use remained fairly stable in the 1980s), percentage of the school-age population in primary school (average 1965-1987), the rate of deforestation in the 1980s, and the general "appropriateness" of agricultural policy during the period 1980 to 1987. (The methodology applied is described in more detail in the Annex, which also presents the data used for this analysis.) Except for the rate of deforestation, the values for each variable were converted to their natural logarithm and a regression equation was fit to these data; the coefficients reported below therefore represent elasticities. Policy appropriateness is represented by a dummy variable having the value 1 for countries where policy is judged to have been conducive to profitable agriculture, and 0 where it is judged to have been inappropriate. Of the 38 countries considered, 24 were judged to have pursued inappropriate policies, 14 appropriate. This rating of countries is consistent with the categorization by the World Bank; it is, however, highly subjective. The role of women in agriculture and the effect of the land tenure situation could not be quantified and therefore were not tested in their impact on yields.

5. The equation is as follows, where the dependent variable is average cereal yields in 1984/86 (natural logarithm):

Independent Variable	Coefficient	T-statistic	2-Tail Significance Test
Constant	5.45	10.1	1%
Cultivated ha per person (a)	-0.33 (b)	2.5	2%
Fertilizer use per ha (a)	0.10 (b)	1.7	10%
Primary school enrollment rate (a)	0.17 (b)	1.2	24%
Deforestation rate	-0.05	0.9	39%
Agricultural policy dummy	0.30	1.9	7%

Adjusted R squared = 0.45
F Statistic = 7.0

(a) Converted to natural logarithm.
(b) Represents elasticity.

6. The equation explains about 45% of the differences in cereal yields among the 38 countries, which is less good than the pooled time series cross-country equation.

7. Consistent with the hypotheses and with the results from the pooled time series cross-country data, the lower the cultivated area per person, the higher are cereal yields, all other things being equal. The coefficient is identical using the two sets of data (0.3). The statistical relationship is highly significant, with a T-statistic of 2.5 and with a 2-tail significance test of 2% (indicating only a 2% probability that the coefficient is actually zero and a 98% probability that it is not zero). It suggests that the pressure to intensify production mounts with increasing population density on cultivated land; it is true even when the use of fertilizer and other modern inputs, the policy environment and primary school enrollment rates are held constant. This reflects farmers' ability to respond to rising population density with simple innovations. But, also consistent with the hypotheses, the coefficient is less than 1, suggesting that an annual decline in cultivated area per person (due to population growth) will only stimulate people to intensify farming at a rate of about one-third that of population growth itself. Historically, this is what happened. Crop land expanded at less than 1% p.a., and yields increased on average by slightly more than 1% p.a., giving an agricultural output growth of only about 2% per year for SSA as a whole for the 1965-1990 period.

8. A 1% increase in fertilizer intensity is associated with a 0.1% increase in cereal yields. The coefficient is significant statistically (2-tail test of 10%, indicating a 90% probability that the coefficient is not zero). Since fertilizer use is extremely low in SSA (averaging 85 grams per ha in 1987/88, compared to China, for example, where it is 2,360 g/ha), there is vast scope for increasing its use. This is also true for other modern tools and inputs, with which fertilizer use is highly correlated; given this correlation, the fertilizer variable also picks up the effect of the use of other modern inputs. Growth rates of fertilizer use (and other modern inputs) of 10-15% per year during the next decade are feasible. This would stimulate growth of cereal yields, according to this equation, by between 1.0% and 1.5% per year.

9. A 1% increase in the proportion of primary school-age children enrolled in school is associated with an 0.17% increase in cereal yields. The statistical relationship is weak, but when added to the evidence cited in the text and the significance of this variable in the pooled cross-country time series tests, it suggests that better overall educational attainment having a positive impact on farm productivity. This makes sense, since in most SSA countries the majority of the adult population is working in agriculture and associated activities.

10. The dummy variable representing agricultural policy adequacy is statistically significant in explaining cereal yield variation between countries. A better policy environment is associated with higher yields, all other things equal. This is consistent with the pooled cross country-time series analysis showing the significance of the nominal protection coefficient.

11. Consistent with the hypothesis, countries experiencing the most rapid deforestation have lower cereal yields, all other things equal. But the statistical relationship shows no significance. The problem may be that deforestation is endogenous. The statistical tests summarized in the following box suggest that deforestation itself is related to population density on cultivated land, intensity of fertilizer use, and agricultural policy. Therefore, when assessing the determinants of crop yields across countries, these other factors are already picking up the impact of deforestation, thus leaving deforestation as such with a coefficient not significantly different from zero.

12. The above analysis also suggests the plausibility (though not the likelihood) of achieving 4% p.a. average growth of agriculture in SSA. This could occur from: more labor use per ha facilitated by continued population growth (causing a 1% increase in annual output growth); 1.5% annual yield growth attributable to a 15% annual increase in the use of fertilizer (and of other modern inputs); and a rate of expansion in cropped area of 0.5% p.a. This gives a total output growth rate of 3.5% p.a. An increase in the number of countries with appropriate agricultural policy, and primary school enrollment increasing at 2% per year, should suffice to provide the additional 0.5% annual growth rate required to reach the postulated aggregate target. However, in the long run, as population growth slows, the scope for policy improvement narrows, and further expansion of cropped area becomes less feasible, sustaining 4% annual growth will become more difficult. It will depend increasingly on greater use of modern inputs and equipment, genetic improvements in crops and livestock, and improvements in people's educational attainment. Hence the importance of improved agricultural research and extension and of general education.

Statistical Analysis to Explain Inter-Country Variations in the Rate of Deforestation

1. The analysis in Chapter IV suggests that deforestation is related positively to population pressure on cultivated area (the lower the cultivated area per person, the higher the rate of deforestation), to the rate of population growth (the higher the rate of population growth, the higher the rate of deforestation due to land clearing and fuelwood gathering), and with policies favorable to agriculture (the more profitable agriculture and logging, the more rapid the clearing of forests). It is negatively related with the use of modern farm inputs such as fertilizer (the greater the use of modern farm inputs, the lower the need to clear more forest land for farming). Open access land tenure situations were also hypothesized to stimulate deforestation, but this cannot be quantified.

2. To test the above hypothesis, regression analysis was undertaken with the rate of deforestation as the dependent variable. The two separate data sets were used, as described for the analysis of crop yields (see the Annex for a discussion).

3. The nominal protection coefficient has no statistically significant relationship with deforestation, contrary to the hypothesis. Using the data set with single observations per country, the dummy variable distinguishing countries with good agricultural policy (the variable has a value of 1) from those having poor policy (value 0) is nearly significant (2-tail test of 11%, or significance at the 89% level). The coefficient is positive, as hypothesized. The result is therefore ambiguous with respect to the policy variables. Even if poor agricultural policy were to reduce the rate of conversion of forest to crop land, it would not appropriate to pursue poor agricultural policy in order to conserve forest resources, because the objective of accelerating agricultural growth will override that of reducing the rate of deforestation in every country. However, this finding does suggest the need for mitigating actions to retard deforestation when agricultural policy is good. Land use planning will be important in the development of these mitigation efforts.

4. The hypothesis that population pressure on cultivated area increases the rate of deforestation could not be confirmed with the data. In the pooled cross-country time series analysis, the relationship is not statistically significant. In the simple cross-country sample, this variable had the expected negative coefficient (the less the cultivated area per person, the higher the rate of deforestation), but the significance level was very marginal (2-tail significance test of 15%). The result is therefore ambiguous and unconfirmed.

5. Drought proved to increase the rate of deforestation significantly.

6. As hypothesized, the use of modern farm inputs such as fertilizer is negatively related to the rate of deforestation. Intensifying agriculture slows the rate of deforestation. This is likely to be the most important policy available to deal with this problem.

V. THE ROLE OF WOMEN IN RURAL PRODUCTION SYSTEMS

A. Introduction

5.1 A central aspect of the population-agriculture-environment Nexus is the role of women:

- in their traditional child bearing and rearing role, women directly influence both the size and the quality of the future stock of human resources;
- in their household management role, women are the primary managers and users of a variety of natural resources (most notably fuelwood and water);
- in their farming role, women are responsible for a very substantial share of foodcrop production and a variety of other agricultural activities,[1] and their decisions and activities have a direct bearing on soil fertility and erosion, water infiltration and retention, and waste and by-product recycling.

5.2 Women's triple responsibility -- child bearing and rearing, household management, and production activities -- and the increasing pressures on their time and energy have important consequences for human resource development, agricultural productivity and environmental sustainability. As their agricultural workload grows, women face rising pressures in their role as household managers, and their childbearing and child caring burden remains as heavy as ever. Legal, institutional and technical developments have added further constraints on women (e.g., land titling, access to credit and extension, research orientation, etc.). The promotion of cash crops, mechanization, extension and formal credit systems have mainly been directed at men. As men turn to non-farm employment, women increasingly become *de facto* managers of the family farm. In many areas, 50 percent or more of all farms are managed by women -- yet traditional and legal constraints remain severe. Fuelwood and water are becoming increasingly scarce, and more time is required to obtain them.[2] The intensifying time constraint means that women either reduce the time spent on certain tasks or depend increasingly on the labor of their children. This may be one of the factors explaining the persistence of high fertility rates.

Women in Kenyan Smallholder Farming

According to the 1979 census, 33 percent of all rural smallholder households in Kenya were headed by women, with the highest percentages in Nyanzxa, Eastern, Western and Central Provinces. Data from Kakamega and Machakos District show that even these high percentages do not fully represent the extent of *de facto* female-headed households. Surveys report that 55 and 47 percent, respectively, of the farms in these areas were in fact managed by women. Smallholder farm production is increasingly the responsibility of women. It is estimated that 96 percent of rural women work on the family farm; women provide three fourths of the labor on smallholdings and actually manage about two fifths of these smallholdings (World Bank, 1989b).

A village survey in central Kenya found husbands absent in 70 percent of the households surveyed and the wives cultivating the entire holding. In the other 30 percent of households the wives cultivated their own plots within the holding. In the majority of cases, women made the decisions on crops to be grown and input purchases and use. Only credit decisions were taken by the husbands or by both spouses jointly (Due, 1988).

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[1] In addition, most rural women in Sub-Saharan Africa also pursue non-agricultural production and income-earning activities.

[2] Coupled with their often inferior health, nutritional and educational status, these pressures also render women poorly equipped to take advantage of emerging and better income earning opportunities outside agriculture.

5.3 Efforts to intensify agriculture, conserve natural resources and reduce population growth will therefore have to be focused to a significant extent on women. These efforts will have to aim, *inter alia*, at: reducing women's severe time constraints; lowering the barriers to women's access to land, credit and extension advice; introducing technologies useable by and beneficial to women; and upgrading women's educational standards and skills.

B. The Female-Headed Household Syndrome

5.4 Female-headed households (FHHs) are a widespread and increasing phenomenon in many parts of Sub-Saharan Africa. It has always been common in societies which practice polygyny and spousal separation of residences, or where divorce has been fairly easy and frequent. In some regions, where long-term or seasonal male outmigration is particularly prevalent,[3] female-headed households account for 50 percent or more of total rural households. This also means that an increasing number of smallholder farms are managed by women.

5.5 The concept of the female-headed household is often misunderstood or misinterpreted. It is not a static concept, but a life-cycle issue. African women may move in and out of being household head several times in the course of their lives (due to marriage, divorce, husband's death, remarriage, husband's outmigration, husband's return). Female-headed households are not simply a marginal group -- remnants of "nuclear families" that have lost their male heads due to death, divorce or migration. They are a common and economically and socially important reality with far-reaching implications for development policy. The great majority of women in Sub-Saharan Africa who reach adulthood are likely at one or more times throughout their adult lives to head a household that is without a resident adult male. One important implication is that all women must be reached with development assistance interventions -- since they all are likely at some time(s) during their adult lives to be household heads when they will have to manage without the support of an adult male.

Male- and Female-Headed Households: Differences in Access to Resources and Markets

Male-headed households (MHHs) in **Zambia's** Lusaka Province are far more likely than female-headed households (FHHs) to own oxen; hence, the farm area that can be cultivated is larger in MHHs. MHHs also have better access to other support services. In the Western Province, MHHs are six times as likely as FHHs to have oxen. The introduction of oxen into farming and of cash earning opportunities have both essentially been limited to men, leading to significant differences between male- and female-headed households -- a "feminization of poverty" (Sutherland, 1988).

5.6 Female-headed households differ from male-headed households most importantly in that most of them lack ready access to adult male labor. They are usually also underendowed in other important respects -- notably in land, capital, farm equipment, and transport aids. Land farmed may be far less than land allocated or controlled, due to labor constraints and the lack of access to draft animals, farm machinery and hired labor. Capital may or may not be a constraint, depending on the incidence, amount and timing of remittances from absent husbands or other relatives.[4] For most FHHs, access to various public sector services is also severely limited, especially in the case of extension, institutional credit and services delivered through formal cooperatives.

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[3] In Lesotho, about 60 percent of all males aged 20 to 44 are employed in South African mines (Plath *et al.*, 1987).

[4] Men's remittances are often small, since they themselves are poorly remunerated, have to pay for their own food and lodging, may have taken a second wife, or prefer to retain their savings for major purchases of their own. Remittances tend to be used to purchase essential food supplies. Sometimes they are used to buy fertilizers and hire labor. Only rarely are remittances sufficient to permit investment in labor-saving machinery or livestock.

C. The Gender Division of Rural Labor and Farming Systems

5.7 Women are estimated to provide between 50 and 80 percent of all agricultural and agro-processing labor in most countries of Sub-Saharan Africa -- prompting Ester Boserup to write of Africa as "the region of female farming par excellence" (Boserup, 1970). The gender division of labor (in farm and non-farm production, processing, marketing, household maintenance, subsistence and survival activities, child rearing, etc.), its determinants, and changes over time are important for agricultural and poverty alleviation policies. This division of labor varies widely among cultures. It is also determined by characteristics of the household,[5] the individual, the farming system, the local natural resource base, the community, and the national economic and political system. Gender roles and responsibilities may undergo seasonal variations, due to farm production requirements, for example, or to seasonal male out-migration (Dixon-Mueller, 1985, pp. 119-123). Gender roles in farming systems also change over time, in response to cultural, technological, political, commercial, ecological, demographic and other factors.

Women in Agriculture: The Data Problem

In **Malawi**, agricultural tasks are assigned by gender and are sensitive to seasonal variation. A 1970 ILO estimate reported 40 percent of the agricultural labor force to be women; but the 1972 Census, with only a one-week reference period, reported merely 12 percent of the labor force to be female. The 1977 Census, using a one-year reference period, reported 51.6 percent of the agricultural labor force to be women (Doorenbos *et al.*, 1988).

5.8 Gender divisions of labor have implications, for instance, as regards the promotion of various crops, subsidization of certain inputs, targeting of research and extension, pricing, land tenure policies, etc. Shifts in cropping patterns will have different effects on labor required by genders. Control over returns affects incentives to work. Social norms need to be ascertained and considered to avoid mistakes. Three fifths of respondents to a survey in Botswana considered selling crops (but not cattle) a job for women only; extension, credit, transport and marketing interventions for crops would therefore need to focus on women to make sense (Dixon-Mueller, 1985). In the Eastern Uluguru Mountains of Tanzania, male involvement in such activities as fetching water and fuelwood or preparing meals is completely taboo (Mtoi, 1988, p. 349); efforts to address the water and fuelwood problems in this region would therefore need to be directed at women.

Women's Farm Work: Perceptions vs. Reality

In **Tanzania**, awareness of female involvement in farming was extremely poor among officials and researchers -- despite widespread visible evidence to the contrary. Farming systems research in Kilosa showed women contributing about half the labor on major crops and more than that on minor crops and on all other household tasks. Women were particularly active in planting (56%), weeding/thinning (52%) and harvesting (58%), and also contributed significantly to activities often assumed to be strictly male domains, such as land preparation (46%). Women's labor input was particularly high in rice (67%) and beans (59%), followed by maize (48%), sorghum (40%), sunflower (39%) and cotton (39%). Men dominated the marketing of all crops, except rice where women's contribution was 50%.

In **Zambia**, women in male-headed farm households were found, to the astonishment of male researchers at the University of Zambia, to contribute more hours daily than the men to farm work (8.5 hrs vs. 7.4 hrs) as well as to non-agricultural tasks (5.0 hrs vs. 1.1 hrs) (Due, 1988).

5.9 The organization of farm labor and production responsibilities varies widely, but tends to be highly gender-specific. In some regions, men and women farm fields jointly, usually in a gender-sequential mode, but sometimes side by side. In other areas, a substantial portion of agricultural activities is gender-segregated: women grow their own crops on separate plots -- but they are also required to work

[5] Household size; gender and age composition; resource endowment; differential gender access to resources, services, equipment, credit, information, employment, markets, etc.

on the plots/crops owned/managed by their husbands. In much of Sub-Saharan Africa, men and women farm separate fields and grow different crops. Labor may be allocated by crop and/or by task -- men performing certain tasks on women's fields and women certain others on men's fields. In some areas, men may work fields communally with other men, or gender-based work parties carry out certain tasks jointly. Hired labor is important in some areas and for certain activities. Labor sharing is common in some regions, usually within lineages or communities and often along gender-specific lines. The introduction of commercial crops (which may be food crops intended for commercial marketing) or the commercialization of traditional crops often leads to changes in gender specificity of farming activities and responsibilities. Men tend to take on the market-oriented production, leaving women to cope with providing for the family's subsistence needs.

5.10 The gender-specific separation of farming responsibilities, with men and women producing different crops on separate plots, is often so explicit that there are two distinct gender-specific farming systems operating side by side. Details vary considerably among regions and socio-cultural groups, but in most of these dualistic systems, and where markets have developed for farm products, women tend to be responsible for the production of food crops for home consumption, while men more often produce explicitly for the market. This has often been couched in the simple dichotomy: cash crops = men's crops, food crops = women's crops. In this extreme simplicity, this statement is clearly not valid.[6] Although industrial and export crops tend to be the domain of men, men also engage in substantial food production where food crops have good markets or where custom places the responsibility for producing the main staple on men. Where farming is generally subsistence oriented, men often produce the main staple on their fields (usually with considerable labor input from the women), while women grow a variety of supplemental food crops. Conversely, women do not necessarily limit their production activities to subsistence crops. Where market outlets exist and social customs permit, they not only sell part of their surplus (even if it is a temporary one and they have to purchase supplies in the market when the quantity stored at home is depleted), but they also produce a variety of "minor" crops for sale to pay for other household necessities.

The Gender Division of Farm Labor

In southern **Ghana**, men used to clear land and fell trees; women planted, weeded, harvested, transported and processed the crops. With the introduction of cocoa, men moved into pure cash cropping, leaving food crop cultivation for home consumption entirely to women. Without male help, women often could no longer grow yams, the traditional staple, and switched to cassava which requires less labor and can be left in the ground for up to two years to be harvested when needed. Today, most women grow plantains, maize, cocoyam, cassava, and vegetables; they also help the men, especially in headloading farm produce (Dey, 1984b; Date-Bah, 1985, pp. 214-216).

In **Zambia's** Luapila Province, the gender-based labor division in farming varies with the farming system. In semi-permanent fields, men prepare mounds for cassava and ridges for maize; women plant, weed and harvest. In *chitemene* fields, men (usually sons-in-law) lop branches, while women pile and burn them, seed and harvest. Men dominate decision making for cash crops; women are responsible for food crops (Sutherland, 1988).

5.11 The male and female farming systems differ in many important respects. They have different primary objectives and distinctly different resource endowments. They face different incentive systems and different constraints. Risk perceptions and risk management strategies differ significantly, as do access to factor and product markets, to improved technology, to information, and to various support services. There also are important resource and commodity flows between the two systems. In most cases, the direction of these flows tends to be heavily biased in favor of the male systems. These factors

[6] Among the Gulmantche in northern Burkina Faso, men traditionally cultivated and controlled the millet and cotton crops. When groundnuts were introduced as a cash crop in the 1940s to facilitate payment of taxes, women became the major producers of this crop. Men only began to take up groundnut cultivation in the 1970s when cotton cultivation became less remunerative (Hemmings-Gapihan, 1982).

all have implications for women's productivity, time and resource use, status and fertility decisions as well as for household-level food security and child welfare.

5.12 A major difference between the two farming systems concerns access to land. Where women have specific and gender-segregated crop production responsibilities (as distinct from participation in farming activities controlled by men), this requires access to specific and distinct plots, and women's rights to land assume special importance. Although there are a number of exceptions, particularly in matrilineal communities with matrilocal residence systems, women's tenurial security is usually far less certain than that of men. Moreover, as men expand the scale of their farm operations in response to

Women's Rights to Land in Traditional Tenure Systems

In **Ghana**, there are differences among ethnic groups. In most groups, land belongs to the lineage. Any member of the lineage, male or female, is entitled to occupy unappropriated communal land and thereby acquire usufructuary rights to that land. For most practical purposes, this approximates ownership. In practice, lineage members seeking land to farm ask the lineage head to assign them a piece of land. It is widely claimed that there is discrimination against women in this allocation process: fewer women obtain land; women often get less fertile land; and women obtain smaller parcels. On low-fertility land, women can only grow cassava, and with smaller holdings they cannot practice shifting cultivation and must farm the same plot every year. Some women also farm on land they receive as gifts from their parents or husbands. In some patrilineal groups, such as the Krobo, women usually have no access to lineage land, except some unmarried women living in their parental home and farming land allocated to them by their father. The commercialization of farming has led to increasing commercialization of land, and land sales are now taking place, eroding the principle of inalienable lineage landholdings. Tenancies have emerged as the other major form of rural land alienation (Date-Bah, 1985, pp. 221-222).

In **Kenya**, women traditionally did not inherit land, but their rights to use land belonging to a male relative were assured. Today, unless the land is registered in their own name, women's rights to the use of land are threatened by land commercialization. Except in some areas with matrilineal traditions, women make up a minuscule percentage of registered land holders. Property rights after divorce or husband's death differ considerably among tribes, and customary laws are held up in courts. Among the Luo, Kisii and Masai, widows or divorced women may have to return to their native families, because wives have no property of their own. Kikuyu women are entitled to property acquired before marriage and to some share of property acquired with joint effort during marriage (Ventura-Dias, 1985, pp. 172-173).

In the rice farming systems of **Madagascar**, the household is the basic unit of production and consumption and the rice crop is the property of the household unit, but men and women have differential access to resources and complementary labor roles. Traditionally, men controlled the usufruct rights to most land. These were inherited by their sons; daughters could inherit land where there was enough. With increasing land pressure, control over land has become tighter and more individualized, with rights akin to ownership although these may not be officially registered. Women therefore do not generally have independent access to land, but grow household food and cash crops on their husbands' land. However, there are four ways in which a woman may acquire ownership of, or usufruct rights to, land on her own: a women may purchase land; on divorce a woman has the right to a third of any land bought during the marriage by the household (even though the husband may have controlled the money and negotiated the purchase); widows may use their young sons' land to provide for raising their children; and widows and divorcees sometimes farm on a sharecropping basis (Dey, 1984b).

In the matrilineal-matrilocal communities in **Malawi**'s Zomba district, women's tenurial security is very high, while that of men is low. Women tend to live in the settlements of their birth and obtain plots for cultivation either from their mothers or grandmothers or from the village headman (who has the formal right to allocate and reallocate land, a right increasingly rendered mute by the non-availability of vacant land). Women do not lose their land in the event of divorce, separation or widowhood (Hirschmann and Vaughan, 1983, p. 89).

Land ownership in **Sierra Leone** is communal. Women have access to communal land, but clearing and ploughing are too difficult for women who cannot afford hiring tractors or wage labor to do this. They therefore work mainly on land owned by their husbands or other male kin or as laborers on other farms for payment in cash or kind. Men and women cooperate in farming: women are mainly active in planting, weeding and harvesting, men in land clearing and tilling. Women also have home gardens or grow groundnut and cassava on abandoned rice fields for home consumption; surplus production is sold. They sometimes grow cotton which they spin, the men selling or weaving the yarn for themselves or the women. Rice is the main staple, and rice processing is female work (Stevens, 1985, pp. 285-286).

market incentives and by making more use of improved technology, they often reserve the better land for themselves, pushing women to more marginal land. Krou women living near the Tai Forest in Côte d'Ivoire had to leave their own fields because of expanding coconut and oil palm plantations and increasing immigration of new settlers from the Sahel. They were forced to move into the forest where they farmed clearings left by loggers. In these areas, farming caused environmental damage and soils were not suitable for the cultivation of annual crops (Bamba, 1985).

Gender, Farm Labor and Market Access

In a village study in **Cameroon**, men were found to work an average of 32 hours per week, women over 64 hrs/wk. Domestic tasks took up 31 hrs/wk for women, 4 hrs/wk for men. Farm work averaged 12 hrs/wk for men and 26 hrs/wk for women. Men worked mainly on cocoa, but some also produced bananas and plantains for sale. Women produced mostly food crops, for home consumption and for sale – food sales being their main source of cash income. Men engaged in a far wider range of non-farming activities than women, although trading in food, drinks and cigarettes was a frequent secondary activity for women. Men's hourly returns from non-farm activities were considerably higher than women's hourly returns from food crop production. Men helped their wives with some land clearing activities; women had to work on their husbands' plots when they were asked to do so.

When a road was opened through their village, women responded by more than doubling their time spent on growing food crops for marketing. Men responded by growing more bananas and plantains for sale to wholesalers and spending less time helping their wives grow food crops (Henn, 1985).

5.13 Access to labor is another problem. Women's farming systems depend very heavily on female and child labor. Adult male labor may be available from husbands or other male relatives, but usually only for very limited and specific tasks. In many communities, women try to ease their peak labor constraints by participating in various forms of kinship- or community-based work group and labor exchange arrangements. But in most settings, women's only resource is their own labor and that of their children to meet their production obligations in the face of multiple other demands on their time. This may contribute to the maintenance of high fertility rates. For female-headed households, limited access to male labor is a particularly severe constraint. A serious consequence of the decline in available male labor can be observed in many forest- and bush-fallow cultivation systems. In Côte d'Ivoire, for instance, men are often late carrying out their traditional tasks of clearing, burning and fencing women's upland rice fields; this results in late planting and reduced yields (Dey, 1984b). In some countries, lack of male labor for clearing dense vegetation and women's inability to do it with the simple hand tools available to them is forcing women to continue cropping land that needs fallowing to recover. Since women can clear light secondary bush, fallow periods are also being reduced (Dey, 1984b). In both cases, the result is more rapid degradation of such plots.

5.14 Another example is the rapid deterioration of the natural resource base in parts of Zambia where *chitemene* farming is the traditionally predominant form of land use and where adult male labor is increasingly scarce at the farm level. With mainly women, old people and children as sources of labor, the traditional practice of climbing trees and lopping branches for burning on *chitemene* fields is being replaced by the felling of whole trees. This severely affects the regeneration capability of the available and accessible resource base (Vedeld, 1983, pp. 98-99). Moreover, the long distances between village and fields and the rising pressure on women's time are forcing people to shorten drastically the regeneration (fallow) period on their fields, cutting it from the traditional 25 years to as little as ten years (Stølen, 1983, pp. 32-33).[7]

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[7] Although millet is preferred in the diet in Zambia, cassava has increasingly replaced it as the main staple because millet production is constrained by labor scarcity. Millet is now used mainly for brewing beer to generate cash income. Most people's *nshima* now consists of about 70 percent cassava meal and 30 percent millet meal; cassava meal is nutritionally inferior to millet meal.

Chitemene Farming In Zambia

In the *chitemene* farming system of the Bemba in Zambia's Northern Province, crops are grown on cleared forest plots fertilized with ash obtained by burning tree branches collected from an area five to eight times the size of the cultivated field. Millet, groundnuts and sorghum are grown for three years; then the plot is abandoned to regenerate. Men lop and fell trees and turn the soil. Men and women share in scaring birds away, harvesting and building storage facilities. Women turn the soil, plant, weed, scare birds, harvest and carry the produce home. They also cultivate pumpkins, sweet potatoes and groundnuts. Men hunt, fish and engage in inter-regional trade. Male outmigration became significant during the colonial era and caused gradual changes in the farming system. Since women could not easily lop trees, ash fertilization was reduced; where they tried to maintain the system, they cut down entire trees, but this inhibited regeneration. Cassava was introduced in the 1950s after a locust attack had caused severe food shortages. Traditionally, women had access to land, but with the rising emphasis on cash cropping of maize, cotton, sunflower, tobacco and groundnuts, men increasingly used the better land themselves and became less willing to allot good land to women for food cropping. Maize is eaten on the cob for a few months and is not significant in the diet; pounding meal takes too much time, and the crop is largely sold. Sweet potatoes are no longer grown in significant amounts. Neither is sorghum, due to the time-consuming task of scaring birds away. Male outmigration continues and is significant. The use of oxen has helped make up for declining male labor availability, but does not reduce the time needed for sowing, weeding and harvesting which are women's tasks (Tembo and Phiri, 1988).

5.15 Since women more often lack the means to invest in agricultural intensification and soil conservation, farms managed by women are likely to be particularly constrained as regards possibilities for increasing productivity and particularly susceptible to resource degradation. Where farm machinery is available to the household or family, it is not necessarily available to the women; if it is, then rarely at the critical time (see para. 5.26). Since women cannot afford to take any risk with the family's food security, they proceed instead with the traditional tools available to them, depending on their children (and sometimes other women in their village or kinship group) to provide the needed labor.

Project Impact on Female Labor and Income

A project among the Tiv in central **Nigeria** assumed the operation of a joint-family farm -- although men and women traditionally have distinct labor roles and control of specific crops: men control millet, rice, benniseed and melons, women yam, cassava, maize, sorghum and cowpeas. Intended to raise productivity for all food and cash crops, the project had an uneven impact on male and female labor. Annual agricultural labor input increased by 17 percent for women, compared with 6 percent for men. Moreover, male labor requirements were distributed more evenly throughout the year, while much of the additional need for female labor was concentrated in October-December, adding a new major labor bottleneck. The gender-specificity of farming responsibilities and income control also meant that serious conflicts arose for both men and women at times of peak labor demand -- tradeoffs having to be considered between working on one's own crops or on those controlled by the other gender (Burfisher and Horenstein, 1985).

5.16 In most SSA farming systems, women also provide significant labor input on the men's fields. Polygamy allows men to command more labor (wives and children) and thereby extend farm size. Under most traditional tenure systems, land was/is assigned on the basis of ability to cultivate. Hence, more wives increase the capability to cultivate and the amount of land that can be controlled.[8] As men expand their farming operations, their demands on women's labor (for planting, weeding, harvesting, crop transporting and processing) increase. Project interventions often exacerbate the problem. In a project in Cameroon, men received land, water, seed and training to produce rice; women were expected to carry out their traditional tasks in the men's rice fields in addition to cultivating sorghum for family subsistence (Dankelman and Davidson, 1988, p. 13).

[8] Women often welcome an additional wife, because the husband is no longer solely dependent on a single wife and because a co-wife facilitates other methods of coping with survival needs.

The Balanta Brassa in Guinea-Bissau

The farming system of the Balanta Brassa, the single largest ethnic group in Guinea-Bissau, is based on intensive irrigated rice cultivation in salt water *bolanhas* (swamp paddies), supplemented with upland cultivation of such crops as millet, sorghum, fonio, maize, cassava, groundnuts, beans, and upland rice. Fruit trees are cultivated on upland areas, especially cashew. Rice is the main staple, and the men are responsible for providing it. Women are obliged to provide labor on their husbands' *bolanhas* as well as for furnishing the ingredients (vegetables, milk, fish, etc.) for the sauce that is eaten with the rice. Cattle are important to the Balanta Brassa, and both men and women can own cattle, but women more frequently own small livestock. Cattle are managed by boys and young men. Milk and dung are hardly utilized, cattle being primarily used to store wealth and for ritual purposes and social exchanges.

Land is collectively owned by the patrilineage, and the male head of the lineage allocates land to the compounds. The male compound head in turn determines the allocation of this land to collective as well as individual uses. Men have both collective and individual *bolanhas* and control the product from both. They also control most of the upland fields (*lugars*) which they prepare and seed; the women help with weeding and harvesting. Men undertake all the land preparation activities on fields intended for subsistence crops. Twice a year, they prepare the *bolanhas*, utilizing male age-group work teams if they can afford to feed and pay them (in kind and/or cash). Young men, usually in work groups, clear all new land for cultivation and build the ridges. They also ridge the *lugars*. Repair and maintenance of irrigation dikes and canals, regulating the water flow, and desalinating the *bolanhas* with rainwater is done by adult males, usually in work groups. Rice nurseries are prepared by each individual family, the men preparing the land, the women doing the seeding. Women are responsible for seedling transplanting (although men often help), weeding (men and particularly children will help), winnowing the threshed rice, and transporting it to the storage houses in the village. Rice harvesting and threshing is done by younger men in work groups.

Most men give their wives separate small *bolanhas* in the drier fringes of the swamps as well as *lugars* to grow a few crops of their own. The women cultivate their individual *bolanhas* and *lugars* on their own, usually by hoeing, with the help of their daughters and/or foster daughters. For ridging a groundnut field, they may obtain the help of their husband or hire a work group by providing rice and other compensation for them. Women also have their gardens in or near the village to grow vegetables.

The rice produced on the husband's *bolanhas* is owned by him, but the bulk of it is consumed by the family. Parts of it are given by the man in compensation for labor provided to his wives (for sale), parts are exchanged for tobacco or other consumer goods during the year, and any surplus is used to invest in livestock, preferably cattle. By contrast, crops produced on the women's fields and in their gardens are their personal property and may be sold by them.

With the increasing outmigration of males for urban employment, women are faced with greater direct responsibility for *bolanha* cultivation, but increasingly lack access to sufficient adult male labor to maintain these systems. Changes in hydrology, caused by prolonged drought and by upstream dam construction, are causing increasing salinity in the *bolanhas*, with significant negative effects on productivity. As a result of these developments, the pressure on upland areas for increasing cultivation is rising, with negative consequences for the environment and the sustainability of the traditional farming systems. Women are expanding their involvement in the production of palm oil and wine, are increasing their vegetable production for commercial sale as well as their commercial fishing and fish processing activities.

Balanta Brassa women are active in various artisanal activities: the production of ceramics, soap, palm oil and wine, salt, dried, salted and smoked fish. They also collect cashew nuts for sale and produce cashew wine for the market. They fish for shrimp and small fish and collect molluscs. Women also derive income from trading and from the sale of cashew wine, palm oil, processed fish, vegetables and rice.

Husbands' and wives' incomes are not pooled, and women have the legal right to dispose of their income as they please. It is not unusual for women to have more disposable income than their husbands. Husbands have full responsibility for the survival of the family and, except in times of abundance, all of the products from the male fields are kept for home use. Women's contribution is, thus, completely met through their labor on male fields. Women use their income primarily for their own and their children's personal needs, to compensate work parties, and to pay for ceremonies (Lifton, 1991).

D. The Separation of Budgets

5.17 In most societies of Sub-Saharan Africa, men and women also maintain separate budgets, and there are intricate, but well established conventions concerning their respective sources of income and the responsibilities that are to be met from such income. Husbands and wives may sell to each other, even lend to each other at considerable interest rates. The support men are obliged to provide to wives (and children) varies considerably among communities. So does the importance of the immediate and extended family and of the household and compound as resource pools and as production and consumption units.

5.18 In most cases, women depend heavily on their own, independent (cash or kind) income sources, from farming and non-farm activities, to meet their responsibilities. This has crucial implications in terms of the incentives faced by men and by women with respect to investing labor and/or capital in specific farming activities or other ventures (including soil conservation or fuelwood production). Research from Kenya highlights this: "In female-headed households, weeding raised maize yields by 56 percent while in male-headed households, yields increased by only 15 percent. ... where women controlled the crop and the income from that crop, they did have the incentive to provide the necessary labor input for weeding which resulted in significant increases in yields" (Horenstein, 1989, p. 13). Case studies abound documenting intra-family conflicts over the allocation of women's labor between crops considered to be under their own control and those controlled by their husbands.

Budget Separation among the Fula and Mandinga

Among the Fula and Mandinga in **Guinea-Bissau**, men are responsible for ensuring an adequate supply of staple food for the family. The women are entitled to the produce and income from their own fields; they use it primarily to meet their own and their children's personal needs as well as to meet social obligations, but the husbands may take part of it. Among the Balanta Brassa, the men are responsible for filling the communal granary as well, women being required to provide labor to their husbands as well as the condiments that are eaten with the daily rice. Women, in fact, often have considerably more disposable income than the men, derived from farming and from artisanal and trading activities, and are free to decide upon its utilization. Papel women also have quite specific responsibilities concerning their financial and material contribution to household maintenance and consumption expenses. Husbands have some control over the utilization of their wives' income which is derived mainly from the sale of agricultural produce, fish, and cashew and palm wine (Lifton, 1991).

Gender Separation of Budgets Among the Wolof

A Wolof man in **Senegal** is responsible for providing his wife with decent housing and a bed, a hoe and sickle, new articles of clothing on the Islamic feast *Tabaski*, the payment of taxes, and the main part of the bride-wealth of his sons. In addition, he buys the rope and the bucket for drawing water and salt. The woman is responsible for providing the herbs and relishes when it is her turn to cook, firewood, and the payment of about one sixth of the bride-wealth of her sons. She also buys the pulley for drawing water and the medicines used by herself and her daughters. A substantial part of household expenses is, thus, not borne by the women -- nor are new expenses always on the account of the women. For example, grain threshing is paid by the men, while grinding mills are paid for by the women. The cost of modern medicine is shared between husband and wife -- the women looking after themselves and the girls, the men looking after the boys. However, medicines used by very young children are always bought by the women.

Nevertheless, women's household expenses are increasing. Due to population pressure, the area cultivated has increased and many useful trees and plants have disappeared or now only grow far away from the village. Many women now buy herbs and relishes they formerly gathered in the forest. They also buy ingredients not formerly sold in the shops (e.g., dried fish, tomato paste, onions and sugar). Women now buy soap and matches (in former times soap was homemade, and the fire was left burning continuously). The Wolof woman also takes charge of purchasing household articles. Today, these are increasingly more numerous and include not only handicrafts, but also imported items such as plates and glasses. Even if these articles are initially bought with the husband's brideprice, it is the wife who pays for replacements.

Sharing of household expenses has also been reported among Senegal's Hausa, Mandinga, Bambara and Fulani (Venema, 1986, pp. 90-91).

Women, Food Security and Nutrition

Nutrition is a function of a number of factors, including not only food availability, but also suboptimal food preparation and feeding practices, pressures on women's time, lack of essential micronutrients, and poor sanitation and water supplies. The way mothers feed children and treat diarrhea also matters, as does the manner in which household income is controlled and spent or the selection and preparation of food. These behaviors appear to be independent of income levels and are compounded by poor health. Until progress is made in lowering birthrates and increasing food availability, efforts to improve nutrition must focus primarily on family-centered interventions to modify feeding practices. Nutritional status can be improved at any level of food availability. Women are obviously the main audience for nutrition education programs, especially as concerns the value of breastfeeding and young children's needs at weaning and beyond.

Food insecurity and malnutrition are, in large part, also a gender and generational issue. Even within the groups that suffer malnutrition most frequently (urban poor, landless laborers, subsistence farmers, nomadic populations), women and children tend to be most affected: "... within households, women get less food than men in absolute terms as well as in terms of their own nutritional requirements" (Horenstein, 1989, p. 14, citing McGuire and Popkin, 1988). Small children and lactating mothers are the most vulnerable groups, and malnutrition is probably the biggest single contributor to high child mortality.

At the household level, food security is directly influenced by agricultural performance. Many of those facing food insecurity are small farmers – often women – in isolated areas with high transport costs and little or no access to markets. In most of these cases, increased production of food and greater stability in availability are likely to be the only ways to provide food security. Women face multiple constraints in securing adequate food for their children and themselves. Foremost among them are those rooted in the gender separation of farming and family maintenance responsibilities noted above. This highlights the need to redress the biases against women farmers in access to credit, extension, and research and development. Reforms in rural credit policies and institutions to promote female access to credit would help increase women's productivity in agriculture and their income from trade. In addition, the increasing fuelwood scarcity is having an effect on food preparation and feeding practices, with particularly serious consequences for small children. So are the difficulties women face in obtaining adequate quantities of safe potable water (see paras. 9.10-9.14).

Technology improvements are needed for processing and storing local foods. Shorter preparation time will become increasingly valued as urbanization proceeds and as women face more demands on their time. Grain varieties amenable to central processing and easier to transport need to be developed. Improvements in storage would reduce physical losses and improve the regularity of food supplies to local markets.

5.19 Given the separation of farming systems and budgets, the benefits of improved technology and productivity on male farming do not always translate into improved welfare for the women and children. Men often spend their additional income on further inputs for their own production activities or on personal consumption. It is not uncommon for children's nutrition to deteriorate while wrist watches, radios and bicycles are acquired by the adult male household members (M. Carr, 1985, p. 125). With women responsible primarily for family food and maintenance, men in fact often reduce their contribution to family and child maintenance costs (food, fuel, clothing, medical expenses, soap, etc.) as women's incomes rise (Henn, 1988). In the Banfora region of Burkina Faso (as among the Mandinga in The Gambia and Senegal), women spend a significantly higher proportion of their income on food, medicine, clothing and school fees for their children than do men. Men spend relatively large amounts for bicycles, beer or additional wives (Dey, 1984a, p. 64). A study of two villages in Malawi found that the nutritional status of women and children in particular was better in the subsistence village than in the village with significant cash-crop (tobacco) production. Although other factors might have played a role, women's greater labor input to tobacco production on men's fields contributed to lower subsistence food production and availability and reduced time available for cooking. Cash income generated from tobacco production was not used to purchase more food to compensate for lower subsistence production (Engberg *et al.*, 1988, pp. 99-100).

5.20 Where men and women have clearly defined complementary roles in providing for the family, the man often has no obligation to take over any of his wives' responsibilities even when they may have

become unable to fulfil these themselves. If women lose their independent income, due to changes in farming systems induced by development projects or market forces, they may not be able to meet their customary obligations. This is not only shameful and distressing to them, reducing their social status and respect, but the family, especially children, suffer: nutritional levels fall, cleanliness may be affected (women spend a relatively large proportion of their money on soap), clothing may be less than adequate, and school attendance may well decline (Dey, 1984a).

E. Farm Technology and Gender

5.21 The separation of budgets also affects women's access to technology. Women farmers often are, or perceive themselves to be, restricted to low technology farming because they cannot afford purchased inputs. Lack of collateral (mainly of land title) is only one part of the problem. Ability -- real or perceived -- to service debt is the other. Risk aversion is often far stronger among women than men, partly because a woman usually bears prime, if not exclusive, responsibility for feeding and maintaining the children and herself.

5.22 Gender is an important aspect of the farm technology problem (non-adoption, slow adoption, low utilization). Technology transfer is often hindered when intra-household dynamics are not taken into account. In many cases, women will have to provide the aditional labor required. Or they may be involved in the decision whether to adopt the proposed new technology or not. Failure to understand these factors or to consider who receives the benefits and who bears the costs, who will pay for follow-up maintenance costs, can be fatal to efforts at introducing new technology.

Gender-Specific Work and Family Maintenance Obligations and Their Impact on Technology Adoption and Farm Productivity

In the Mwea settlement scheme in **Kenya**, young (mostly nuclear, but sometimes polygamous) families were settled to cultivate irrigated rice. Rice fields were leased for life to male tenants, and small plots for growing traditional self-provisioning foods were lent to the household. This effectively meant that food plots were allocated to wives as long as they stayed with their husbands. In polygamous households each wife had use of such a plot. Although women were by tradition responsible for providing the family's food and had done so with small surpluses for sale from their food fields, the food plots in the new settlements were too small to ensure family food self-sufficiency. Planners simply assumed that part of the rice crop would go to family maintenance.

This led to serious difficulties. In addition to working their food plots, women shared in all rice cultivation tasks and did all the weeding -- while the men had little to do on their rice fields between planting and harvesting and often left for several months. Many women, unhappy over their increased workload and the lack of control over the returns from their additional labor on husbands' fields, exercised passive resistance to work on the rice fields and did only minimal weeding, especially when this competed with work on their food plots. Although these plots were too small to supply the household with food, women wanted to work them as carefully as possible since they had full disposal rights over the produce. They also needed rice as well as cash to purchase additional food and other household necessities. They received some remuneration from their husbands, usually in the form of paddy, but this was insufficient; it was used to meet family food needs or sold to purchase preferred foods. This left the women with inadequate cash to purchase firewood, a critical necessity since there were no forests nearby. A women was considered fortunate if her husband bought six months' supply of firewood.

Community issues were discussed in tenant associations chaired by leading farmers appointed by project management -- not appropriate fora for women to voice their complaints. Action was taken only when project management became concerned over the unexpectedly low rice yields and when some women took their complaints directly to management. It came in the form of better milk and firewood supplies, which ameliorated women's cash problems. It did not touch on the new and unfavorable set of intra-household exchange relations created by the scheme (Palmer, 1985a, p. 18; FAO, 1985, pp. 36-37).

5.23 In Zimbabwe, hybrid maize was introduced directly to women farmers and production has increased substantially. In contrast, a program in Tanzania to promote hybrid maize cultivation through extension and the distribution of subsidized seeds, fertilizers and pesticides to men encountered resistance from women farmers who predominate in foodcrop production because it increased their workload without concurrent control over the income. There was also some resistance among the women to the cultivation of pure stands of hybrid maize, since maize is traditionally intercropped with beans or cassava. The latter represent a valuable complement to maize, and their reduced importance in the farming system could have negative nutritional consequences (Dey, 1984a, pp. 54-55). In Ghana, women were reluctant to switch to a new hybrid maize variety because it had an unpleasant taste, was hard to prepare, was less resistant to insects and drought, required different storage methods, and needed fertilizers which affected its taste (Dankelman and Davidson, 1988, p. 18).

5.24 Few of the farm technology improvements developed and introduced to date have been geared to, or even cognizant of, the needs and constraints of women. The provision of mechanized equipment, new seed varieties, fertilizers and herbicides has largely been linked to the introduction or expansion of industrial/export crop production and has, thus, mainly gone to men. Female farmers have benefited little. In many cases, women have in fact been left worse off. The introduction of animal-drawn ploughs may help men farm more land and/or reduce the time needed for land preparation -- but it does not help the women who then have to plant, weed and harvest. In Sierra Leone, the introduction of tractors and ploughs eased men's work load in rice cultivation, but women's workload increased by 50 percent due to more weeding and harvesting (Dankelman and Davidson, 1988, p. 13). Women's time constraints and the low productivity of their labor are already critical constraints to production increases, both on their own and on their husbands' plots. Yet women have not, on any significant scale, gained access to technology which would increase their labor productivity.

5.25 The adoption of animal draft power in Sub-Saharan Africa is usually motivated by the men's desire to reduce (male) labor requirements and/or increase the acreage cultivated. A major multi-country study found that the additional area tends to be used to produce market crops (such as cotton, groundnuts and rice), while the area under subsistence crops usually remains unaffected by the introduction of animal draft power on the farm (Pingali *et al.*, 1987, p. 101). This finding confirms, of course, that farming intensification and investments in technological advances are associated with commercialization and market access. It also confirms, however, the technological gap between male and female farming systems even within the same household. Men take up animal-powered ploughing and expand their cash crop acreage and production, while women remain stuck with hoe cultivation on their subsistence crop plots (and are often required to provide more labor on the men's fields as well).

Cassava Processing in Nigeria

In **Nigeria**, *gari* production from cassava involves a number of steps: peeling, washing, grating, bagging, pressing, fermentation, sieving and roasting. For a typical 125 kg bag of *gari*, 200 tubers are needed, and the total time required for processing averages over 50 hours. Peeling (30 hours) and roasting (13.6 hours) are the most time-consuming tasks. With costs of Naira 24.5-30.1 per bag and gross revenues of N 31-37.6 per bag, net revenue per bag of *gari* ranged from N 3.24 to N 10.60 in 1981/82 -- equivalent to N 0.06-0.21 per hour of work. Women in the sample surveyed produced between 4 and 12 bags per year. Initial efforts to introduce mechanization into *gari* production were not very successful. Widespread adoption was reported only for mechanical graters -- but they were all owned by men who could afford the investment. Women benefitted only by having the drudgery of manual grating reduced (Adekanya, 1985).

5.26 Farm machinery may be available to the household, but not necessarily to the women. If it is, then rarely at the right time. In Senegal, "farming equipment is used first in the fields of the household head, then on those of his younger brothers or sons, in order of priority based on age. Finally, the women have use of the machinery. Thus, women who wait for the use of seeders and hoes

are late in planting and weeding, significantly reducing their yields" (Loose, 1979). Household possession of improved equipment or technology does not necessarily result, therefore, in time saving for women or in productivity improvement in women's farming activities. And, as noted above, improved technology and productivity in male farming do not necessarily improve the welfare of women and children in the household.

F. Women's Time Use and Productivity

5.27 Overcoming agricultural stagnation and food insecurity hinges on increasing the productivity of farm labor in general and in the production of foodcrops in particular. In many parts of Sub-Saharan Africa, where subsistence agriculture is largely a female task or where male outmigration has led to significant feminization of farming, this means placing strong emphasis on increasing the labor productivity of women. And while this, in many ways, will require the same kind of measures that improve the productivity of male labor, it also requires far greater sensitivity in policy, program and project design to the different constraints and incentives faced by men and women in rural production systems. Efforts to increase rural women's labor productivity will achieve very little unless they take into account (a) the exact modalities of their involvement in agricultural and agro-processing work and (b) the severe limitations imposed on such work by other time-consuming child rearing and household management tasks.

Female-Targeted Technology Introduction

In northern **Togo**, men grow the staples (sorghum and millet), while women provide the vegetables, meat, seasoning and sauces. Deforestation has sharply reduced the number of *dawa dawa* trees from which women collect wood and the seed which they boil into a condiment important in their diet. Child malnutrition is widespread. This led to an innovative and successful farming and family health project in **Togo**, **Mali** and **Ghana**, supported by World Neighbors and Family Health Advisory Services. It used soybeans as the entry point, but differed from other soybean projects by introducing them not as a cash crop, but as a legume for making sauces. Hence, the men did not object when the women asked for small plots to grow soybeans. The project began with demonstration plots and cooking demonstrations, visits to soybean-growing villages, and workshops in women's homes. Initially used as a substitute for the increasingly scarce *dawa dawa* seed, soybeans gradually also came to be used in other dishes and for a high-protein porridge for children (Gubbels and Iddi, 1986).

5.28 Rural women work not only in farming. In much of Sub-Saharan Africa, they dominate many of the rural non-farm activities that grow most rapidly as rural economies undergo structural transformation -- activities such as food processing and preparation, tailoring, trading and many services. They also hold major interest in many of the declining rural non-farm occupations -- basket making, mat making, ceramics and weaving. Women will therefore be key actors in the economic transition of Africa's rural economy. To facilitate their contribution to an accelerated rural transformation requires that governments and donors explicitly recognize their key role (Haggblade *et al.*, 1987).

5.29 Increased female productivity contributes to economic development. It helps increase aggregate productivity in the economy, reduces the incidence and the negative welfare outcomes of poverty, reduces fertility levels, and increases household demand for health and education services. Increasing the returns to female labor raises aggregate family income, but also women's control over that income and, hence, the share of total "family income" spent on food, health care and other basic needs. Increasing female productivity also increases the opportunity cost of child bearing and thereby strengthens the incentives for families to invest in women's health and education.

5.30 "The real rural energy crisis is women's time" (Tinker, 1987). The single most binding constraint to increasing female productivity in farming, and in other income earning activities, may well be women's lack of time -- or rather the inordinate amount of time women spend every day on time-consuming low-productivity tasks that are essential for family maintenance and survival. Easing this time constraint requires measures which reduce women's domestic work burden. The provision of water and

woodfuel sources close to the home would be an important first step. Essential, too, is affordable and appropriate time-saving technology to reduce the drudgery of food processing and preparation, water collection, and fuel fetching and preparation.

5.31 To improve the productivity of women farmers, a variety of measures are needed; many of these, particularly those concerning agricultural extension services, are already being implemented in a number of countries (para. 8.62). Far less has been done so far in other important areas to help improve the productivity of Africa's female farming systems. Researchers need to be far more cognizant of women's heavy involvement and of their special needs, objectives and constraints; important aspects in this context are species characteristics and processing requirements for new varieties. Women's rights to land and access to credit are two more areas in need of attention.

Improved Technology for Ghanaian Women

Some successful attempts at introducing improved technology for women in **Ghana** included a low-cost, high-productivity fish smoking oven that required only minor adjustments from traditional smoking methods, sun-drying racks for fish, and improved cassava processing technology. Cultural taboos among certain groups, such as restrictions on women's participation in weaving and on women touching cattle, prevented the adoption of some technologies. Technologies accepted have generally been those that improved upon or upgraded traditional techniques -- because this tended to ensure social acceptability by not disrupting accustomed practices, tastes, beliefs and taboos. Other important aspects of successful technology projects for women have been the involvement of intended beneficiaries in the identification and development of improvements, and the propagation of improved technology within a package comprising group formation, training and credit (Date-Bah, 1985).

5.32 Improved tools and equipment are essential to improve the productivity of rural women. Many small "appropriate technology" projects supported by voluntary agencies have successfully introduced simple yet effective devices that are affordable, require little maintenance and are easy to use. Equipment for milling, shelling, dehusking, initial conditioning and processing of crops and conservation of seeds offers many benefits in terms of raising productivity and allowing farm women to spend more time on other tasks. Small carts, wheelbarrows and bicycles could substantially reduce the drudgery and time required to transport agricultural produce and inputs on the farm and to markets. These innovations have been largely neglected outside programs and projects supported by NGOs. They deserve far more emphasis in research and extension programs as well as in endeavors to promote local artisanal and small-scale industry.[9]

Technology, Women's Time, and Productivity

Hand-operated cornmills were introduced into **Cameroon** in 1958. By 1961, membership of the societies founded by women to own and operate these mills numbered 30,000. With the time thus saved, the women turned to a variety of community and individual projects. They dug roads to their villages so that trucks could take out their produce; they piped water from small streams into storage tanks to provide water in the dry season; and they built meeting houses in central locations where they could hold classes throughout the year. They learned how to look after their children, to cook and make soap, to read and write, and to do simple arithmetic. They fenced in their farms and set up cooperative shops. Above all, they learned how to improve their farming techniques. (Carr and Sandhu, 1987; citing E. D'Kelly, Aid and Self Help, Charles Knight, London, 1973.)

5.33 Policies that alleviate women's capital and labor constraints are more likely to help increase food production than policies designed to attract men into food cropping (Henn, 1988). Steps taken in Zimbabwe, for example, to improve women's access to services and production incentives helped increase small farm output from 6 percent of the national total in 1982 to over 40 percent by the mid-1980s; one such step was to eliminate the requirement for husbands' signatures on wives' credit papers (Due, 1988).

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[9] A Bank-supported transport project in Ghana is moving in this direction: it supports the local manufacture of bicycles, bicycle trailers and wheelbarrows and, working with local NGOs, their acquisition by local women under a hire-purchase system linked with a labor-intensive road construction and maintenance and tree planting program (World Bank, 1990c).

5.34 Programs for promoting women's development encounter few ethical difficulties, but there is little evidence of rapid change in the role and status of women. Projects combining the provision of information and education about family planning with other activities directed at women's development have been successful; but most are small-scale efforts. A far more broad-based and sustained approach is needed. Women's education and technical training should be given priority. Women's organizations need to be fostered. And women's non-farm and entrepreneurial skills must be upgraded to diversify the sources of family income.

VI. A FRAMEWORK FOR ACTION

A. A Continental Perspective

6.1 Successfully addressing the problems discussed in the previous chapters will require simultaneous efforts in three areas: (i) significantly, and as quickly as possible, reducing the rate of population growth through efforts that bring down the TFR; (ii) changing farming systems and cultivation practices from extensive to intensive systems which incorporate adequate soil conservation and fertility management measures to ensure long-term sustainability; and (iii) improving natural resource management so as to ensure that the natural resource base and agro-ecological environment remain intact. Essential to the achievement of these objectives will be addressing the special problems faced by rural women and the emerging land tenure constraints.

(i) Some Basic Targets

6.2 These closely interlinked objectives can be expressed in a basic set of quantitative aggregate targets for each SSA country regarding desirable and achievable population growth rates, food consumption, agricultural growth and environmental resource conservation (see Table VI.II, pp. 68-69). Although they are, of necessity, only rough approximations, they illustrate the magnitude of the effort required -- but also the payoff that will result if the challenge is successfully met.

6.3 To summarize, for Sub-Saharan Africa as a whole, agricultural production needs to grow at about 4 percent per annum during the period 1990-2020. This, given the present weight of agriculture in Sub-Saharan economies, is the rate required to achieve aggregate economic growth of at least the same rate. Daily per capita calorie intake should be increased from its present average level of about 2,027 to about 2,400 by the year 2010. The share of the population that is "food insecure" should be reduced from the present 25 percent to zero as rapidly as possible. Unfortunately, scrutiny of the various country situations suggests that it is more realistic to aim for a target reduction to 10 percent by the year 2010 and to 5 percent by 2020. For environmental reasons, the rate of deforestation needs to be sharply reduced, from the present average annual rate of 0.6 percent of the total remaining forest area to about 0.35 percent per year. Loss of remaining wilderness areas should also be minimized: as an indication, approximately 23 percent of Sub-Saharan Africa's total land area should be maintained as wilderness (compared with about 27 percent today). To preserve wilderness and forest areas, cropped land can only be increased from 7.0 percent of Sub-Saharan Africa's total land area at present to about 8.3 percent in 2020. The arithmetic of these indicative agricultural, food security and environmental objectives requires population growth to decline steadily from the present average annual rate of over 3.1 percent to 2.3 percent per annum in the third decade of the next century. This will require lowering the average TFR by 50 percent between today and the year 2020.

(ii) Accelerating Agricultural Growth

6.4 The first requirement is to achieve sustained agricultural growth (more precisely, growth of agricultural value added) of 4 percent per annum.[1] This would permit gradually improving food security and increasing rural incomes and foreign exchange earnings and savings. Slower agricultural

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[1] This is the minimum target set in the World Bank's 1989 long-term perspective study for Sub-Saharan Africa (World Bank, 1989d).

growth would also compromise the minimum macro-economic growth targets for Sub-Saharan Africa. Case I in Table VI.I (p. 63) shows the staggering food import requirements if present population and agricultural growth trends were to continue. The food gap, even at the present low average per capita food consumption levels (about 202 kg/cap/year), would increase from 10 million tons maize equivalent at present to 24 million tons by the year 2000 and to 80 million tons twenty years later.

6.5 Without a reduction in aggregate population growth rates, even sustained food production gains of 4 percent annually would only represent an increase on a per capita basis of less than 1 percent per annum. Even with unchanged average consumption per capita, and with interregional food trade completely liberalized to allow intra-African food movement from surplus to deficit countries, aggregate food import requirements would therefore decline only slowly and would be eliminated entirely only in the year 2004 (Table VI.I, Case II).

6.6 Even in this scenario, average per capita availability of food would not increase. There would, thus, (in the absence of distributional changes) be no change in the percentage of those malnourished and facing food insecurity, but a substantial annual increase in their absolute number. More than one quarter of Sub-Saharan Africa's population were faced with food insecurity in 1980/81 (Table 10), and the available aggregate statistics suggest a possible deterioration in this situation during the past decade. A scenario of unchanged average per capita food availability would imply, therefore, that over a quarter of all people in Sub-Saharan Africa would still be facing food insecurity 30 years from now.

6.7 The importance of making rapid progress in reducing population growth becomes even more apparent, therefore, when the closely related objectives of improving nutritional standards and food security are taken into consideration. Average daily calorie intake should be increased from its present very low level of 2,027 calories per person to about 2,200 by the end of the century and to 2,400 (i.e., the current average for the world's low-income countries) by the year 2,010. This would imply raising per capita food availability from an average of 202 kg/year to about 232 kg/year over a 20-year period. Table VI.I, Case V, depicts this scenario. Since aggregate food consumption requirements would rise sharply, even sustained growth in food production averaging 4 percent per year and a steady decline in the rate of population growth to 2.3 percent per annum during the decade 2020-2030 (implying a continuous reduction, beginning immediately, of the TFR over the next four decades to half its present level), the food gap would remain at roughly its present level of about 10 million tons per annum until 2010 and would not be closed until about the year 2015. The potential food surplus which might gradually emerge thereafter under the assumption of static average calorie intake would presumably not materialize because consumption levels would increase above the 2,400 cal/cap/day level that typifies present average conditions in the developing world.

6.8 It is clear, then, that -- even with 4 percent annual growth in food production -- the important objective of bringing the percentage of the population subject to food insecurity down to zero over the next three decades cannot be achieved, at the aggregate level, unless fertility rates are reduced by 50 percent and the population growth rate is thereby lowered to about 2.3 percent per annum by the year 2025. In addition, this objective will not be attained unless the growth in agriculture is equitably distributed over the population, benefitting urban dwellers as well.

6.9 The technological change required to realize the agricultural growth target of 4 percent per annum will need to be land-saving in most of Africa for environmental reasons and labor-using in order to absorb the growing rural population. With capital also scarce, the technological change being promoted must be carefully matched to farmers' capacity to finance investments. Incremental capital use will not be inconsistent with the objective of environmental sustainability. The present labor scarcity in much of Sub-Saharan Africa at the farm and household level, one of the driving forces behind the high

Are Annual Cereal Yield Increases of 3.5 Percent Achievable?

The statistical analysis of the determinants of cereal yields, summarized in the box on pp. 41-43, can be used to test the plausibility of these projections. According to the equation given there, increased labor use per hectare, facilitated by the growth in the rural labor force of 2.0 percent per year, would generate 0.7 percent annual growth in cereal yields. Annual rates of increase in fertilizer use of 15 percent (and increases in the use of other modern inputs associated with rising fertilizer consumption) would generate cereal yield increases of 1.5 percent per annum. An annual increase of 2 percent in primary school enrollments would lead to annual increases in cereal yields of 0.3 percent. And an end to deforestation (if not an actual increase in forested area) would at least eliminate this cause of declining crop yields. Together, this would give a growth in cereal yields of 2.5 percent per year.

Other factors -- such as more countries adopting appropriate agricultural policy, continually improving policies in all countries, a steadily expanding reach of rural transport infrastructure, improvements in marketing arrangements -- would have to provide the additional stimulus needed to achieve the postulated 3.5 percent growth rate. This is a difficult, but not impossible challenge to meet.

fertility rates, will ease over time with population growth -- rural-urban migration notwithstanding. More labor per unit of land will lead to intensification. But intensification also requires making labor more efficient by adding capital. Part of this will have to be private capital, for fertilizers, animal traction, better tools, and investments in land amelioration and conservation. Much of it, however, will need to be public capital for rural roads and markets, water supply, investment in education, etc.

- To minimize the need for bringing more land under cultivation, the productivity of land will have to increase very rapidly. Allowing for a continuing expansion in total cultivated area at a rate of about 0.5 percent per year (from about 150 million ha in 1987 to about 180 million ha in 2020),[2] land productivity will have to increase by 3.5 percent annually over the next 30 years. Realizing this will be an enormous challenge (see box).

- Were the rural labor force to continue to increase at an annual average rate of about 2.5 percent, meeting the target of 4 percent annual growth in agricultural production would require that labor productivity in agriculture increase by at least 1.6 percent annually. Indeed, since those entering the rural labor force in the coming 15 years have already been born, the decline in fertility rates included in this set of indicative targets will only have a significant impact on the growth of the rural labor force in the outer years of the time horizon used here. If the targets are achieved for a continuous reduction in the average TFR to 50 percent of its current level by the year 2030 and, hence, for an average rate of population growth of 2.8 percent between 1990 and 2030, and if the urban population were to increase at an average annual rate of 4.5 percent due to continuing rural-urban migration, the average annual growth of the agricultural labor force is more likely to be around 2 percent for the period as a whole (higher in the first two decades, substantially lower thereafter). Labor productivity would therefore need to increase steadily over time so as to average about 2 percent per annum. Given the very high proportion of female labor in the total for the agricultural sector, and given the low current productivity of female labor in farming, an appropriate emphasis on improving the productivity of female labor will pay significant dividends in this regard.

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[2] Clearly, the expansion of the land frontier cannot be halted immediately; in any case, in some countries there still are sizeable tracts of potentially productive crop land as yet unutilized -- due partly to technological constraints at the farm level (e.g., heavy bottom soils that require ploughing and possibly drainage), partly to difficult access (lack of roads).

Table VI.I Sub-Saharan Africa: Population and Food Security, 1990-2020

Scenarios	1990	2000	2010	2020
Case I				
Population (millions with total fertility rate remaining at projected levels) a/	494	664	892	1200
Food production (million tons of maize equivalent at current trend growth rate of 2 percent a year)	90	110	134	163
Food consumption (million tons with unchanged average per capita consumption) b/	100	134	181	243
Food gap (million tons) c/	10	24	47	80
Case II				
Population (millions as in Case I) a/	494	664	892	1200
Food production (million tons at 4 percent annual growth)	90	133	197	292
Food requirement (million tons as in case I) b/	100	134	181	243
Food gap (million tons)	10	1	-16	-49
Case III				
Population (millions, with total fertility rate declining by 50 percent by 2030) d/	494	657	875	1169
Food production (million tons at 2 percent annual growth)	90	110	134	163
Food requirement (million tons) b/	100	133	177	237
Food gap (million tons)	10	23	43	74
Case IV				
Population (millions, with total fertility rate declining by 50 percent by 2030) d/	494	657	875	1169
Food production (million tons at 4 percent annual growth)	90	133	197	292
Food requirement (million tons) b/	100	133	177	237
Food gap (million tons) c/	10	0	-20	-55
Case V				
Population (with total fertility rate declining by 50 percent by 2030)	494	657	875	1169
Food production (million tons at 4 percent annual growth)	90	133	197	292
Food requirement (million tons, with rising per capita consumption) e/	100	144	210	280
Food gap (million tons)	10	11	13	-12

a. Population growth at 3.0 percent per annum, as per Table 2.

b. Average of 2027 calories per person per day.

c. Equals consumption requirement minus production; negative sign denotes production surplus. This equaled the cereal imports plus food aid in 1990.

d. Target.

e. Average per capita consumption rising to 2,200 calories per day by 2000 to 2,400 calories per day by 2010 and stabilizing at that level thereafter.

What Will It Take to Arrest Deforestation?

The statistical analysis (see the boxes on pp. 41-45) suggests that a reduction in the area cultivated per person at the projected rate of 2 percent per year will stimulate further deforestation at a rate of 1.2 percent of the remaining forest area per annum. Annual population growth of 2.8 percent will lead to deforestation at a rate of 1.5 percent per year. On the other hand, an increase in the intensity of fertilizer use of 15 percent per year will lead to a reduction in the rate of deforestation of 2.9 percent yearly. The aggregate effect would be an increase at a rate of 0.2 percent per year in land under trees. However, a policy environment conducive to agricultural growth will stimulate farmers to expand cultivation into areas currently forested. The effort to preserve existing forests and expand the area under trees will be lost, therefore, unless environmental action plans and land use plans are prepared and implemented which channel the expansion of farming away from forests and from areas that are to be reforested. The indicative targets shown in Table VI.II imply, more realistically, continued reductions in the forest and woodland areas, but at much slower rates than those recorded at present.

6.10 In the longer run, as the scope for policy improvement narrows, and with increasingly more stringent constraints on the possibilities for further expansion of cropped area, sustaining an agricultural growth rate of 4 percent per year will become even more difficult. It will depend increasingly on intensification through greater use of modern inputs and equipment, diversification into higher-value crops, genetic improvements in crops and livestock, and general improvements in educational attainment of the population. Hence the importance of the improved agricultural research, extension, and of general education discussed in subsequent chapters.

(iii) Managing Forest Resources

6.11 The growing population of Sub-Saharan Africa will need more fuelwood, building materials and other wood and non-wood forest products. Woodfuel demand will increase roughly at the rate of population growth.[3] Demand for other wood products should probably increase more rapidly, to allow development of forest-based industries, especially rural industries. Although the implications of such rising demand on forest area requirements are very difficult to quantify for Sub-Saharan Africa as a whole, orders of magnitude can be delineated here.

6.12 In 1984-86, an estimated 370 million m^3 of fuelwood and charcoal were extracted, much of it in a manner destructive to the forest resources, from Sub-Saharan Africa's forests and woodlands (World Bank, 1989d). This implies an average per capita consumption of about 0.87 m^3 per year and is consistent with the average per capita consumption estimates of about 0.5 m^3 per year in urban areas and about 1 m^3 per year in rural areas. With about 100 million urban and 322 million rural dwellers in 1985, aggregate consumption, using these average parameters, would have been on the order of 372 million m^3.

6.13 With aggregate population growth declining over the next four decades to a rate of 2.3 percent per annum (and, thus, averaging, about 2.8 percent per year over this period), Sub-Saharan Africa's total population in 2020 would be on the order of 1,169 million (Table 4). If urban population growth were to average 4.5 percent per annum (considerably less than in the last three decades), the urban population in 2020 would total about 485 million (up from about 130 million at present).[4] The rural population would rise to about 685 million by 2020, implying an average rate of increase of a little over 2.1 percent per year. Properly managed fuelwood plantations may sustain yields, on average, of

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[3] Efficiency gains in energy conversion/use and some interfuel substitution in urban areas will somewhat dampen the rate of demand growth, but meeting currently unmet demand in fuelwood-deficit regions would have the opposite effect.

[4] Successfully addressing the problems discussed here would help reduce the rate of rural-urban migration.

4 m^3 annually per ha in the savanna zones and about 10 m^3/ha/year in the forest zones. It may be assumed that the urban population in 2020 will be about evenly distributed between these two main climatic zones. With average fuelwood requirements for urban dwellers amounting to 0.5 m^3 per person per year (in view of gradually increasing interfuel substitution and improvements in fuel utilization efficiency), 30.3 million ha of fuelwood plantations would be needed in the savanna zones in 2020 and a further 12.1 million ha in the forest zones to meet urban woodfuel requirements entirely from managed plantations. Assuming a lag of ten years from planting to harvesting, these plantations would need to be established within the next two decades; this implies an annual rate of plantation establishment of more than 2.1 million ha every year, beginning immediately.[5] Thereafter, further expansion in plantation acreage would need to match further growth in requirements (minus efficiency gains).[6]

6.14 Of course, much of the woodfuel for urban markets can and should come from managed forests, rather than plantations. Forests managed for sustainable woodfuel production could yield, say, an average of 1 m^3/ha/year in the Sahelian and Sudanian savanna, about 2 m^3/ha/year in the Guinea savanna areas and an average of 4 m^3/ha/year in the forest zone. Using an average sustainable yield estimate of 1.5 m^3/ha/year for forests in the savanna zones, 81 million ha of well managed forests in the savanna zones and 30 million ha in the forest zones could, theoretically, meet the woodfuel needs of the urban population in 2020. This would imply that about one fifth of Sub-Saharan Africa's entire remaining forest area would need to brought under effective management regimes with the aim of providing an adequate flow of woodfuels for the urban population on a sustainable basis. Since almost half of the remaining forest area is concentrated in a few countries in the central African forest zone (Zaïre, Gabon, Congo, Central African Republic, Cameroon) and on Madagascar, the proposition of meeting urban needs from managed forests in the other countries means, in fact, that a far greater proportion of the forest areas still remaining in these countries will need to be managed in a manner that would ensure sustainable woodfuel supply over the long run. This will be increasingly the case as forests and woodlands are converted to farmland and other uses.

6.15 Rural populations would need to meet their woodfuel needs increasingly through agro-forestry activities. Rural requirements may average about 1.0 m^3 per person annually. If a ten-year old tree yields, at felling, 0.2 m^3 of wood suitable as fuel, this would indicate a need for 5 trees per person per year -- or 50 trees per person in a ten-year planting and harvesting cycle. For a ten-member household, about 500 trees would be needed -- around the compound, on field boundaries, in windbreaks, in mixed tree-crop farming systems, and in village groves and woodlots.

6.16 Clearly, these numbers can merely provide a rough indication of the orders of magnitude involved in satisfying woodfuel needs. As discussed earlier, the various dimensions of the fuelwood issue are highly location- and region-specific and require, thus, careful attention at the national, regional and local levels. Nevertheless, on balance, it is critical to bring about an immediate and drastic reduction in the rate of deforestation and to expand the area of productive managed forests, forest plantations and tree farming to meet the vast needs for woodfuels and other wood products. An attempt has been made to determine realistic targets for the major regions of Sub-Saharan Africa for the area under trees. These are shown in Table VI.II. They reflect projected wood requirements, plantation and tree farming possibilities, and projections of required and feasible expansion in cropped area. Realism suggest that

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[5] To the extent that transport facilities can be improved and the switch from fuelwood to charcoal and briquettes can be accelerated, more productive plantations in forest zones could meet some of the needs of urban populations in savanna zones, thereby reducing the overall acreage needed for fuelwood production.

[6] Many degraded and currently unproductive woodland areas could be reforested; hence, not all this acreage required for fuelwood production would need to be in addition to current forest and woodland areas.

deforestation cannot be stopped entirely. But it should be possible to lower the overall rate of deforestation from the present 0.6 percent per year to 0.35 percent per annum. This means that the average annual rate of cropland expansion would have to be reduced from the present 0.7 percent to about 0.5 percent. These are realistic targets. But achieving them requires that forests used for wood production be managed efficiently, so that wood harvesting would suffice to meet the needs of populations growing at 2.8 percent per annum and also satisfy essential environmental objectives linked to the environmental service functions performed by trees and forests.

6.17 The challenge posed by these targets is enormous -- requiring, as it does, a complete and rapid reversal of past trends rather than merely an intensification of ongoing efforts to accelerate along a growth path already attained. As indicated in the preceding chapters, the destruction of forest resources is the result of a variety of interlinked factors and forces. Achieving the target postulated here will be even more difficult than attaining that for agricultural production growth.

(iv) Conserving Wilderness Areas

6.18 To preserve biodiversity and the economic and social value of non-forest wilderness areas, these areas should not be allowed to decline very much from their present extent of about 27 percent of Sub-Saharan Africa's total land area. A reasonable target was derived by projecting forward the present rate of wilderness conversion to urban and infrastructure development and the postulated maximum expansion of cropped land (which also comes out of wilderness areas). This means that wilderness area would decline to about 23 percent of Sub-Saharan Africa's total land area (this compares with 39 percent of the world's land area currently classified as wilderness areas). This would allow a continuing modest expansion of cropland at an average annual rate of 0.5 percent over the next three decades and an expansion of the area under urban, infrastructural and industrial uses at about 7.9 percent per year as per current trends.

6.19 Achieving this objective of wilderness conservation will be as difficult as achieving that for reducing the rate of deforestation -- and for the same reasons. One difference, however, is that education appears to be successful in creating heightened awareness among local people of the value of wilderness areas. Improvements in the coverage and efficacy of basic education are therefore likely to help, as are agricultural intensification and reduced population growth. On the other hand, a policy environment conducive to agricultural development and growth will provide strong stimuli to farmers to encroach on wilderness areas in order to expand the area under cultivation (the effect is far stronger than in the case of deforestation, mainly because of the far greater ease of converting non-forested land to farming). This underscores the importance of: (a) land use plans and environmental action plans and of their effective implementation to prevent such a development, (b) effective policies and infrastructure development to channel population movement and cropland expansion into less sensitive areas, and (c) the urgent need to ensure widespread farmer access to markets and to yield-increasing farm technology.

(v) Summary

6.20 There are, of course, considerable country variations in what is necessary and attainable, and the above indicative overall targets have been adjusted to each country's circumstances and potential in Table VI.II (pp. 68-69). Nevertheless, these targets are extremely ambitious. They indicate the magnitude of the problems faced and the efforts required. The elements of an appropriate action plan outlined in the following chapters are, therefore, similarly ambitious. Reaching these targets will be possible only by focusing on the synergetic effects inherent in the linkages and causality chains of the population-agriculture-environment nexus. With rising agricultural productivity and outputs and growing incomes, population growth rates are likely to decline more rapidly. With agricultural intensification and

decelerating population growth, environmental protection and resource conservation become more feasible. And preserving environmental integrity makes it easier to achieve sustainable agricultural growth.

6.21 If the objectives set out in the preceding paragraphs are successfully attained, the vision of the future of Sub-Saharan Africa would be one with a more slowly growing population, and with the rural population increasing more slowly than the urban population. Significant gains in both land and labor productivity would permit the population to feed itself and to increase incomes, without expanding the area farmed beyond what is environmentally sustainable and without depleting and degrading the natural resource base. This would be accomplished through the widespread adoption of locally appropriate sustainable agricultural technology and resource management practices, increased land tenure security, and special efforts to improve rural women's productivity and ease their time constraints. Reducing the rate of forest loss and preserving a substantial part of Sub-Saharan Africa's wilderness areas would permit preservation of biodiversity and wildlife and ensure the lifestyles and survival of indigenous forest dwellers. It would also ensure an adequate supply of fuelwood and wood for construction and local industry and of other forest products for consumption and income-generation purposes. These various interventions would have a strongly positive synergistic effect -- as the negative effects of the present situation are synergistically related. Improved agricultural incomes (especially in conjunction with improved education and health care) would further induce declining demand for children, in turn reducing the pressure on the environment and allowing for some environmental regeneration. This in turn should have a positive impact on agriculture.

6.22 Realizing this vision will be enormously difficult, requiring radical changes in governmental policy and a strong commitment to assisting Sub-Saharan Africa on the part of international community. African governments, external aid agencies, and African and international NGOs will all need to pursue this goal. Most important will be the effort of millions of Africans acting, individually and collaboratively, in their own self-interest. The major elements of an action program are described in the following chapters.

B. Some Country-Specific Targets and Implications

6.23 Aggregate targets for Sub-Saharan Africa as a whole obviously are of limited operational relevance for individual countries. But they provide a useful and compelling framework within which appropriate objectives and targets will need to be set at the country level. Policy and public investment decisions are made at the country level. Table VI.II (pp. 68-69) summarizes the present situation and sets out some internally consistent targets for each SSA country with respect to agricultural growth, calorie supply, food insecurity, population growth, deforestation, percentage of land under cultivation, and percentage of land remaining as wilderness areas. There are some trade-offs between growth of agriculture and environmental protection -- but these are far outweighed by substantial and positive complementarity. Nevertheless, the trade-offs require that choices be made -- and these can be made only by the people in the countries themselves. The targets in the table are therefore also indicative of the trade-offs.

6.24 There will be wide differences in the degree of difficulty various countries will experience in meeting the objectives. Some countries are already on course to meet some of the critical targets, but will need to do better in other respects. Others are faced with the necessity of drastic action in all areas concerned to attain a development path that suggests any likelihood of success in reaching the targets postulated here. Still others are likely to face virtually insurmountable obstacles in certain respects, and solutions that go beyond national boundaries will need to be seriously considered.

Table VI. II. Sub-Saharan Africa: Targets for Food Consumption, Agriculture, Population and the Rural Environment

	Annual agricultural production growth rates (percent)		Annual population growth rates (percent)		Daily per capita calorie consumption		Population food insecure[a] (percent)		Deforestation rates per year[b] (percent)		Total land under crops (percent		Wilderness area to total area (percent)	
Country	1980-90	Target 1990-2020	1980-90	Target 2020-30[c]	1988-89	Target 2010	1980-81	Target 2020	1980s	Target 1990-2020	1987	Max. target 2020	Present	Min. target 2020
Sub-Saharan Africa	2.1	4.0	3.1	2.3	2,027	2,400	25	5	-0.6	-0.35	7.0	8.3	27	23
Sahelian countries														
Burkina Faso	3.3	4.0	2.6	2.4	2,002	2,400	32	5	-1.7	-0.6	11	22	3	3
Chad	2.7	3.0	2.4	2.2	1,821	2,200	54	10	-0.6	-0.6	3	6	52	44
Mali	2.3	3.0	2.4	2.7	2,114	2,300	35	10	-0.5	-0.5	2	4	49	42
Mauritania	0.7	3.0	2.6	2.8	2,465	2,400	25	10	-2.4	-0.6	0	1	74	63
Niger	N.A	3.0	3.5	3.1	2,321	2,450	28	5	-2.6	-0.7	3	6	53	45
Coastal West Africa														
Benin	3.6	4.0	3.2	1.9	2,115	2,400	18	0	-1.7	-0.3	17	20	15	13
Cape Verde	N.A	3.0	2.4	1.8	2,500	2,800	NA	0	N.A	-0.3	10	12	0	0
Cote d'Ivoire	1.0	4.0	4.0	2.6	2,405	2,700	8	0	-5.2	-0.3	11	13	10	9
Gambia	7.1	4.5	3.3	2.4	2,339	2,700	19	0	-2.4	-0.3	17	20	0	0
Ghana	1.0	4.5	3.4	1.9	2,167	2,400	36	0	-0.8	-0.3	12	14	0	0
Guinea	N.A	4.5	2.4	2.4	2,007	2,400	NA	0	-0.8	-0.3	6	7	0	0
Guinea-Bissau	5.7	4.5	1.9	1.9	2,437	2,400	NA	0	-2.7	-0.3	12	14	0	0
Liberia	N.A	4.0	3.2	1.9	2,344	2,500	30	0	-2.3	-0.3	4	5	17	14
Nigeria	3.3	4.0	3.3	2.1	2,033	2,400	17	0	-2.7	-0.3	34	40	2	2
Senegal	3.1	4.0	3.0	2.5	2,162	2,500	21	0	-0.5	-0.3	27	32	11	9
Sierra Leone	2.6	4.0	2.4	2.4	1,813	2,400	23	0	-0.3	-0.3	25	30	0	0
Togo	5.7	4.0	3.5	2.1	2,110	2,400	29	0	-0.7	-0.3	26	30	0	0
Central Africa forest zone														
Angola	N.A	4.0	2.5	2.5	1,742	2,400	NA	0	-0.2	-0.3	3	4	26	22
Cameroon	1.6	4.0	3.2	2.4	2,142	2,400	9	0	-0.4	-0.3	15	18	3	3
Central African Rep.	2.2	4.0	2.7	1.8	1,965	2,400	39	0	-0.2	-0.3	3	4	39	33
Congo	3.6	4.0	3.5	2.7	2,519	2,700	27	0	-0.1	-0.3	2	3	42	36
Equatorial Guinea	N.A	4.0	1.9	1.7	..	2,400	NA	0	-0.2	-0.3	8	9	0	0
Gabon	N.A	4.0	3.9	2.4	2,398	2,600	0	0	-0.1	-0.3	2	3	35	30
Zaire	2.5	4.0	3.1	2.0	2,079	2,400	42	0	-0.2	-0.3	3	4	6	5
Northern Sudanian														
Djibouti	N.A	3.0	3.3	2.1	..	2,400	0	0	N.A	-0.6	NA	NA	0	0
Ethiopia	0.0	4.0	2.9	3.0	1,684	2,200	46	10	-0.3	-0.6	13	26	22	19
Somalia	3.3	3.0	3.0	2.5	1,781	2,400	50	10	-0.1	-0.6	1	2	24	20
Sudan	2.7	4.0	3.1	1.8	1,981	2,400	18	0	-1.1	-0.6	5	10	40	34
East Africa mountain and temperate zones														
Burundi	3.1	4.0	2.8	2.7	2,320	2,400	26	5	-2.7	-0.2	52	52	0	0
Kenya	3.3	4.0	3.8	2.4	2,016	2,400	37	5	-1.7	-0.2	4	5	25	21
Lesotho	-0.7	3.0	2.7	1.5	2,275	2,500	NA	0	N.A	-0.2	11	12	80	68
Madagascar	2.4	4.0	2.8	2.0	2,174	2,500	13	0	-1.2	-0.2	5	6	2	2
Malawi	2.0	4.0	3.4	2.9	2,057	2,400	24	5	-3.5	-0.2	25	28	10	9
Rwanda	-1.5	3.0	3.3	3.2	1,817	2,300	24	10	-2.3	-0.2	45	45	0	0
Swaziland	3.9	4.0	3.3	2.0	2,554	2,600	0	0	0.0	-0.2	10	11	0	0
Tanzania	4.1	4.0	3.5	2.9	2,186	2,400	35	0	-0.3	-0.2	6	7	10	9
Uganda	2.5	4.5	3.2	2.7	2,034	2,400	46	0	-0.8	-0.2	34	38	4	3
Zambia	3.1	4.5	3.9	2.5	2,028	2,400	48	0	-0.2	-0.2	7	8	24	20
Zimbabwe	2.4	4.5	3.7	1.4	2,193	2,400	NA	0	-0.4	-0.2	7	8	0	0
Other South East Africa														
Botswana	-4.0	3.0	3.4	1.4	2,251	2,400	NA	5	-0.1	-0.3	2	3	63	54
Comoros	N.A	3.0	3.5	2.3	2,059	2,300	NA	5	-3.1	-0.3	44	44	NA	NA
Mauritius	2.6	4.0	1.0	0.6	2,690	2,900	9	0	-3.3	-0.3	58	58	NA	NA
Mozambique	1.3	4.0	2.7	2.3	1,604	2,200	49	5	-0.8	-0.3	4	5	9	8

a. Defined as percent who do not have adequate food all the time.
b. A negative number means deforestation as percent of total forested area per year.
c. Average annual rate for 2020-2030 if the target of reducing the total fertility rates to 50 percent of their current levels is achieved by 2030, see table 4.

Methodology used to develop these targets and projections

1. The target agricultural growth rates reflect what is necessary in the long term to contribute to the minimum 4 percent p.a. economic growth rate established in the World Bank's: Sub-Saharan Africa, from Crisis to Sustainable Growth, 1989. The targets require good agricultural policy and investment of the type described in the text, and are significantly, above projections. Present agricultural growth rates are shown in appendix Table 9.

2. The target population growth rates were established as discussed in appendix Table 4. They reflect the projected outcome in each country of the achievement of a reduction in the total fertility rate by almost 50 percent by 2030. Present growth rates: Table 2.

3. Minimum target calorie consumption was initially set for all countries to equal the present average in all the world's low-income countries; it was then adjusted upwards for those countries that already have comparatively high average levels of per capita calorie consumption and downwards for those with currently very low levels. Present levels of intake: Table 10.

4. The target percentage of the food-insecure population is based on a subjective judgment about the possibility of reducing food insecurity in each country given the present numbers involved, the target agricultural growth rate, and the available new land for cultivation. Present percentage: Table 10.

5. Reduction in deforestation is related to the tree cover to supply projected wood needs of populations growing on average at 2.8% p.a, with improved management, and also satisfying essential environmental objectives, while allowing for continued expansion of cropland (See paras 6.10-6.13). The source for these estimates is Mr. F. Wencelius, World Bank, Africa Technical Department, March 1992. Realistic targets, accommodating a minimum expansion in cropland, were set for each sub-region rather than each country. The results in millions of hectares of forest are as follows:

	Year	
	1990	2020
	(millions ha.)	
Sudano Sahel	90.0	75.4
Humid West Africa	43.0	38.6
Central Africa	215.0	192.4
East Africa	46.0	42.8
Southern Africa	206.0	189.2
Total	600.0	538.4

6. The target percentage of land under crops was determined on the basis of available wilderness, forest, and other uncultivated land for cultivation, given the constraint imposed by the need to reduce deforestation to the target rate for each country. For Sub-Saharan Africa as a whole, the target deforestation rate is 0.35% p.a. This amounts to a reduction of forested area by about 2.3 m.ha per year compared to the present 3.7 million p.a. But only about 30% of the land taken out of forests are cultivated, allowing about 650,000 ha. p.a. in expansion of cultivated area. This is equivalent to a 0.5% p.a. expansion in cultivated area for SSA as a whole. This would result in about 8.3% of SSA's land area put under crops by the year 2020. The amount of change would vary by sub-region since the rate of deforestation varies by sub-region; hence a similar calculation was undertaken for each country.

7. The minimum target wilderness area to be retained was arrived at as that remaining after taking out the postulated maximum increase in cropped land (1.3 percent expansion in total area by year 2020), and loss on account of urban, industrial and infrastructure development at its present rate of 5.8% increase every 22 years (table 16). The result is that wilderness loses 2.8% of total land to urban, and 1.3% to crops, hence declining by 41% of total land area, on average. A similar calculation was undertaken for each country.

6.25 Mauritius, for example, has already achieved the targets for population growth, calorie intake, and the percentage of its population facing food insecurity. It also has achieved modest agricultural growth, averaging about 2.6 percent per annum during the 1980s. At present, the rate of deforestation is high (3.3 percent p.a.), and the objective should be to reduce the rate of deforestation to about 0.3 percent per year. Crop land cannot be expanded on this island nation. This underscores the necessity for substantial effort at further agricultural intensification and/or economic diversification to meet rising needs for food and other agricultural products through international trade.

6.26 Ethiopia is at the other extreme. Adverse climatic conditions and prolonged civil strife have had a severe impact. Agricultural production has stagnated during the past decade, average daily food intake is a meager 1,684 calories per person, 46 percent of the population are food insecure, and forests are disappearing at a rate of 0.3 percent annually. At 2.9 percent per year, population growth is somewhat below the SSA average -- not so much because of declining fertility, but because of the high child mortality and overall death rates. The targets set out here for Ethiopia are more modest than those for most other countries, simply because of its critical situation. The area under cultivation will need to increase from 13 percent to 26 percent of the total land area by 2020 to meet the target of 4 percent annual growth in agriculture. Deforestation cannot be halted with this expansion of cropped land, but is in fact likely to accelerate, given the difficulty of intensifying agriculture in a dry environment.

6.27 Uganda provides yet another picture. Its agricultural performance has been poor, owing largely to civil strife, with some impressive improvements in recent years. Agricultural growth averaged 2.5 percent annually during the 1980s. Population growth has been rapid (3.2 percent per annum). Most of the arable land is already under cultivation (34 percent), and there is little wilderness area left (4 percent of total land). The rate of deforestation has averaged about 0.8 percent per annum recently. Uganda has enormous agricultural potential: its agricultural sector could grow at a sustained rate of 4.5 percent annually. If population growth can be reduced to 2.7 percent per annum by the year 2020, average daily calorie intake per person could rise from 2,034 to 2,400, and the number of people facing food insecurity could be brought down dramatically. This would have to occur mostly through intensification on currently cropped land, because there is little additional land left to cultivate. AIDS already is a more serious problem in Uganda than in many other African countries; this suggests that efforts to improve the reach and effectiveness of health care and family planning services are critical.

6.28 A number of countries are facing scenarios of extreme difficulties and constraints: Rwanda, Burundi, the Sahelian countries, Kenya and Malawi. The case of Rwanda is particularly dramatic. Agricultural performance has been poor, with production declining at an average rate of 1.5 percent per year in the 1980s. Population growth has averaged 3.3 percent per year during the 1980s. Per capita daily calorie consumption is only 1,817, and 24 percent of the people are food insecure. There is little wilderness left, although nearly 15 percent of the country has been set aside as protected areas. The rate of deforestation has been 2.3 percent per year, and 45 percent of the entire land area is cropped. The modest agricultural growth target of 3 percent per year can only be achieved through agricultural intensification. Population growth must be reduced to the maximum extent possible. The very high population density may be creating demand for smaller family size; family planning interventions should seek to capitalize on this. Reforestation must be intensified, on land unsuitable for crops. The difficulties are immense. Indeed, the targets spelled out here imply that 10 percent of the population will still be food insecure in the year 2020. Out-migration to other countries will clearly be inevitable.

6.29 Nigeria's example is important, if only because of the country's size. It's agricultural performance during the 1980s has been marked by widely fluctuating production, with a trend growth rate of 3.3 percent per year, matching the population growth rate. The country has such potential for growth that, with appropriate policy reforms in key areas, it can achieve 4 percent agricultural growth

per annum in the medium term. As much as four fifths of this growth can be realized without expanding the area under cultivation because of the availability of proven yield-increasing technology for several key crops and the scope for double-cropping through small-scale irrigation. The remainder will come from modest expansion of the area cropped. Realignment of public expenditure toward small-scale irrigation, provision and maintenance of rural roads, improvement in agricultural support services, reduction of the fertilizer subsidy and liberalization of fertilizer imports and marketing are key areas requiring policy reform. Without such reforms, future agricultural growth would have to come primarily from area expansion which would not be sustainable. The country's family planning effort, very weak at present, will have to improve considerably for the target population growth rate of 2.1 percent per annum to be reached by the year 2020. As population pressure on cultivated land is rising, demand for FP services appears to be increasing in parts of the country, and FP programs will need to foster such demand growth and meet this rising and largely unmet demand. Substantial policy reforms will be needed to stop the rapid destruction of existing forest resources and to induce sufficient private investment in agro-forestry, fuelwood and industrial plantations if the target of reducing deforestation to an annual rate of 0.3 percent is to be met.

VII. REDUCING POPULATION GROWTH

A. Population Policy

(i) Key Issues and Challenges

7.1 Chapter III suggested several avenues for reducing population growth. Fertility rates can be brought down by emphasizing direct actions such as improving knowledge and availability of family planning (FP) services. But to have maximum impact, these "supply-side" efforts need to be backed, if not preceded, by efforts to stimulate demand -- such as improving education, especially of females, reducing infant mortality, reducing environmental degradation, and, possibly, improving food security. Family planning education can be provided through FP services, along with the means to control fertility. By providing nutrition advice, FP services can also help in reducing infant mortality and improving nutritional standards. Increasing density of population on cultivable land may also stimulate demand for fewer children. Acceptance and adoption of FP will spread most rapidly in countries where demand for FP services is increasing fastest. This is likely to be in countries with the highest levels of female education, the lowest infant mortality, the highest population densities on cultivated land, the least environmental degradation, and possibly the greatest food security.

7.2 Governments are increasingly aware of the consequences of rapid population growth. In 1974, only Botswana, Ghana, Kenya and Mauritius had adopted policies to reduce population growth. By 1987, 14 countries had adopted explicit national population policies (Cochrane, Sai and Nassim, 1990, p. 229), and a number of others have done so since then. In 1989, 26 governments in Sub-Saharan Africa considered their population growth rates, and 29 their TFRs, to be too high (Stephens *et al.*, 1991, p. xxxv). But few have so far provided adequate technical, financial and managerial resources to promote and deliver FP services broadly. Hence, progress has been slow.

7.3 Only a few countries on the continent -- notably Botswana, Kenya and Zimbabwe -- have been implementing population programs that have shown some measurable success (Tables 2 and 8). The Contraceptive Prevalence Rate (CPR) in Botswana more than doubled, from 16 percent to 33 percent, between 1984 and 1990, as FP services were placed within easy reach of the majority of the population. Botswana's TFR declined from 6.9 in 1965 to 4.7 in 1988. Kenya succeeded in raising the CPR from 5 percent in the mid-1970s to 17 percent in 1984 and to 27 percent in 1989, and the TFR declined from 8.0 in 1965 to 6.5 in 1989. In Zimbabwe, the CPR is now estimated at 43 percent, and the TFR dropped from 8.0 to 5.3 between 1965 and 1988; the creation of a network of FP clinics and of a community-based outreach program which widely distributed contraceptives was instrumental in providing access to FP services. An indication of changing attitudes concerning fertility and of growing demand for FP services is evident in the number of children desired by women in these three countries. In 1988/89, women wanted only 4.7, 4.4 and 4.9 children, respectively, in Botswana, Kenya and Zimbabwe -- far fewer than their counterparts in other SSA countries and also far fewer than women in the same three countries only ten years ago (Table 8).

7.4 Government policies in these countries have played a major role in achieving fertility reduction through an expansion of FP services and education. However, in each of these countries the fundamental forces have also been working: relatively dense population on cultivated land, relatively high female school enrollments, good agricultural performance contributing to enhanced food security, and declining infant mortality. Yet even in these three relatively successful countries, the TFR must be brought down still further.

7.5 To lower the population growth rate to 2.3 percent per annum for Sub-Saharan Africa by the year 2030, the average TFR for Sub-Saharan Africa as a whole must drop steadily to 3.3 by that time (Table 4). This is possible, as shown by evidence from countries outside Africa where per capita incomes are low and populations largely rural, and where infant mortality rates and life expectancy, when the effort was initiated, were comparable to those in Sub-Saharan Africa today. It requires determined effort and commitment from the political leadership to shape public attitudes and implement policies and programs to reduce population growth.

7.6 Significant reductions in fertility cannot be expected until the CPR reaches 25-30 percent. Slowing population growth to only 2.3 percent per annum during the period 2020 to 2030 would require increasing the CPR substantially above even this level. This underscores the need for fostering greater awareness of the consequences of population growth as well as the need for measures to stimulate demand for FP services. Increasing the availability of FP services raises the level of their use. There is evidence that, even at the present levels of demand for family planning, the CPR in Sub-Saharan Africa could be raised to 25 percent within the current decade by making services widely, regularly and reliably available. It will require a rapid expansion of access to FP services, and this, in turn, will require strengthening and expanding public health care systems and developing multiple channels (public sector, private commercial, NGO, community organizations) for delivering services as well as information, education and communication (IEC). The progress achieved in Botswana, Kenya and Zimbabwe shows what is possible, when the various other factors that bear upon demand for children are also moving in the right direction (Table 8).

7.7 The ethical issues in family planning in Sub-Saharan Africa form a complex web of social, economic, cultural and developmental concerns, and dialogue on ethical issues in family planning is crucial if the process of 'depoliticizing' family planning is to continue (Sai and Newman, 1989). The promotion of family planning as a basic human right and as an important health measure has increased its acceptability, and family planning is now increasingly regarded a legitimate component of overall development efforts. But the "human right" to controlling one's own fertility remains elusive without full and ready access to FP information, education and services. This entails full and voluntary choice of method, right of access for young people, and financial affordability of fertility regulation services. Each of these has caused ethical controversy in some countries. The right of access to FP services is derived from the basic right to make decisions about reproductive behavior. This, too, has been controversial in some countries.

7.8 Family planning is also a major element of the rights of women. Many women prefer to have fewer children, but are discouraged from adopting family planning by socio-cultural factors, including their husbands' wishes. This highlights the importance of reaching men, either at the workplace or through other means such as the agricultural extension services. It also suggests that women's groups would be an effective channel for delivering family planning services because they foster solidarity among women and may help them take fertility decisions on their own.

7.9 In about a dozen countries, fertility regulation programs are part of national population policies.[1] In other countries with FP services, the rationale is not so much to reduce fertility but to

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[1] It is important to distinguish between population policies and family planning programs. Population policy includes family planning, but also includes a range of measures to influence decisions at the family and community levels as well as education and health programs effecting family size. It also comprises changing laws to encourage small families and providing effective incentives and disincentives (e.g., cost sharing for health and education). A comprehensive population policy must also include policies to cope with the consequences of population growth. This means general development policies that encourage optimal use of resources in agriculture, urban development, and so on.

improve maternal and child health (MCH). The health rationale for family planning, especially for preventing high-risk pregnancies, is proven and especially pertinent in Sub-Saharan Africa where infant and maternal mortality and morbidity rates are high. One key element of primary health care is MCH care, and this includes family planning. By providing the means to postpone childbearing until after adolescence, helping to space births at 2-3 year intervals, and preventing pregnancies after the age of 35, family planning can greatly improve maternal and child health.

7.10 Where the rationale for FP programs is demographic, it is often a matter of controversy whether government has the right to influence the reproductive behavior of the citizens. Clearly, unless population policies command broad popular support, the prospects for reducing population growth rates are dim. And where poor governance is causing people to question the legitimacy of governments, governmental population policies and FP programs tend to be viewed with particular skepticism. It is critical that anti-natalist policies be seen to apply to entire populations and be evenly implemented. Policies can justifiably become discredited when they appear designed to modify the balance of ethnic groups.

7.11 Needed is a deliberate fostering of pluralism in efforts to extend access to FP information and services by encouraging and supporting local government, community and private initiatives. The successful involvement of non-governmental groups in FP in Sub-Saharan Africa strongly suggests the viability of such an approach. Fostering pluralism entails a broad agenda of activities to facilitate local and private initiatives and learn from them. It involves difficult choices about how and where to expend governments' limited technical and administrative resources. Governments must take the lead in promoting the dissemination of FP information and in developing a social consensus on its legitimacy. Especially in rural areas, where the government is the major provider of modern health care and specifically of MCH services, the public sector may have to be the principal provider of FP services for some time to come. Many factors still bear on the ethics of family planning in Sub-Saharan Africa, and these point to the need for a sensitive approach (Sai and Newman, 1989).

(ii) Promoting Demand for Fewer Children

7.12 Even greatly improved supply of FP services will not succeed in bringing about the required declines in fertility, unless **demand** for fewer children rises considerably.[2] The evidence of attitudinal and behavioral changes regarding fertility in many parts of the continent suggests that it is possible to create such demand. Between 20 and 40 percent of women in the countries of Sub-Saharan Africa wish to space their children at least two years apart (Table 6). Rising pressure of the rural populations on cultivated land is stimulating demand for smaller family size. Migration and urbanization are loosening extended family ties and raising the private costs of children. Education of women is increasing, there is a clear trend toward later marriage,[3] and there are indications of considerable unmet demand for modern contraception (Table 6). These changes in attitudes can be encouraged, promoted and accelerated by a variety of means, including effective information, education and communication (IEC) programs, so as to lead to increased demand for FP services.

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[2] A recent evaluation of past World Bank operations in the population sector confirmed that FP services have been offered in many countries when there was little evidence of any significant demand for them (World Bank, 1991e).

[3] Average age at marriage increases with education level – and this correlation is stronger in SSA than in other regions. This may be because education for women is more rare in SSA and differences in age at marriage therefore reflect the exceptional differences in the lives of the most educated. Since female education is a more recent phenomenon in SSA, the difference in age at marriage may also capture both education and cohort effects. Interestingly, these larger differences in age at marriage were not yet reflected in differences in fertility in the early 1980s (Cochrane and Farid, 1989).

7.13 Improving the legal, economic and social status of women is critical to overcoming the constraints imposed upon them by their traditional roles that perpetuate high fertility. This entails, *inter alia*, recognizing and emphasizing that women's status also derives from their **economic** contributions to family, community and society. It requires, therefore, expanding the range of opportunities available to them and supporting developments that provide women with greater control over their own lives and the output and income generated by their work. Greater educational opportunities, removal of discriminatory laws, raising the age of marriage, ensuring women's rights to land, improving their access to credit and training, meeting their needs for technology and information, opening up employment and income-earning opportunities beyond those traditionally open to them, and strengthening women's organizations all help to raise women's status and give them greater control over their lives. At the same time, efforts must be made to relieve both the environmental degradation and the work burden on women, both of which fuel demand for additional family labor.

7.14 To promote demand for FP services, actions such as the following are essential:

(a) Political leaders and communities need to be sensitized to the environmental and economic consequences of rapid population growth. People's demand for family planning and contraception, as well as for later female marriage, must be increased through widespread IEC programs. To ensure that people regard such programs as legitimate, governments must demonstrate continually their legitimacy and credibility, through good governance. Governments lacking credibility and popular acceptance are very likely to confront popular distrust of population programs.

(b) Effective measures are needed to expand education, especially for females, and to improve women's income-earning opportunities. This will tend to raise women's marriage age and reduce both their desired and actual number of children. To the extent that improved income-earning opportunities for women lead to increased control by women over such income, this will have strong positive effects on child health and welfare, on infant and child mortality and, hence, on women's fertility preferences.

(c) Health services need to be expanded and improved to deal with major epidemic diseases and reduce infant and child mortality. This will increase the security of having descendants at death and weaken one of the major traditional motivations for desiring large families. It will also reduce the economic incentive for having larger families, since fewer, but surviving, children can assure adequate availability of family labor.

(d) Expanding access to effective primary health care is also essential to address the problems of sexually transmitted diseases (STDs). STDs are major causes of infertility, which in some regions discourages any interest in fertility control. High incidences of STDs are also an important factor contributing to the rapid spread of AIDS.

(e) Incentives for smaller families and disincentives for large families (e.g., limitations on tax deductions for children) may help in the longer term. Community leaders, teachers, agricultural extension agents and the mass media should be used to convince people of the economic, environmental and health benefits of having fewer children.

(f) Land tenure reform as well as improved access of women to land, to agricultural extension and to credit are likely to reduce the pressure on women to have many children. Greater food security may also lead to reductions in fertility rates.

(iii) Improving the Supply of, and Access to, Family Planning Services

7.15 Improving the supply and accessibility of FP services to respond to the demand created by measures such as those outlined above requires the combined efforts of governments, NGOs and aid donors. The target must be to raise the CPR in each country sufficiently to achieve a 50 percent reduction in the TFR by 2030 (Tables 4 and 5). For Sub-Saharan Africa as a whole, this implies increasing the average CPR from less than 11 at present to over 45 by the year 2020 and to over 50 by 2025 (Table 5).

7.16 The family planning effort of nearly every country in Sub-Saharan Africa ranks near the bottom of developing countries, with the notable exceptions of Botswana, Kenya, Mauritius, Zimbabwe and, arguably, Ghana (Table 7). Fertility can be reduced and population growth slowed if governments, schools, employers and NGOs take measures to increase the demand for smaller families while supplying the services needed for families to limit family size. The FP services provided must be of high quality and responsive to clients' needs, and there must be adequate provision for monitoring and evaluation.

7.17 In most countries of Sub-Saharan Africa, FP services are integrated with and delivered through the public health system, usually as part of MCH care. But in many countries the public health system is and unable to deliver widespread and effective FP services. Rapid expansion of access to family planning will require strengthening and expanding public health care systems as well as developing alternative and supplementary channels to deliver FP services and IEC. Where AIDS is important, this will be all the more critical, since sex and health education and the provision of condoms are the key instruments for combatting its spread.

7.18 The promotion of modern family planning can build on long-standing traditions of spacing births through prolonged breastfeeding and post-partum sexual abstinence. The significant potential health gains from family planning appeal to policy-makers and to the people affected. And new methods of delivering FP services have been shown to be workable and to make a difference in parts of Sub-Saharan Africa. A focus on birth spacing, rather than on family size limitation, would appear to be most appropriate where demand for fewer children is not strong. This is most common in countries where the population pressure on cultivated land is comparatively weak and where traditional incentives for wanting large families remain strong.

7.19 Supply and accessibility could be substantially improved by measures such as the following:

(a) Governments should establish and strengthen public institutions charged with population and FP programs. This will involve staff training, management improvements, and strengthened program content.

(b) The role of NGOs in family planning should be expanded NGOs have demonstrated their effectiveness in dealing with family planning issues effectively all over the world.

(c) Private FP organizations, non-governmental health care networks (churches, employers' schemes), private health care practitioners (including traditional health care providers), other non-governmental development groups (women's groups and community associations), non-health outreach networks (agricultural extension and community development workers) can all be effectively used as channels for FP services. So can commercial outlets such as pharmacies, market traders and rural stores, particularly for marketing contraceptives. With AIDS an increasingly severe problem in many countries, a massive effort to expand the range of providers of condoms will be critical.

(d) Community incentive schemes should be developed and funded to induce communities to take action to reduce population growth through community-managed family planning programs. These programs can be managed, with government funding, by schools, employers and community groups.

7.20 Periodic demographic and health and contraceptive prevalence surveys are needed to establish baseline data and provide essential information on fertility, family planning and maternal and child health to policy makers and planners. Such data would reveal unmet demand for family planning and would indicate where service expansion or improvement is warranted and most needed.

B. Primary Education

7.21 In most countries of Sub-Saharan Africa, two important development objectives are (a) to improve the quality of primary education and (b) to expand primarily school enrollment, especially of girls. Indeed, one of the most critical issues in the education sector in much of Sub-Saharan Africa is the urgency to increase primary school enrollment of girls. In some countries, girls account for less than 20 percent of primary school enrollment and even less in secondary and tertiary education. The lower rates of female school enrollment and the higher rates of female drop-out at earlier grades are due in large measure to the high demand for girls to help with domestic work, such as caring for younger siblings, fetching water and fuelwood, etc. (e.g., Ventura-Dias, 1985, p. 183). Caring for younger siblings is particularly prevalent among girls aged six to nine -- an age at which they should attend primary school. Once they have missed that, their chance to receive schooling is almost inevitably lost forever. These girls are very likely to remain in the low-education, low-income, low-status, high-fertility trap.

7.22 The gender gap in education has a high cost. Primary schooling beyond the first three years lowers women's fertility. Female education also has a strong effect on family welfare: the mother's education may be the single most important determinant of child health and nutrition. Moreover, since the majority of agricultural subsistence producers are women, better education for women can be expected to improve agricultural productivity -- as well as women's incomes, opportunities and decision-making power within the household.

7.23 A number of possibilities exist and have been successfully tried in various settings to increase primary and especially female school enrollment. These need not be repeated here. One such possibility

Increasing the Private Costs of Having Children

Some observers argue for deliberate policy actions designed to impose more of the social costs of children directly on their parents. In some countries and under certain conditions, this would create pressure for reducing family size. Where, for example, education is a highly valued commodity, shifting the cost of schooling increasingly to the parents is likely to have a dampening effect on fertility rates. This appears to have been an important factor contributing to the decline in the TFR in Kenya.

Such a policy thrust conflicts, of course, with the important development policy objective to meet basic needs. Moreover, such a policy potentially faces very important pitfalls. There is a very high likelihood that parents would, out of economic necessity, decide to ration access to education among their children, favoring boys at the expense of girls (even more so than is already the case). This would have profound longer-term implications -- not least for fertility rates.

Moreover, in many SSA settings, the cost of children is not necessarily borne by those responsible for their having been born. Not only do fathers often have very limited responsibilities for child maintenance (or evade their responsibilities altogether through divorce or migration), but child fostering is a widespread custom in many societies.

merits mention, as it may be of particular relevance in the present context. It concerns changing school schedules -- daily hours as well as vacations -- to fit better into rural production systems and agricultural seasons. Children will need to help with farm work, especially at peak periods, and if school is scheduled accordingly this may help improve attendance. Current vacation schedules are often still those established on the model and patterns of the colonial powers. European school breaks were scheduled to allow child labor in farming activities (planting, weeding, harvesting). The farming seasons in the Sub-Saharan Africa are different. Regional school administrations should be given authority to adjust schedules to local realities.

C. Conclusion

7.24 Rapid population growth is detrimental to achieving economic and social progress and to sustainable management of the natural resource base. But there remains a sizeable gap between the private and social interest in fertility reduction, and this gap needs to be narrowed. Policies and programs which influence health, education, the status of women and the economic value of children in turn influence attitudes toward childbearing, family planning and people's ability to control family size. Efforts to reduce fertility through explicit population policies, therefore, should be integrated with policies to improve health, education and women's status.

7.25 The various components of human resource development programs are strongly synergistic. Family planning is more readily accepted when education levels are high and mortality low and, in particular, when child mortality is low. Healthy children are more likely to attend school. Clean water and sanitation are more beneficial if combined with health education and nutrition education. Educated mothers are more likely to have fewer and healthier children. These human resource development efforts also have positive effects on agricultural productivity and, hence, on food security. This, in turn, stimulates demand for fewer children. Improvements in human resource development are therefore critical in multiple ways for long-term sustainable development.

7.26 Broad-based improvement in human resource development performance requires reorienting policies and financial resources to focus on delivery systems that respond to the critical needs of the vast majority of the population, including the poor. This calls for far greater emphasis on primary education and basic health care. It also requires financial resources and, hence, substantial and sustained economic growth to generate sufficient resources to invest in human resource development (the significant potential and need for improving cost effectiveness notwithstanding). Without substantially improved agricultural growth performance, this will not be attainable.

VIII. PROMOTING SUSTAINABLE AGRICULTURAL DEVELOPMENT

A. Sustainable and Environmentally Benign Agriculture

8.1 As suggested by the analysis in Chapters IV, V and VI, agricultural development efforts must focus on innovations which improve the productivity of land and of farm labor. Incentives which encourage increases in further expansion of the cultivated area are consistent with agricultural growth objectives, but **not** with environmental protection concerns. The objective, therefore, must be to increase the productivity of both land and labor, in order to permit output growth while minimizing the increase in the area farmed. The required increase in productivity must be achieved with the least possible destruction of the environment.

8.2 A critical issue to keep in mind is the extraordinarily high risk faced by most farmers and herders in Sub-Saharan Africa. Rainfall is unpredictable in all but the most humid zones, and much of the continent has a significant chance of drought each year. Even in years of adequate overall rainfall, rains may start late or end early, and dry spells can occur at crucial times in the growing season. Most African soils need skilled management to ensure sustainable production, and most are easily degraded when their vegetative cover is thinned or removed. The dryer areas are dominated by sandy porous soils deficient in nutrients, while many of the humid lowlands have acid soils where aluminum toxicity can damage plants. The most fertile soils are in the East African highlands, where slopes and intense downpours increase the risk of erosion. The dark clay and alluvial soils in valley bottoms are prone to waterlogging and difficult to cultivate without animal traction or mechanized equipment. And the potential for irrigation is limited.

8.3 Crop farming in Sub-Saharan Africa, as in other tropical regions, is also characterized by extreme seasonality of labor requirements and labor peaks (Ruthenberg, 1985, pp. 77-78). Labor shortages are very common at the stages of land preparation, weeding and harvesting. With traditional tools, land can only prepared once the rains have started -- but then it must be done very quickly to allow sufficient time for crops to grow on the available moisture. With the onset of the rains, growth conditions also become ideal for weeds, and weeding becomes critical. Similar urgency prevails at harvest time to prevent crop losses. These labor constraints are compounded by the effects of climate, health and nutrition. In humid tropical and subtropical climates, only light work is possible during the midday and early afternoon hours when there is no shade. Heavy work must be interrupted by frequent and prolonged rest periods. If people are poorly nourished and/or afflicted with disease, their capacity for hard and sustained work is further diminished.[1] An obvious implication of this is the pressing need for technology which saves labor, particularly at times of peak labor demand.

Peak Labor Periods, Nutrition and Health

All farming systems research in Sub-Saharan Africa shows tight labor constraints at certain critical periods in the crop cycle. One of the most interesting insights from data collected in northern Malawi is the relationship between labor demands and health: most illnesses were reported toward the end of the rainy season (February-April) and most deaths during March-June -- explained largely by reduced food availability, heavy work loads, dampness and water problems in the house (Due, 1988, p. 334).

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[1] Ruthenberg (1985, p. 78; citing research published by H. Brandt in "Work Capacity Constraints in Tropical Agriculture Development," in Medizin in Entwicklungsländern, Heft 8, Verlag P. D. Lang, Frankfurt, Germany, 1980) points out that the "admissible work load" for a healthy person would be 300 kcal per hour in agricultural field work at 27° C (or about 80° F) with no insolation, but only 225 kcal working with full insolation. A sick worker, by contrast, working in full insolation, can only expend about 180 kcal/hour. Work capacity declines very rapidly with rising temperatures. At 30° C, a healthy worker in the shade can put in about 150 kcal/hour, while sick people should be resting in the shade.

8.4 Generally poor and heavily dependent on local natural resources and family labor, farmers and herders in Sub-Saharan Africa cope with uncertainty and with sustainability problems by adopting a variety of flexible strategies that minimize risk and make optimal use of the resources available to them. Examples of such strategies include planting multiple crops and multiple varieties of multiple crops; diversifying herds and maintaining a high degree of mobility; establishing social arrangements to gain access to additional resources at times of stress; engaging in various off-farm income-generating activities, particularly during the off-season. These strategies aim to diversify income and food sources, stabilize aggregate production and income, minimize risk, and maximize returns to labor under low-technology conditions. In crop production strategies, the central objectives almost invariably are: (a) ensuring optimum stable aggregate output of multiple crops over time, rather than maximizing yields of individual crops (see also para. 8.15), and (b) maximizing output per unit of labor, rather than per unit of land.

8.5 Farmers seek to maximize production per unit of land only when land becomes scarce relative to labor. This is now occurring in many parts of Sub-Saharan Africa. The weakness of the traditional coping strategies, as discussed in Chapter IV, is that they are not capable of adjusting quickly enough to prevent serious negative impact of rapid population growth and increasing population pressure on soil fertility, farm size, fuelwood availability, land tenure systems, and so forth. The challenge is to increase farmers' and communities' ability quickly and effectively to confront these problems, building on their traditional mechanisms of coping with their environment.

8.6 Another critical issue is that of ensuring the longer-term sustainability of agricultural production systems. Sustainability has several dimensions and must be considered in terms of environmental, technological, economic, social and institutional aspects and constraints and of the interactions among them. It also must be considered in a dynamic sense, since there will be change, probably quite rapid in certain areas. If the rapidly rising demand for agricultural products is to be met without further depletion of the natural resource base, this requires modification of agricultural production systems in the direction of intensification (i.e., more output per unit of land).

8.7 Numerous environmentally benign agricultural technologies have been developed experimentally on a small scale in Sub-Saharan Africa. Examples include contour farming to reduce water run-off and soil erosion, mulching, minimum tillage, intensive fallowing, crop mixtures and rotations which assure continuous soil cover, terracing and bunding, integration of livestock and cropping to maintain soil fertility, agro-forestry, integrated pest management, and water harvesting. In some countries farmer-managed small-scale irrigation has considerable potential. Behind each of these terms lies a considerable body of agricultural knowledge which to date has found little application in Africa outside of a number of NGO projects. Accelerating the widespread adoption of such technology, carefully adapted to the widely varying local agro-ecological and socio-economic conditions, is essential if the critical problems faced by African agriculture are to be overcome.

8.8 Such technologies need to be mastered by national agricultural research and extension systems so that they can be more widely adapted to farmers' circumstances. There is a basic constraint, however, which is as much responsible for the lack of successful introduction of these technologies as has been poor research and extension. Farmers have not **demanded** these technologies -- much as most people have not demanded family planning. There has been little incentive for individual farmers to introduce such technologies in place of traditional methods. As Boserup suggested, as long as there is free land to open up for farming, investing labor and capital in more intensive agriculture makes little sense from the farmer's perspective. When inappropriate macro-economic and agricultural policies reduce the profitability of farming, the incentive for farmers to intensify is further weakened. But policies that encourage opening up additional land for farming are not the answer, since the cost in environmental resource destruction can be substantial. This complicates the search for solutions to the problem.

8.9 Agricultural intensification on a wide scale requires more effective research and extension. It also requires policies that induce farmers to intensify production. Making intensive farming profitable requires the kind of price, tax and exchange rate policy environment suggested in the World Bank's long-term perspective study for Sub-Saharan Africa (World Bank, 1989d). Farm input and output prices must be determined not by decree or by monopolistic or monopsonistic parastatal marketing agencies, but by market forces and must be closely linked to world prices. Exchange rate policies must ensure efficient equilibration of international and internal prices. And marketing, trade and investment policies must facilitate private response to market opportunities.

8.10 In the short to medium term, subsidies may be necessary for certain farm inputs (such as seeds of improved varieties) which are needed to introduce intensive sustainable farming techniques, while the conversion of forests, rangeland and wetlands to crop land may need to be taxed for environmental reasons. Such measures improve the profitability of agricultural intensification and raise the cost of land. Another, complementary, approach would involve providing compensation to individuals and communities to narrow -- or even eliminate -- the gap between private and public costs and benefits of resource-conserving production methods.[2] Such programs would need to be carefully designed and monitored (see also paras. 8.64-8.66).

8.11 Environmentally benign and sustainable technologies of the type noted in para. 8.7 are, by themselves, unlikely to be sufficient to permit most countries of Sub-Saharan Africa to achieve agricultural growth rates of 4 percent per annum. Improved crop variety/fertilizer/farm mechanization technologies will also be necessary, and the most desirable scenario would involve the widespread adoption of location-specific appropriate combinations of both. A gradual shift to locally suitable higher-value crops and livestock products will also be necessary. Over time, this will be stimulated by the policy reforms summarized above, by growing market orientation of agricultural production and by rising urban incomes. Nevertheless, in certain agro-ecological settings, some trade-offs between agricultural intensification and environmental resource protection will be inevitable. The following sections discuss environmentally benign low-input, low-risk technologies that deserve greater emphasis in research and extension.

(i) Soil Conservation and Fertility Management

8.12 Soil erosion is influenced by a combination and interplay of many factors -- including soil characteristics, climate, topography, land use and farming practices. It is therefore site-specific, and individual control measures that are appropriate and successful in one set of circumstances cannot automatically be transferred without modification to another location.

8.13 Farmers adopt soil conservation measures when they clearly perceive them to be in their own interest. In low-resource and labor-constrained settings, and with risk-averse farmers, measures recommended for adoption must increase crop yields (probably by a fairly significant margin), require little or no cash outlays, and conflict as little as possible with existing peak labor demands. If tree planting is involved, local rules concerning tree tenure must be considered, as must the often considerable

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[2] If, for example, constructing rock bunds on steep slopes or the afforestation of severely degraded land to prevent gully erosion provide high economic returns, but low financial returns to the farmers and communities who would be undertaking these works, it would make sense to provide appropriate compensation to cover the difference. This might take the form of partly or wholly subsidized provision of key inputs (such as seedlings), of direct wage payments (under food-for-work schemes, for example), or of the provision of village-level infrastructure facilities in exchange for community action on resource conservation. This approach is discussed and analyzed in detail in FAO/World Bank Cooperative Programme, 1991, and a land resource conservation project recently initiated with World Bank support in Ghana will test it in practice.

differences in the allocation of costs and benefits between genders (see para. 8.41). If men are to invest in tree planting and maintenance, trees must produce cash crops and/or timber (or fuelwood for sale). Women far more readily value trees that provide fuelwood for own use, livestock fodder, fruits and other non-wood products. Many soil conservation efforts require additional labor -- which often has high opportunity costs or is simply not available. Even off-season labor availability cannot be taken for granted. Rural people pursue various non-farm income-earning activities when farm labor needs are slack, and seasonal outmigration of men is common in many areas. The shortage of labor has been one major reason for the poor record of many soil conservation programs. The other has been the perceived low rate of financial return to most of the techniques that would be technically effective. Where, however, the labor/land ratio is high, as in parts of the East African highlands, various labor-intensive soil conservation techniques are financially attractive and, indeed, widely used. This suggests that farmers' willingness to undertake soil conservation measures will increase as population densities rise as soil degradation and erosion problems intensify and as policy reforms make intensive farming more profitable (see also paras. 8.72-8.73).

8.14 African farmers already use a variety of techniques, highly adapted to local conditions, to manage soil fertility and conserve soil. Many of the "more innovative" practices now being evaluated and refined on research stations are in fact based on techniques developed by farmers themselves. These techniques are founded on the recognition that the only truly effective way of controlling soil erosion is the maintenance of vegetative soil cover, especially during the rainy season. Many traditional farming practices contain a number of features that are designed, in part, to meet this requirement: mixed cropping, intercropping, relay cropping, multi-story farming,[3] various forms of fallowing, crop rotations, no-tillage and minimum tillage, a variety of agro-forestry techniques, and so forth. Farmers have also resorted to engineering techniques to combat soil erosion and improve water retention on farm land. In many parts of the Sahel, the construction of terraces, stone lines and stone bunds, and earthen ridges, often laid out in grids, have a long tradition; these methods are still used in Mali, Burkina Faso and Niger (Reij, 1988, pp. 19-23).

8.15 All these techniques also meet other important requirements. Particularly essential are these: spreading total labor requirements as evenly as possible over the year; making optimal use of cultivated land through spatial arrangement of crops in mixed cropping systems;[4] and minimizing risk and stabilizing aggregate output from multiple crop species in environments characterized by considerable climatic uncertainty. It has been repeatedly documented that African farmers "outperform" the weather: indices of crop yields over time fluctuate considerably less than indices of rainfall (Dommen, 1988, p. 27).

8.16 Basing improvements on this rich tradition of farmer ingenuity and adaptation to local circumstances and constraints holds the greatest promise for success in overcoming the problems now facing agriculture in Sub-Saharan Africa. By the same token, failure to recognize this potential and to

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[3] Multi-story compound farms are found throughout Sub-Saharan Africa, and especially in the forest zones. Such plots contain a variety of plants that grow to different heights (trees, vines, bushes, low-growing plants, and root and tuber crops), attract and/or repel different animals and pests, and have widely different life cycles and, hence, labor requirements and yield peaks. In essence, multi-story gardens represent local people's efforts to utilize the synergies of the rainforest ecology for crop production. A recent survey of compound farms in eastern Nigeria identified 146 species being cultivated in compound farms, with as many as 57 grown in a single compound (Bass, 1990, p. 136).

[4] In mixed cropping systems in the humid tropical forest zone, 20 to 30 different species appear to be the "norm" on a single farm, but as many as 60 species have been found. In the semi-arid regions, 15 to 20 species appear to be the normal range for a single farm (Dommen, 1988, p. 36).

tailor supportive efforts accordingly has been an important factor contributing to the non-adoption of many technical "solutions" proffered in the past to overcome the continent's agricultural crisis.[5]

8.17 Numerous effective and low-cost or no-cost techniques can be made available to farmers that would permit intensification and greater sedentarization, improve yields, and maintain soil fertility. Which of these are appropriate -- technically and economically -- depends very much on local conditions. A few examples of techniques aimed at soil conservation and soil fertility management are the following:

- Vegetative soil and water conservation methods are highly effective and far less labor-intensive to establish and maintain than terraces and other soil-moving techniques. Except on very steep slopes, grassy strips (sometimes called infiltration bands) have been found to be as effective in combating erosion as bench terraces -- these being the two most effective techniques. Permanent strips of suitable species, established on the contour at proper intervals down the slope, are highly effective in slowing runoff, reducing soil erosion, improving moisture retention, and creating natural terraces over time. If fodder grasses are used, periodic cuttings provide animal fodder. Variations of this method are already in use, for instance, in Ethiopia, Kenya, Madagascar, Nigeria, Rwanda and Tanzania.[6]

- Where draft power is available, ploughing along the contour on sloping land will considerably reduce soil erosion and increase water infiltration. The effectiveness of contour farming is further improved if permanent contour key lines are established at appropriate intervals down the slope by means of permanent strips of suitable plant species (such as *Vetiveria spp.*).

- "Intensive" or "managed fallowing" -- sowing deep-rooted legumes when land is taken out of production, rather than simply waiting for natural revegetation -- will greatly improve soil fertility even in a single year. Where new land remains available for clearing, however, or where livestock are allowed to graze fallow land, farmers may be slow to change their fallowing practices.

- Minimum tillage and no-tillage methods, which involve planting directly into a stubble mulch without ploughing or hoeing, can virtually eliminate soil losses, increase water infiltration and retention, and reduce labor input per unit of output. Minimum tillage is, of course, a practice very familiar to farmers in forest fallow systems. Soils in forest fallow systems are, however, almost entirely free of weed seeds and very easy to work with a planting stick. Neither condition is likely to apply in minimum tillage or no-tillage systems practiced on more permanently cultivated land.

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[5] A long-time student of the situation in northern Nigeria has written that the "basic rationality" of indigenous land-use systems "emerges unfailingly from almost every field investigation" and "the rationale of indigenous land-use systems must become the basis for conservationary resource management for the simple reason that the land belongs to, and must continue to be occupied by, its present population" (Mortimore, 1989a, p. 207).

[6] For best effect, the species used should be a grass or a shrub with deep roots and strong and dense leaves and stems; it should be drought, fire, livestock and flood resistant, should not take up much crop land, and should not harbor pests or diseases. *Vetiveria zizanioides*, a clump grass, exhibits all these characteristics and more. It thrives in arid and humid conditions, seems to grow on any soil (including shallow rocky soils) and survives wide temperature ranges. It is virtually maintenance-free, produces a dense hedge, and is extremely effective in trapping silt, slowing runoff and increasing water infiltration. It is used for soil conservation purposes in regions as diverse as China, Fiji and India. Extension services in Nigeria, following successful field trials, are now promoting its use, as well as that of its close relative *V. nigritana* which has long been used by farmers in parts of northern Nigeria to mark their field boundaries, as a vegetative erosion barrier.

- Mulching can considerably reduce soil erosion, improve in-situ water retention, raise soil fertility and increase yields. But mulching annual crops is difficult. It can only be done after the seedlings have emerged, so that the mulch will not prevent germination. Consequently, mulch will not be in place at the onset of the rains, when much soil erosion takes place. Moreover, many annuals are low to the ground and mulch, with its micro-environment that harbors insects and molds, is close to the leaves of the young plants. The techniques of mulching annual crops are proving to be extremely demanding. Most experimental work in this area has been conducted by the International Institute of Tropical Agriculture (IITA), which has generally had to resort to pesticides (Jones and Egli, 1984).

Alternatives to Slash-and-Burn

Results of ICRAF field tests of environmentally benign, low-input sustainable technologies for tropical forest areas suggest that farming on newly cleared land must begin with low-input cropping. The initial slashing and burning clears the land, adds nutrients to the soil, and reduces soil acidity for the first year of cultivation (tropical forest soils generally being very acidic). Acid-tolerant crops such as upland rice and cowpeas should then be planted. First-year yields are usually very high. All crop residues (cowpea tops and rice straw) should be returned to the soil to improve its organic content. The plot should then be sown to pasture legumes or grasses; kudzu is recommended because is grows easily and smothers weeds. This "managed fallow" is more effective than the traditional forest fallow in restoring soil fertility. In subsequent years, more intensive techniques are necessary to maintain soil fertility. This may involve agro-forestry, tree crops, legume-based pasture or, if the farmer can afford it, the use of chemical fertilizers (Sanchez, 1991).

8.18 Labor-intensive approaches and mechanical or engineering works (such as terracing and bunding) are suitable only in certain settings. Moreover, engineering works will not be satisfactory in isolation. The primary requirement is appropriate land use, and mechanical conservation works must be accompanied by good farming practices (Hudson, 1987, p. 158):

- Terracing is common in some parts of Sub-Saharan Africa, mainly on steeply sloping land.[7] When properly constructed and maintained, terraces are highly effective in preventing soil erosion and increasing the retention of water in the soil, but they have drawbacks. Most important, they require considerable labor to construct and maintain and are far more expensive per unit of soil retained than almost any other alternative for soil erosion control.

- Earthen bunds also require frequent maintenance and repair. Unless properly maintained and stabilized with grasses, they last only two to five years. On slopes of more than 10 percent gradient, they silt up rapidly; their trap efficiency may be 30 to 50 percent in the first year but falls to zero in the second (Grimshaw, 1989). They have been found useful only on well-drained soils. Elsewhere, they are susceptible to breaching or cause water logging.

- In Rwanda and Burundi, contour ditches introduced by colonial governments to control soil loss were abandoned after independence because farmers, who have a good idea of the cost in labor of digging and maintaining ditches, felt the ditches were not worth the maintenance they required (Brown and Wolf, 1985, p. 42; Jones and Egli, 1984). The practice is now slowly being reintroduced, along with tree planting, mulching and other complementary conservation measures.

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[7] From 1976 to 1985, with support from several external aid agencies, Ethiopian farmers constructed 60,000 km of bunds and 470,000 km of terraces for reforestation; however, this amounts to just 6 percent of Ethiopia's threatened highlands.

Soil Conservation in Kenya

In Kenya, grass-roots interest in soil conservation began to emerge a few years after independence, encouraged by good leadership and a strong sense of national unity based on the *harambee* philosophy. An important step was the adoption of soil conservation by the *Mwethya* groups, voluntary self-help groups which form each year to carry out communal work during the dry season and disband with the onset of the rains to tend to their individual farming activities. Leadership comes from the women, but men are persuaded to join for some physically demanding tasks. The range of activities includes bush clearing, water carrying, management of grass and tree nurseries, and ploughing arable land on group members' farms in turn.

Presidential support for a national conservation program and the creation of a Permanent Presidential Commission on Soil Conservation and Afforestation provided a strong boost to this movement. At the same time the increasingly serious problem of soil erosion in Kenya attracted the attention of national and international aid agencies, who supported development projects which include soil conservation elements. In 1974, the Ministry of Agriculture began a soil conservation extension program with the assistance of SIDA. Farmers were encouraged to terrace sloping land by leaving unplowed strips along the contour, and the concept of a new type of terrace called *Fanya Juu* (meaning "throwing upwards") emerged: a ditch is dug on the contour, with the excavated soil placed on the uphill side to form a bund. The steeply sloping riser and the bund are planted with grass, providing a self-terracing effect as the grass and the bund retain soil washed down the cultivated inter-terrace strip.

To compensate farmers for keeping some land out of crop production, fruit and fuelwood seedlings and cuttings of quality fodder grasses were provided for the unplowed strips. Tree crops diversified the produce farmers could sell. High-quality fodder enabled farmers to limit the free grazing of cattle. Terraces retained water and soil and raised yields on the upslope side. In semi-arid Machakos district, maize production in some fields increased by half after introduction of the terraces.

By 1983, terraces had been built on 100,000 farms, and extension agents were reaching over 30,000 new farms each year (Brown and Wolf, 1985, pp. 41-42; Hudson, 1987, pp. 165-166).

- On the Yatenga Plateau in Burkina Faso, farmers have adopted a technique of ranging lines of stones along the contour on land suffering from, or threatened by, erosion. The lines of stone slow water run-off, increase water infiltration, trap dislodged topsoil and have helped revegetate heavily degraded land. Farming had become threatened, and because labor was available to carry out the work, this comparatively heavy investment in soil conservation and land improvement works made economic sense to farmers. Some 6,000 ha have now been "treated" in this manner, and yields have increased by 15 to 30 percent. Labor cost are high and increasing, however, because rocks have to brought from increasingly greater distances. The success of the stone contour bunds in the Yatenga Region could not be replicated in Mauritania's Affole mountains, where rainfall is much lower, slopes are steeper, and the population density far lower. This underscores the limitations to "technology transfer" and the critical importance of adapting "solutions" very carefully to local agro-ecological and socio-economic conditions (Reij, 1988, p. 27).[8]

8.19 Kenya offers an example of a promising combination of conservation and new farming practices that increases vegetative cover and reduces the likelihood of severe erosion. Farmers are free to choose which practices to adopt and which trees to plant. Hundreds of thousands of smallholdings have been terraced by now, with farmers doing the work themselves (see box).

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[8] Another interesting dimension of the stone line technology was observed on the Mossi Plateau in Burkina Faso. There, women do not own land and do not benefit directly from the profits of their husbands' fields. They do, however, benefit directly from working on their collective fields, which are "borrowed" from the men, because the yields are distributed to all participants. Most women were soon discouraged from building rock lines. They had labored hard to treat their fields, but then often found the men reclaiming these improved plots for their own crop production and forcing the women to move again to another untreated piece of land (Wardmann and Salas, 1991, p. 77).

8.20 There are a number of other simple and effective ways in which farmers' production systems can be made significantly more productive and sustainable, without increasing farmers' risks or the requirements for additional labor and/or capital beyond what the productivity gains will cover. Table 24 summarizes the results of a financial and economic analysis of many of these techniques under current conditions in Nigeria (FAO/World Bank Cooperative Programme, 1991). This analysis showed that many of these techniques are highly effective in reducing the decline of crop yields on continuously cropped land by reducing, to varying degrees, soil fertility losses and erosion. Almost all of the techniques assessed showed high economic rates of return and financial rates of return of 10 percent and more. However, the pitfalls of attempting to introduce such techniques on a wide scale are also evident in these data. A few, such as stone-faced terracing and improvements of grazing reserves, are either unprofitable or only marginally profitable. Moreover, even a financial rate of return of 10 or 15 percent may not be sufficient to induce investment by farmers whose private discount rates are likely to be as high as 25 percent and more because of the high uncertainties and distorted markets they face. However, as the costs of soil degradation and erosion rise, as labor availability increases, as economic policy renders agriculture more profitable, the financial returns to these measures will increase. Knowledge transfers through extension workers will find an increasingly favorable reception by farmers as these changes occur. This is evident in the Kenya and Burkina Faso cases reported above, in farmer investment in stone terracing and tree planting in Ethiopia, and in windbreak establishment to protect millet fields in Niger (FAO/ECA, 1992, pp. 10-11).

(ii) Water Management

8.21 Highly variable rainfall in many parts of Sub-Saharan Africa makes water conservation vital, particularly in semi-arid areas and where dry spells are frequent. In the Sahelo-Sudanian zone in particular, moisture deficiencies pose the primary constraint on cropping, and effective water management is critical to reduce erosive and wasteful runoff and to maximize water infiltration into the soil. In most settings, in-situ water management through improved infiltration and moisture conservation is likely to be far less costly, more effective and less stressful for the environment than the construction of water harvesting and storage structures. Many techniques recommended to combat soil erosion (such as contour farming, establishing vegetative contour strips, intercropping, ridging) are also extremely useful for in-situ moisture conservation.

8.22 However, under certain conditions (notably in low-rainfall areas), water harvesting techniques may be both necessary and effective. Water harvesting involves the collection and utilization of runoff for farming or other uses. A very common form of water harvesting involves collecting runoff from a large area by means of earthen or stone bunds and guiding it through ditches or channels on to smaller areas where field crops or trees are grown. Another common traditional technique is waterspreading: diverting runoff from seasonal streams or gullies to cultivated fields. By increasing the quantity of water available on cultivated land, these and other water harvesting techniques greatly improve land productivity; they usually require little capital and are labor-using. Water harvesting has proved effective and successful, for example, in Burkina Faso's Yatenga Region and in Kenya's Baringo District.[9]

8.23 Only about 5 million ha are irrigated in Sub-Saharan Africa today,[10] about half by modern means and the rest by traditional small-scale methods. The additional area potentially suitable for

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[9] See Reij, Mulder and Begemann (1988) for an extensive review of technical, environmental, agronomic, economic and sociological aspects of water harvesting.

[10] Only three countries -- Sudan (1.75 million ha), Madagascar (0.96 million ha) and Nigeria (0.85 million ha) -- account for more than 70 percent of this total (Barghouti and Le Moigne, 1990, p. 7).

irrigation is estimated at about 15 million ha (Barghouti and Le Moigne, 1990, pp. 9 & 13) -- not much in terms of Sub-Saharan Africa's total potential arable land area. Topography, soil characteristics and high water losses due to evapotranspiration from water storage facilities pose significant constraints to irrigation development. Moreover, irrigation development in many parts of the continent would entail very high environmental costs in terms of increased threats from water-related human diseases and of irreversible damage to ecologically valuable floodplain ecosystems (*ibid.*, p. 13). Nevertheless, in a number of countries -- notably those of the Sahel, but also Ethiopia, Malawi, Nigeria and Uganda -- irrigation development holds considerable promise for improving the productivity of farm land in a manner consistent with resource conservation objectives.

8.24 The emphasis should lie on individually or communally managed systems with development costs of US$2,000 per ha or less, which can be developed and maintained by individual farmers themselves or by farmers' groups. Such low-cost schemes include irrigation from wells or pumps, controlled flooding, and small-scale development of inland valleys and flood plains. Such developments have often spread spontaneously. Good examples are the private small-scale schemes developed by Mauritanian farmers in the Senegal valley, the rapidly spreading development of small groundwater irrigation systems in northern Nigeria's *fadama* areas (alluvial river valley bottoms), and shallow aquifer exploitation with low-cost tubewells and pumps in Chad and Niger (Brown and Nooter, 1992).[11]

(iii) Livestock Production and Utilization

8.25 Mixed farming systems, combining crop and livestock activities, show promise in meeting environmental sustainability criteria. Farm animals are an important link for recycling resources within the farming system and, in the case of draft animals, represent a major step towards farming system intensification and, through the provision of transport services, market orientation. Indeed, the largely unutilized potential for using animal traction in both farm operations and transport needs to be realized. Cattle acquisition and maintenance involve considerable capital expenditure, however, and are therefore likely to be feasible only for relatively better-endowed households. In any case, switching to animal draft power becomes economical only when the cost of hoe cultivation exceeds the cost of the transition to animal power. This usually happens only with the emergence of continuous cultivation.[12] Moreover, animal traction is generally adopted first to provide transport services, and only later for purposes of land preparation (Pingali *et al.*, 1987). Maintaining draft animals will not be economically attractive to farmers if their sole use is in land preparation. This suggests that developing rural transport infrastructure -- roads, tracks and trails suitable for animal-powered traffic -- is important to accelerate the incorporation of draft animals on a wide scale into rural economies and farming systems. Upgrading rural transport activities -- the movement of farm inputs and output, fuelwood, construction materials and water -- from headloading to animal-powered means, will greatly reduce the pressure on women's time.

8.26 Nevertheless, there is good potential for greater incorporation of livestock components into farming systems. In many mountainous areas, this process is already well underway. Approaches and solutions will vary. The full potential of sheep, goats, pigs and poultry has not been exploited in much of SSA. Small ruminants, especially if herded together, are very efficient users of a wide variety of

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[11] Brown and Nooter (1992) review a number of successful small-scale irrigation schemes in the Sahel and identify several common characteristics: simple and low-cost technology; private and individual institutional arrangements; adequate infrastructure to facilitate access to inputs and output markets; active farmer participation in project design and implementation; and high financial (cash) returns to the farmer.

[12] The switch from hoe to plow tillage is usually motivated by the desire to expand the area cultivated or to economize on the labor required for land preparation (Pingali *et al.*, 1987, p. 104).

forage and browse resources. They are less restricted by seasonal variations in feed resources and maintain their body weight far better throughout the year than cattle. They also withstand the effects of drought, even a prolonged one, and recover far more quickly from its impact than do cattle (FAO, 1991, pp. 28-36). Goats, pigs and poultry are likely to be more easily integrated into farm operations managed by women, because they tend to stay near the compound. Sheep present a different management issue because they require herding (and this may have implications for boys' school attendance).

8.27 In humid and sub-humid zones, the tsetse fly can be controlled (although not eradicated) through low-cost traps and spraying. Priorities for promoting the integration of cattle into farming systems should be to popularize cattle breeds such as the N'Dama which are tolerant to trypanosomiasis and at the same time to develop transport and farm equipment which such animals can power. In the sub-humid zone, where cattle are concentrated, it will also be important to develop fodder banks to provide feed reserves for the dry season; analysis in Nigeria has shown this to be potentially quite profitable (Table 24).

8.28 In the drier cultivated zones, the integration of cattle into sedentary crop farmers' production systems will generate increasing pressure on the available pasture and forage resources, leading to stiffer competition and potential conflicts with transhumant pastoralists whose herds graze on crop stubble and bushy fallows during the dry season. The pastoralists' difficulties are further exacerbated by the increasing development of river valley bottoms in many parts of the Sahel and Sudan for cropping, often year-round by means of small-scale irrigation facilities, because this closes off essential migration routes and feed resources for their herds during the dry season. Improved land allocation between pastoralists and farmers to permit both to survive would be desirable, but no effective means of achieving this has been found as yet. Better land use planning and appropriate land tenure arrangements would be needed.

8.29 Traditional pastoralists are very efficient users of the meager rangeland resources in the arid and semi-arid zones. They possess enormous knowledge and understanding of the desert and savanna ecologies in which they live and upon which their economies depend. Their husbandry of land, water, plant and animal resources and their migratory movements are highly skilled, complex and organized, reflecting generations of careful observation, experimentation and adaptation. Their livestock production systems are, as recent studies have demonstrated, extremely productive. They utilize the marginal resources to which they have access not only very efficiently, but also in a manner that is environmentally sustainable over time. Traditional pastoralists produce as much protein per hectare as do ranches in areas with similar rainfall in Australia and the United States -- but with vastly lower capital inputs (Bass, 1990; Odhiambo, 1991, pp. 79-80; Independent Commission on International Humanitarian Issues, 1985).

8.30 But the potential for increasing the output and productivity of pastoralist production systems is low. Moreover, the most critical aspect of their traditional resource management system -- mobility -- is under increasing pressure as sedentary farmers appropriate land resources for cropping, close off vital migration routes and seasonal feed sources, and lay claim to scarce water resources. Forcible (and often violent) prevention of herd movement across national borders as well as armed raids on herds to procure food supplies for rival factions in civil wars further threaten pastoralists' production systems and way of life. Overgrazing is acute around public waterholes and urban centers and a major cause of environmental degradation. In these regions, water resource development and utilization require a refocusing of efforts to develop a network of more widely dispersed wells tapping shallow aquifers. At the same time, water and range resources should be placed under local communities' control and management to help prevent excessive concentration of livestock.[13] Integrated water/livestock/forestry

[13] This argument is well developed in Shanmugaratnam *et al.* (1992).

management is required instead of investment and policy efforts which stress one objective to the detriment of overall efficiency and/or environmental sustainability.

Kenya's Turkana District: Lessons Learned

In Kenya's Turkana District, these and other costly lessons from previous failed interventions appear to have been heeded. Young Turkana men have been trained as para-vets and are moving among the pastoralists as "livestock scouts" to promote improved husbandry methods and sell veterinary medicines. Mobile veterinary extension units have succeeded in sharply raising the percentage of vaccinated animals. Oxfam gave (on grant or loan basis) small herds of goats and sheep to families who had lost their herds to help them get started again in their traditional way of life. NORAD has funded a scheme to market livestock in Nairobi and other urban centers where demand for meat has been rising. Thousands of trees (especially *Acacia tortilis*, an important source of fodder, food and fuelwood) have been planted by the Turkana themselves with the help of NORAD in an effort to offset tree losses suffered as a result of drought and of changes in the hydrology along the Turwel river brought about by water abstraction for irrigation schemes. And many Turkana have established small farms, utilizing water harvesting techniques taught to them by extension workers, to grow some crops for their own use (Harden, 1990, pp. 205-208).

8.31 To improve the incentives for livestock production, the linkages from rural producers to urban consumers of meat and milk need to be strengthened. Several countries in Sub-Saharan Africa, including Kenya and Tanzania, are now developing cooperative dairy collection and marketing systems, similar in some respects to the highly successful Indian model. Other countries, such as Ghana and Nigeria, are considering to do the same. Restrictions on cross-border trade in live cattle should be eliminated to improve producer incentives and simultaneously consumer access to meat. Private abattoirs should be licensed (and regularly inspected) to provide market outlets for livestock producers and to serve urban concentrations of demand for meat. The provision of veterinary services should be increasingly left to the private sector. National animal health services should concentrate on regulating private veterinarians, organizing and subsidizing mass vaccinations, and responding to emergency situations. In the more remote pastoral areas, improved livestock care should be provided through "para-vets" who could be compensated for their work through commissions on veterinary drug sales. In all areas, agricultural extension workers should be made fully competent in improved animal husbandry, forage production and animal traction.

(iv) Inputs

Indigenous Pest Control Practices in The Gambia

Harvested cowpeas are steamed or stored in oil, ash or chilies to repel cowpea weevils. Broadcasting wood ash on plants, especially vegetables, is widely practiced to deter insect pests. Fresh cow dung, bran or green baobab fruit are used to lure insects to a site away from the field, where they are killed by burning or burying. Burning of blister beetles is reported to produce an odor that repels other blister beetles. Dried *neem* tree berries are pounded and used as seed dressing to ward off field pests (Norem *et al.*, 1988, p. 311).

8.32 For environmental as well as cost reasons, the use of organic fertilizers should be emphasized. The integration of livestock into farmers' production systems is especially important in this regard. Similarly, disease and pest control efforts should emphasize cultural and biological controls.[14] To support this, subsidies on inorganic fertilizers and pesticides should be drastically reduced, if not removed entirely.[15] Needed are pest- and disease-resistant varieties, as well as cultivation methods and intercropping and crop rotation systems that reduce the spread of pests and diseases. Some positive results in this field have been achieved, for example, by the

[14] Greathead and Waage (1983) discuss various possibilities for biological control of agricultural pests, and substantial research findings have been accumulated since then. See also Kiss and Meerman (1991), Singh (1990) and Odhiambo (1991).

[15] On environmental grounds, a case might be made in certain settings for some degree of temporary subsidization of chemical fertilizers in order to induce more farmers to use this input to maintain soil fertility.

International Institute of Tropical Agriculture (IITA). Integrated pest management (IPM) programs for rice and other tropical crops have been developed that minimize the need for chemical pesticides. Yet many governments continue to provide substantial subsidies on chemical pesticides that reduce farmers' incentives to adopt such techniques. Past efforts at biocontrol of pests have focused on predators and parasitoids of insects, but research is now also being directed at the development of biopesticides to replace chemical pesticides and of plant pathogens to replace herbicides. Research in all these areas deserves strong donor support.

Research in Integrated Pest Management (IPM): Some Examples

The International Centre of Insect Physiology and Ecology (ICIPE) in Kenya is working on various techniques that would eliminate the threat of periodic devastating invasions of desert locusts into Sahelian farming regions. Work is ongoing, for example, to utilize the locust's natural enemies (parasitoids and pathogens) and, more importantly, to use pheromones to control the locusts' gregarization and sexual maturation and thereby prevent the emergence of marauding locust swarms while ensuring the locust's continuing existence as an important part of the African savanna ecosystems (Odhiambo, 1991, p. 81).

The International Institute of Biological Control (IIBC), an affiliate of CAB International conducting research and development work in IPM, is exploring the use of pathogens and the development of bio-pesticides to replace chemical pesticides and of plant pathogens rather than herbicides to combat weeds. Fungi sprays are being tested, in collaboration with IITA, under Sahelian conditions to ascertain their utility in controlling locusts. In collaboration with the Département de Formation en Protection des Végétaux of Niger, a fungal pathogen effective against desert locusts is being tested, along with strains from Pakistan, for incorporation into formulations for field trials. And, based on the confirmed key role of predatory ants and beatles against the *Helicoverpas armigera* moth, local IPM techniques are being developed to combat moths which attack cotton, sunflower and other African crops (CAB International, 1991).

8.33 Chemical fertilizers and pesticides will be important, even essential, components of intensified cropping systems. But they are costly in terms of foreign exchange, and their subsidization discourages the use of available and less expensive alternatives. Policy and infrastructure constraints to the use of chemical farm inputs need to be removed, however. There are no gains to be obtained from shifting to a rigid anti-chemicals bias in agricultural policy.

8.34 More efficient tools and equipment are essential to raise the productivity of farm labor (see also para. 5.31). Particularly useful are implements that can be locally manufactured (preferably from locally available materials), are cheap, require little maintenance and are easy to use. There is a tremendous need throughout much of rural Africa for more efficient tools for land preparation, planting, weeding, harvesting and crop processing, as also for small carts, wheelbarrows, bicycles and other locally suitable transport aids. Efforts to develop, adapt and disseminate such technology have been largely confined to non-governmental organizations (NGOs). Research and extension programs need to place far greater emphasis on these aspects of rural technology development and dissemination, drawing on the experiences of NGOs and collaborating with them. The production and marketing of such technology are obvious areas for promoting the development of a viable local artisanal and small-scale industrial sector.

(v) Agro-Forestry

8.35 From an environmental and agricultural perspective, agro-forestry holds high promise. There are a variety of techniques and approaches for different agro-ecological conditions and production systems which can increase farm productivity and incomes and simultaneously improve the prospects for environmental sustainability of rural production systems (Nair, 1990). Indeed, a multitude of agro-forestry systems and practices are already in use in different parts of Sub-Saharan Africa (Cook and Grut, 1989). Utilizing indigenous trees and shrubs, these are appropriate, low-cost, low-risk and high-return means for maintaining soil fertility, improving soil structure, recycling water and nutrients from lower soil strata, combating soil erosion, and providing secure supplies of fuel, fruits, fodder, mulches, building

and fencing materials, and the like.[16] Increased supply of tree products from agro-forestry will also help preserve the remaining forest resources.

8.36 Whether agro-forestry efforts should be based on individual or some form of communal planting will need to be determined at each site and with each community. Farm forestry is likely to be more readily incorporated by farmers into their production system in densely populated areas where common forests are no longer available and wood needs must be met from the farm or where wood fetches a good market price. This is already happening in parts of East Africa: there may now be more trees in Rwanda than at independence, even though the natural forests have all but disappeared.

8.37 If trees are to play a greater role in soil conservation and agricultural production, it must be on farmed land -- through farmers' agro-forestry activities on their own land. This can take many forms: shade trees in and around living areas; live (wood-producing) fences replacing dead (wood-consuming) fences around fields and homesteads; and trees and shrubs planted very closely in lines along the contours of sloped fields to prevent soil erosion. Cocoa, coffee, rubber and tea are valuable not only as cash crops, but also as environmentally important components in agro-forestry systems. More species should be added, especially trees that produce fruit, nuts or fodder. Trees can diversify the basis of food production. In semi-arid areas where wind is a threat to farming through desiccation or eolian erosion, windbreaks can be very beneficial. Appropriately designed and managed multipurpose windbreaks of mixed species and heights are particularly attractive, since they will also yield sustainable flows of fuelwood and/or other tree products for the local people.[17]

8.38 In humid areas, multi-story farming may be desirable, in which various trees, shrubs and crops of different heights are intercropped to provide total and continuous ground cover and a variety of micro-climates (see also para. 8.14, footnote 3). In humid and sub-humid areas, alley-cropping -- a variation of traditional agro-forestry practices adapted to sedentary farming -- may be effective and adopted by farmers, if the labor requirements involved can be made to fit actual on-farm labor availability. Crops are grown in 4-8 m alleys between rows of leguminous trees such as *Leucaena* or *Gliricidia*, with the prunings providing fuelwood, stakes and fodder, or nitrogen-rich mulch for fertilizer.

8.39 Agro-forestry systems also hold considerable promise in the context of buffer zone development around environmentally valuable forest stands that should remain under protection (see para. 10.15).

8.40 Farmers will not invest in agro-forestry unless there are adequate incentives at the farm level to produce trees for own use or for the market. The emergence of such incentives depends on a

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[16] The presence of *Acacia albida*, a leguminous tree often found in fields sown to millet, sorghum or groundnut in much of the Sahelo-Sudanian Zone, consistently increases the yield of the associated field crops. The tree has many appealing features. A particularly important one is that it sheds its foliage during the rainy season and therefore does not compete with crops for light and moisture. The tree provides ample shade during the dry, hot season, and its leaf litter provides nitrogen and organic matter to farmers' fields. Yields have been found to be about twice as high under the trees as they are beyond its crown. Each tree also supplies about 75-125 kg of nutritious pods per year for livestock feed (Gritzner, 1988, p. 99).

[17] CARE began the Majjia Valley Windbreak Project in Niger in 1975. Farmers have now established some 350 km of windbreaks to protect about 3,000 ha of rainfed millet and sorghum fields. Crop yields in protected fields have been 15 to 23 percent higher than in neighboring unprotected fields.– Once fully established, the annual sustainable yield of firewood from the *Azadirachta indica* used in these windbreaks is about 5 kg per tree. Spaced 4 m apart, 400 m of double-row windbreaks provide 1 ton of fuelwood annually (Nair, 1990, p. 45). The seed pods of *Acacia scorpioides*, also used in windbreaks in Niger, are sold for use in leather tanning (*ibid.*, p. 45).

combination of factors.[18] Climate, stage of deforestation, institutional arrangements, tenurial conditions, effectiveness of forestry extension and other factors all are important (Barnes, 1990a; 1990b) -- along with pricing. If trees are to be grown for sale as fuelwood or construction material, it must be profitable. Such incentives are gradually emerging. As populations grow and trees are felled, fuelwood becomes scarcer. Although this scarcity creates a market value for fuelwood, this market has been developing too slowly, for the reasons discussed earlier. The development of fuelwood markets will be accelerated if: cutting in protected forest areas is restricted; farmers are not restricted or licensed/taxed in marketing fuelwood they produce on their farms; nurseries are established to produce appropriate species; research and extension services incorporate tree farming as a major theme; and land tenure reform provides ownership of forests to farmers and local communities so that they are more likely to invest in forests rather than merely mine them for fuelwood. If appropriate price signals are to be developed, fuelwood must not be obtainable as a free good. Provided the appropriate species are used, agro-forestry techniques can, however, be very profitable in many areas because of their potential to generate a combination of benefits (fuelwood, poles, fodder, fruits, and associated crop yield increases).

8.41 Economic pricing of woodfuels is critical to encourage conservation and interfuel substitution. Pricing policies based on taxing incoming supplies would encourage economies in the use of woodfuels in urban areas (UNDP/World Bank ESMAP, 1988). Such policies can also provide a way to raise revenues that could be used to improve the forestry services (Falloux and Mukendi, 1988). Higher taxes could be levied on fuelwood coming from open access areas and lower taxes on fuelwood coming from wood plantations and private plots.

8.42 In many regions, there are significant socio-cultural obstacles to widespread tree farming, at least in the short run. In Kenya's Kakamega District, for example, women are not allowed to plant trees because this would undermine their husbands' authority; they are subjected to superstitious threats of barrenness or the death of their husbands (Aloo, 1985, p. 28). In many communities, trees have rarely been deliberately planted -- even where their utility is recognized and they are protected and prized for their contribution to livelihood systems. Trees may in fact be regarded as an obstacle to crop cultivation, especially where tenurial considerations (such as separation of usufructual rights to land and to trees) or technology aspects (such as animal or mechanized ploughing) are important. In some countries, because all forest land is owned by the state, people fear that if they plant trees their land will revert to the government. In parts of the Sahel, farmers are unwilling to plant certain trees because they are on the forest department's protected list, and to crop or prune them would require going through tedious procedures to prove they own the land and planted the trees and to obtain a cutting permit (Timberlake, 1986, p. 56).

8.43 It is important to involve the local women in any projects that concern fuelwood production, provision and use. Men and women almost always have vastly different views concerning the utility of community or farm forestry activities (Molnar and Schreiber, 1989). In Senegal, the men in the village

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[18] Even transhumant livestock herders will plant trees if they face the right incentives (notably clear economic benefits and uncontested resource ownership) and if the establishment and management techniques are suitable to their means and lifestyles. In Kenya's arid Turkana district, the Turkana have long depended on the riverine forests along the Turkwel river for fodder, fuel, food and other uses. These forests provide the Turkana with an important source of fodder for their herds in dry seasons and especially in drought years. Individual families own the user rights to each individual tree, *Acacia tortilis* with its long tap root and ample production of edible pods being the most important. Prolonged drought and irrigation and fishing schemes along the river had significantly reduced the number and productivity of trees by 1984 when NORAD began to assist the Kenya Forestry Department in seeking ways to conserve the woodlands in Turkana District. Well aware of the value of these trees for their herds' and their own survival, the Turkana dug thousands of planting pits with micro-catchments around them and planted *A. tortilis* in the next few years and made sure they were not destroyed by foraging herds (Harden, 1990, p. 206).

councils planned to sell as poles the timber from community woodlots, which had in fact been established to provide fuelwood for local households and to reduce local women's work load (Dankelman and Davidson, 1988, p. 54). Where women are actively involved, chances of success are high. In The Gambia, for example, the National Women's Bureau and the Forestry Department promoted the establishment of woodlots-cum-orchards managed by village women's groups, and these are now producing locally significant quantities of fruits and vegetables as well as fuelwood (Marenha, 1985, p. 56; Dankelman and Davidson, 1988, p. 21). Where women face traditional restrictions concerning the planting of trees, careful investigation may reveal possibilities, acceptable under local norms, to plant certain species of brush that are suitable for fodder and fuel.

8.44 Several successful programs in Kenya are based on strong involvement of local women. One of the best known and most successful non-governmental afforestation programs is the Green Belt Movement, started in 1977 by the National Council of Women of Kenya (Maathai, 1988). Another successful program is that of the Kenya Energy Non-Governmental Organization (KENGO), an association of over 200 NGOs dealing with energy issues, which includes a number of women's groups and organizations. KENGO is active in the promotion of fuel-saving stoves as well as in reforestation with indigenous trees. Information on medical, cultural, ecological and economic values of trees is collected from local women and passed on to women's groups through workshops, exhibitions, mass media, pamphlets and posters. The Kenya Woodfuel Development Programme promotes a self-sustaining system of tree planting to supply fuelwood. Based on surveys of agroforestry practices and cultural background of local people, its approach accommodates indigenous expertise with traditional beliefs and taboos. Women are especially encouraged to develop solutions that will not conflict with traditional values (Chavangi, Engelhard and Jones, 1985; Leach and Mearns, 1988, pp. 142-145).

(vi) Stoves that Save Fuel and Women's Time

8.45 A second major effort to address the fuelwood and household energy problems has been aimed at improving the efficiency of energy use: slowing the rise in fuelwood consumption by introducing more fuel-efficient wood and charcoal stoves or stoves using non-wood energy sources (e.g., solar cookers). Most rural African women cook on some version of the three-stone stove or on other simple stoves with an energy efficiency of 10 percent or less. Various technical improvements have been advanced, tested, promoted -- and in most cases not adopted by the women for whom they were meant. On the whole, little headway had been made by the mid-1980s: few programs had distributed more than 5,000-8,000 stoves (WRI/IIED, 1987). But there have been exceptions -- such as KENGO's program in Kenya (see box) and the *Mai Sanki* stove program in Niger (see para. 8.47).

The Stove Program in Burkina Faso

A promising possibility for poor and scattered rural populations is indicated by the stove program in Burkina Faso. Based on a design developed at the Burkina Energy Institute, the stove is basically a shielded traditional three-stone stove, with a circular shield or shell built of clay, dung, millet chaff and water around three stones that support the pot. A woman can build the stove in half a day to fit any desired pot size; the simple design and construction method require only half a day's training. There are no cash costs. Fuel savings range from 35 to 70 percent. Most women recoup the investment of a day's training and labor within one or two weeks through savings in fuelwood. By April 1986, some 85,000 improved three-stone stoves were in use (WRI/IIED, 1987, pp. 232-233).

8.46 The reasons for failure have varied. The driving motive of those developing and promoting new stoves has usually been to save fuel, but women in the "target population" have often had a number of other, and frequently overriding, concerns which the designs proffered did not address to their satisfaction. Women in some villages in Mali responded poorly to cookstove programs because their perceptions of their time constraints differed from those of the program planners. These women

considered the time required for food preparation and cooking to be more burdensome than the time needed to collect fuel; they preferred a stove that would reduce cooking time, rather than save fuel (Molnar, 1989, p. 41). Cultural and dietary reasons are important, as are cost, local availability of materials, convenience of use, cooking time, suitability for local cooking implements and utensils, suitability for different fuels and a variety of other factors. Women may be averse to cooking outside. The stove's capacity may be too small to cook for large families or to prepare several dishes simultaneously. Solar cookers are useless in the evening when meals are prepared. Stoves may be used not only for cooking, but also heating; etc. (M. Carr, 1985, pp. 133-134). Other important reasons for non-adoption include: unaffordable cost; drastic changes required in cooking habits and cultural taboos; design inappropriate to multiple purposes, including water heating, space heating, and smoke generation to repel insects under house roof. Complications also tend to arise because it is often men who buy the stoves while women operate them (Elnur, 1985, p. 36).

The Kenya Renewable Energy Development Project

This project, launched with support from USAID in 1982, sought to sell or give away 5,000 stoves by the end of 1986. By the end of 1985 it had spawned a new industry whose main producers alone had sold 110,000 improved stoves at a profit. They had captured a large slice of the market previously dominated by the cheap one-unit-a-year *jikos*, scrap-metal charcoal stoves with a fuel efficiency of about 19 percent. The new stove was designed to compete directly with these traditional ones. Local participation in the design was extensive: scrap-metal artisans were consulted to ensure easy manufacture, and prototypes were tested in 600 households to ensure acceptability. The final design comprises a scrap-metal casing, waisted for stability, with an insulating ceramic liner, a grate in the top half, and an ash chamber at the bottom. The other main reason for success is the stove's very favorable cost-benefit ratio: it costs more, but lasts longer than the old stove, resulting in actual savings over two years. Its measured fuel efficiency is 29-30 percent, theoretically offering fuel savings of 34-37 percent, but many users reported savings of up to 50 percent (probably due to more careful fuel use). For the average user family in Nairobi, the stove paid for itself within eight weeks and provided an annual return of up to 1,000 percent on the investment (WRI/IIED, 1987, p. 232).

8.47 Stove promotion efforts must begin with careful studies of local dietary and cooking habits and practices. It is particularly important to involve women from the start. In the Sahel, simmered stews are the mainstay of the diet, and a lot of wood is used to prepare these on a three-stone stove. Whatever replacement is recommended, it must meet a number of conditions (e.g., suitability for cooking practices, affordability, transportability, repairability, replaceability, smoke may be desirable, etc.) Successful programs which involved the targeted women from the inception of the program include: KENGO's cookstove projects (the ceramic *Jiko* and the *Kuni Mbili* stoves) in Kenya, supported by USAID's Renewable Energy Development Project; the Women and Energy Project initiated in 1984 with GTZ-support by Maendeleo Ya Wanawake in Kenya;[19] the ILO/World Bank Stoves Feasibility Project in Ethiopia which focused on urban women in Addis Ababa; the *Ban-ak-Suuf* stoves program in Senegal; the program in Burkina Faso based on the stove design of the Burkina Energy Institute; and the portable metal *Mai Sanki* stove in Niger.[20]

8.48 For urban users, reliable, economically accessible and appropriately priced alternative energy sources, such as kerosene and liquefied petroleum gas (LPG), must be developed. Low-income urban users may need assistance with appropriate credit schemes to purchase stoves and appliances which use these fuels.

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[19] Under this project, local women are trained to construct low-cost one- and two-pot woodburning stoves with clay liners, which use considerably less wood and allow the kitchen area to be kept much cleaner. This is backed up with training in agro-forestry techniques and the establishment of nurseries and fuelwood plantations by village women's groups (Dankelman and Davidson, 1988, pp. 85-86).

[20] 40,000 of these stoves have been produced and sold, and users have been able to reduce their expenditure on fuelwood by 30 percent, thus recovering the cost of the stove in two months.

B. Policy and Institutional Aspects

8.49 Although environmentally benign technologies of the kind discussed here have been tested widely and successfully in Sub-Saharan Africa, they have generally not been adopted by large numbers of farmers. The "imported" technologies involving fertilizers, pesticides and herbicides, HYVs and farm mechanization have not fared much better. The reasons for non-adoption vary, but the basic problem has almost always been a poor fit with the resources available to farmers, combined with farmers' risk aversion. Inappropriate price, tax and exchange rate policies, inadequate rural infrastructure, inefficient marketing systems, and poor agricultural support services have all contributed to keeping resources out of the reach of farmers and to increasing the risks inherent in innovation. In this situation, and as long as uncultivated land remained available for clearing and cultivation, it made sense to farmers to cultivate new land rather than to use more labor-intensive and/or financially costly production methods. This continues to be the case in much of Sub-Saharan Africa.

8.50 These problems have been more apparent with respect to "imported" technologies -- not only because these have tended to be the ones promoted most actively by governments and aid agencies alike, but also because these technologies have tended to require significant departures from familiar resource management and production techniques and in relative factor utilization. Placing greater emphasis on improving and adapting the types of techniques discussed above should considerably lower the adoption threshold. But a number of measures will be necessary to create a policy and institutional environment that is conducive, rather than inimical, to agricultural intensification and resource conservation.

8.51 Farmers require incentives and assistance to adopt yield-enhancing and soil-conserving technologies. Sustainable farming must be made profitable -- and environmentally unsustainable practices must be made unprofitable. To promote the switch to environmentally sustainable farming, the cost of resource degradation and destruction must be increasingly shifted to farmers instead of being borne entirely by society at large and, in effect, by future generations. Privatizing the social costs of resource-depleting farming practices will discourage their use. Government policy must be such as to permit farmers to profit from switching to sustainable agriculture and to incur obvious costs if environmentally destructive methods are used. The major tools for this are: (a) land tenure reform, (b) economic policy that increases the profitability of market-oriented farming, and (c) agricultural services which help farmers through the transition to sustainable agriculture.

(i) Land Policy and Tenure Reform

8.52 It is essential to ensure the security of land tenure -- to halt the erosion of security traditionally provided by customary tenure systems. Secure rights to land (individual or communal) are necessary to encourage management practices and investments that ensure sustainable use of a fragile natural resource base. Over time, population pressure and agricultural intensification will make formal land titling necessary. The administrative machinery for land titling needs to be established to permit those seeking titles to obtain them. The transition to full land titling will require more than a decade to achieve in most countries of Sub-Saharan Africa and should be undertaken only in response to demand from below, not as an imposition from above. In the interim, respect for traditional tenure systems needs to be codified. Judicial mechanisms for dealing with disputes between owners claiming traditional versus modern land rights are needed. Land laws and regulations should respect traditional tenure systems, permitting modern titles only when land is fairly purchased or acquired with the agreement of traditional owners. Women's tenurial/usufructual rights must be safeguarded, if not enhanced. Titles provided to groups for collective ownership should also be available. Kenya has begun this by providing land titles to group-owned ranches, with groups organized by clan. French aid projects and the World Bank are planning to experiment with community titles in several of the Sahelian countries. Governments should

divest themselves of most land, except parks, to individual or community owners. This would be a first step in inducing farmer landowners to conserve the land. Where such divestiture is impossible -- because, for example, of the breakdown of traditional communities due to large-scale migration -- Governments might retain state ownership but provide legally protected use rights to local inhabitants.

8.53 Local people and communities must be given a direct and tangible interest in the sustainable management of ranges and woodlands and in the conservation of forests and wildlife. Communities cannot be effective at managing their natural resources unless their authority is clearly established and recognized. In particular, the appropriateness of statutes vesting residual control over all land in the state should be re-examined. In return for legal title, the populations of forest and range lands must accept obligations for proper management of these areas. Economic incentives to conserve could be strengthened by allocating the benefits of forests and pastures to local populations in the form of logging, hunting and gathering rights in forest areas and exclusive grazing rights in pasture areas. Opening up new land for cropping in certain areas might be made subject to heavy land taxes. Only by involving the local people as full partners in conservation, with appropriate incentives, will conservation occur.

(ii) Agricultural Support Services

8.54 Sub-Saharan Africa urgently needs farm technology development and dissemination mechanisms that are effective: agricultural research, extension, education, and farm input supply. Each of these activities will have to incorporate the soil conservation, fertility management, agro-forestry, pest management and environmentally sustainable farming techniques identified above. Not many of these services are working well today anywhere in Sub-Saharan Africa, and virtually none are competent as yet in environmentally sustainable agriculture.

Research Impact on Agricultural Productivity

The success of new crop varieties introduced into SSA in the past 30 years has been limited. Rice in a few parts of West Africa, hybrid maize in parts of Ghana, Kenya, Nigeria, Zambia and Zimbabwe and, more recently, cassava varieties developed by IITA are among the few success stories of yield-increasing varietal improvements adopted by farmers. Productivity in tea production has risen impressively in Kenya, Burundi and Rwanda. Maize yields have increased in Benin and Gabon, and cotton has done well in much of francophone West Africa, Swaziland and Zimbabwe. Coconut in Côte d'Ivoire, oil palm in Zaire, and control of coffee berry disease in Ethiopia and Kenya are other examples of positive research impact on production. Yield increases implied in aggregate data for sorghum and groundnuts, on the other hand, appear to be due to acreage reductions (abandonment of less suitable land and switching of unproductive farmers to other crops), rather than of technological improvements (Lipton and Longhurst, 1985; World Bank, 1987c; 1987d; 1989d.)

8.55 Although there are success stories, agricultural research in Sub-Saharan Africa has, on the whole, not performed well. This has been largely because of weak government commitment and poor management, rather than inadequate funding. Externally financed projects have not provided the needed breakthrough as yet. To develop, test and adapt technologies of the kind identified above, national agricultural research systems (NARSs) must be rehabilitated and given work programs relevant to the task. Most important will be strengthening national capacity to plan, manage and carry out research focused on the issues identified above. Research as well as research management skills need to be developed. Faculties of agriculture, NGOs and the private sector should be drawn into the effort. Aid donors should coordinate their activities so that external aid strengthens national agricultural research systems in this endeavor.

8.56 Agricultural research in and for Sub-Saharan Africa needs to focus on the conditions and constraints that prevail in Sub-Saharan Africa and that determine the production environment of farmers in Sub-Saharan Africa. Direct application of "off-the-shelf" technology imported from other regions has rarely proved successful. As already noted, African soils need careful management, rainfall is

Special Considerations Governing Agricultural Research in Sub-Saharan Africa

A 1987 review by the World Bank of agricultural research in Eastern and Southern Africa (World Bank, 1987c) noted that the impact of agricultural research on economic growth had been less than that experienced elsewhere because of a number of particular characteristics of Sub-Saharan Africa:

- The relative insignificance of irrigation and the large agro-ecological diversity in rainfed farming in SSA.
- The hostile physical environment (droughts, fragile soils) and the more complex systems of farming which African farmers employ to diminish risks and conserve fertility.
- The relative shortage of labor at peak periods of demand for farm labor, which makes mechanization (not necessarily tractorization) important; at the same time, trypanosomiasis raises unique obstacles to animal power in many areas.
- Inadequate macro-economic policies, which have exacerbated deteriorating world market conditions and limited farmers' incentives to adopt new technology and expand production.
- The relatively low efficiency of agricultural support services (extension, input distribution, credit, marketing, and seed production).
- The fact that small countries find it difficult to sustain both adequate agricultural training facilities and a minimum research capacity to test and adapt imported technology to an often wide range of agro-ecological conditions.

unpredictable, the likelihood of drought in any given year is high, and dry spells may occur at any time in the growing season. Since the many different combinations of soil, elevation, slope, aspect, rainfall, temperature and solar radiation result in an enormous diversity of agro-ecological micro-environments, strong emphasis needs to be placed on location-specific adaptive research. For the same reasons, researchers need to pay far more attention to the spontaneous experimentation and adaptation of farmers themselves -- because that is where the real fine-tuning of technological innovations to farmers' complex agro-ecological and socio-economic conditions occurs (Richards, 1991; Chambers and Toulmin, 1991). The similarly vast variety of farming systems -- based not only on the local agro-ecological conditions, but just as firmly on the often poorly investigated and even more poorly understood socio-economic arrangements, institutions and traditions -- lends further weight to this requirement. The highly pronounced gender-specificity of agricultural tasks and entire farming systems in many communities is one important manifestation of this aspect. The parallel existence of individual and communal fields in many communities' land use systems is another. The frequent distinction between rights to land and rights to trees under traditional tenure systems is a third.

8.57 National research priorities must relate to the specific agro-ecological and socio-economic characteristics, production patterns and development objectives of each country. Each country needs to test and adapt technology under its own specific conditions, but it will take time to rehabilitate and develop NARSs and for these systems to introduce the concerns of sustainable agriculture into their work programs. Moreover, most countries of Sub-Saharan Africa are too small to undertake the entire range of agricultural research needed. Much of the basic and applied research on sustainable agriculture will therefore need to be undertaken at the International Agricultural Research Centers (IARCs) and to some extent by universities and research centers in the industrialized countries. Regional and international collaboration and African regional networks of researchers are needed to facilitate sharing of research results and experiments on the subjects relevant to sustainable agriculture.

8.58 The capability of national agricultural research systems to undertake multi-locational verification of international and national research findings on farmers' fields and the analysis of farmers' constraints needs to be strengthened. There is an urgent need to identify more intensive farming systems which can sustain soil fertility and structure and conserve soil moisture. Better integration of livestock and of agroforestry into farming systems will be important in this regard. Low-cost, low-risk techniques found effective in similar environments elsewhere need to be tested and, if found suitable, promoted. Agricultural scientists must learn to fit their research to farmers' real situations. An intimate

understanding of local constraints such as soil conditions, pests and diseases, moisture variation, seasonal labor shortages and the gender aspects of farming systems is essential. New crop varieties must be tested under zero- and low-input conditions and in mixed and inter-cropped situations before being recommended to farmers through the extension services. Appropriate improved drought-resistant and short-duration varieties of millet and sorghum are urgently needed. Work on these and other important indigenous food crops (roots, tubers, plantains) has long been neglected. Research on biological soil fertility maintenance, especially nitrogen fixation and the ecology of microbes in the soil, should complement soil conservation efforts (Brown and Wolf, 1985, p. 43). The enormous importance of insects -- on plant and livestock health and performance and on human health -- in most of Sub-Saharan Africa is rarely reflected in research programs;[21] neither is the need for locally effective and appropriate non-chemical pest controls and integrated pest management (see para. 8.32).

8.59 Social science research, much neglected so far, should be an integral part of adaptive research (World Bank, 1987c). In particular, Farming Systems Research (FSR) must pay far more attention to the importance of non-farm and off-farm activities and incomes in rural households. These are critical elements of such households' resource- and risk-management strategies. They also pose constraints and provide opportunities: off-farm work may preclude on-farm labor intensification, but off-farm income may allow cash expenditures not otherwise possible. Off-farm work is far more often recognized as important in the case of men -- notably when and where it involves outmigration (be it daily, seasonal, or long-term) from the village. It is also very important for women -- yet often totally ignored in rural/agricultural development planning and projects. Throughout Sub-Saharan Africa, women derive important income from such activities as beer brewing, produce marketing, non-wood forest product gathering and processing, etc., and the cash income derived from such activities is often critical for family welfare.

8.60 Extension services that effectively transfer sustainable agriculture technologies to farmers are critical. Equally essential is the need for extension services to ascertain and transmit information to researchers regarding farmers' needs, problems and constraints. Farming systems research is not likely ever to succeed in covering the vast diversity of micro-ecologies of Sub-Saharan Africa or the countless permutations of crop and tree combinations that farmers use. Extension services therefore also need to facilitate farmers' own experimentation and the transmission of such indigenous adaptations from farmer to farmer.[22] If extension services are to offer farmers the best techniques to suit their specific circumstances, they must provide "menus" of options for farmers to choose from -- rather than deliver prescriptive composite "technology packages." Farmers will then experiment to adapt research findings and extension recommendations to their own specific combination of needs and constraints. Extension services must collaborate with their respective NARSs in maintaining a continuous two-way flow of information between farmers and researchers and ensuring that research is geared to farmers' needs and meets the criteria of sustainability and profitability.

8.61 Given the high degree of gender-specificity in farming operations, the widespread prevalence of gender-segregated farming and the increasing incidence of female-headed households and female-managed farms, it is imperative that extension services be far more effectively oriented towards reaching women farmers. Steps to accomplish this have been initiated in a number of countries (see, for example, Murphy, 1989; Saito and Weidemann, 1990). They include: deployment of more female extension staff,

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[21] NARSs would gain immensely by collaborating more intensively with the International Centre of Insect Physiology and Ecology (ICIPE) in Nairobi in this respect.

[22] The International Center for Research on Women (ICRW) has reported excellent results with this approach in an extension program aimed at women farmers in Zaïre.

properly trained and equipped; use of more female contact farmers and of women's groups to facilitate the delivery of extension messages and to obtain feedback; training of extension workers to be aware of, and responsive to, women's responsibilities, needs and constraints; and adoption of special measures to reach women farmers. The latter include, for instance, timing of visits, selection of crops and impact points, and adaptation of technology messages to women's time and resource constraints, to their production objectives and risk perceptions.

8.62 Unified agricultural extension systems are more cost-effective and appropriate to farmers' needs than the multiple subsector-specific or single-commodity services currently operating in many countries, often supported by different aid donors. Such consolidation has been effected successfully in Kenya, Zimbabwe, Togo, Mali and Burkina Faso and is now being implemented in Ghana and Nigeria.

8.63 The content of agricultural education will need to change. It must focus on training for low-input, labor-intensive environmentally sustainable small-holder agriculture under tropical and sub-tropical conditions, rather than for high-input, mechanized farming more suited to temperate climates. This will require teachers competent in these fields as well as appropriate texts and other teaching materials. Most important, it will require refocusing agricultural education in most SSA countries and widening it to include natural resource and environmental concerns.

8.64 Research and extension services, along with private voluntary organizations, should be active in developing and testing prototypes of inputs and investment goods consistent with sustainable agriculture (new hand tools, animal-drawn equipment, crossbred cattle, village- or farm-level grain storage facilities, more efficient stoves, hand pumps, small-scale agricultural processing technology, trees for agro-forestry, organic fertilizers, etc.). These can subsequently be produced and distributed by the private sector.

(iii) Exchange Rate, Trade, Fiscal and Pricing Policies

8.65 Agricultural intensification requires that agricultural production be sufficiently profitable to induce and sustain this process. Profitability depends heavily on the policy environment which creates the incentives and disincentives to which farmers respond. Past government interventions have generally tended to turn the internal terms of trade against agriculture. Generally, the best policy has been found to be a relatively liberal market-based price system, with a fairly equilibrated exchange rate,[23] and open entry to marketing and processing. Price stability might be pursued in the face of international price fluctuations through a system of variable export and import duties.

8.66 There also is a need to provide positive incentives for sustainable use of natural resources and negative incentives to reduce their inefficient use and prevent their destruction. Promoting environmentally benign and sustainable agriculture may therefore require taxing of environmentally unsustainable practices. It may also be advisable for society to assume some of the costs involved in moving farmers from unsustainable to sustainable production systems -- in recognition of the socially desirable externalities involved (para. 8.10). There may be a case for selective and temporary subsidizing of such activities as tree nurseries and seedling distribution, distribution of more efficient prototype stoves, watershed stabilization and soil conservation, water harvesting and small-scale irrigation. Conversely, farm machinery powered by fossil fuels, logging, land clearing, and fuelwood extraction from public forests and woodlands should be taxed.

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[23] In the countries of the West African Sahelo-Sudanian Zone, exchange rate distortions make the recommended agricultural intensification and anti-desertification activities simply not sufficiently productive, below the 800 mm isohyet, to make their widespread adoption financially worthwhile. More realistic exchange rate regimes would make these techniques more attractive (Gorse and Steeds, 1987, pp. 31-32).

8.67 Subsidies influence decisions to employ commercially available inputs (such as chemical fertilizers, farm machinery, seedlings). The effects of subsidies on the environment can be beneficial or detrimental. Input subsidies compensate somewhat for low output prices received by farmers and, hence, may favor conservation -- at least on farms producing for the market. But artificially lowering the price of inputs through subsidization may encourage the use of economically and environmentally inappropriate technologies. For instance, excessive or inappropriate use of chemical fertilizers and pesticides, stimulated by heavy subsidies, can do much environmental harm. Temporary subsidies may be justified and beneficial for environmentally benign inputs -- to popularize a new technology. But in the long term, subsidization of any input is difficult to justify.

8.68 Subsidies for basic anti-erosion activities (especially engineering measures) are frequently advocated -- but where such policies have been implemented, they have often had very undesirable effects. Lack of subsequent maintenance, lack of local identification with the effort, and disruption of local incentive systems (e.g., wage labor markets, investment versus maintenance attitudes) have been the most common and serious problems. Moreover, as noted above, engineering measures are rarely sufficient by themselves and must be combined with changes in on-farm soil and water management practices; these latter are often ignored when attention is focused on engineering works and subsidy administration. Finally, engineering is costly and rarely the most effective technique. Even if subsidies are to be considered for such initial investments (and this may be the case in particular for common investments that may be required, such as runoff evacuation channels and water harvesting/storage structures), the modalities and effects of subsidization must be carefully thought through in all their consequences.

(iv) Local Institutions: Involving the People

8.69 If farmers are to innovate and adopt sustainable agricultural production and resource management techniques, they must be given more responsibility for their own affairs. They should be allowed to associate freely in farmer-managed cooperatives and groups, to market their own produce, to own and manage their land. Tenurial security must be ensured. People will only cooperate in environmental resource conservation efforts if they have a stake in the resources to be conserved and incentives to manage their environment more prudently. Administrative regulations will not suffice -- even if enforcement mechanisms were to be substantially strengthened. Responsibility and authority to manage range land should be vested with pastoral associations. Forest dwellers should be given responsibility to manage the forests where they live and where they should be assured of priority, or even exclusive, rights to hunt, gather and carry out artisanal logging. In return, they should be entrusted with the obligation and requisite authority to protect these forests against farmer encroachment, poaching and illegal logging and fuelwood extraction. If the state is less intrusive and local people are given greater responsibility, people will tend to take more care in conserving their environment (presuming that the other actions discussed here are also taken).

8.70 Resource management interventions must emphasize the social arrangements among people as they interact with each other and with their natural resource base, with particular attention to incentives and sanctions for influencing individual behavior. "[Every] aspect of the inter-relationship between society and nature plays a critical role and if one of them fails then the whole situation is likely to be severely affected" (Timberlake, 1986, p. 42). Natural resource management projects that do not actively involve the local users will fail. National, and even regional, governments cannot effectively manage local natural resources. The sheer scale of the soil and water conservation problems faced in many countries dictates the need to create the necessary conditions for local people and communities to take matters into their own hands again. Programs and projects must become more concerned with the people using natural resources and less preoccupied with the commodities around which projects have

traditionally been organized. An essential ingredient in program and project formulation and implementation is the existence of incentives and sanctions for influencing the behavior of those who live in the area and who depend for their livelihood and survival on the natural resources in question (Bromley and Cernea, 1989).

8.71 Traditional land and natural resource management systems may not have been ideal, but their subtleties need to be objectively and realistically assessed. There is the danger that overzealous, but well-meaning efforts will destroy an imperfect but functioning system, only to find that what replaced it hardly functions at all. Pilot operations in land management are already under way in a number of countries and hold promise of success. The existence of pastoral associations in Senegal and Niger, village land management and water conservation efforts in Burkina Faso and the *comités du village* in Mali have demonstrated that careful attention to the needs and practices of local people can generate enthusiasm for positive action in rural areas. These examples suggest that some governments are beginning to have enough political confidence to relinquish control over resources to local groups as well as the political determination to enact legislation that will support such initiatives. They also show that local communities can improve their situation when they believe their efforts will pay off (Falloux and Mukendi, 1988).

8.72 Whether governments will be willing or able to recognize or create centers of authority and initiative in rural areas remains to be seen. Some governments are already making firm commitments in that direction. Smaller organizational units, such as village or pastoral associations, are better equipped to manage their own resources. Recognizing this is a prerequisite for implementing the strategies aimed at improving production systems and land use. These local associations might provide a far more effective basis for rural development and rational resources management than many other previous efforts which imposed external institutions on rural societies. Group action is deeply rooted in most societies of Sub-Saharan Africa -- for managing land, for cooperative marketing and input supply, for pooling savings and financing credit, for pooling labor for critical tasks at critical times. To succeed, cooperation has to be voluntary and managed from below. Grassroots management is one way to assure this. Alternatively, cooperatives can be based on customary social structures and groups, as they often are. Governments can provide technical assistance, such as advice on accounting, legal rights, and technology, and should provide for legal arrangements that facilitate the creation, recognition and dissolution of cooperatives.

8.73 What is most needed are popular participation and action at the village and community level, using and developing local skills, and responding to the particular characteristics of each area. This is the single most important lesson that has been learned (Shaxson *et al.*, 1989, pp. 12-14). Identifying concrete practical mechanisms to foster popular support is critical. Grassroots organizations and local NGOs have a particularly valuable role to play in this respect. Channeling financial resources, to the extent these are needed, to and through them is important, but more important will be meeting their urgent need for institutional strengthening and training in such critical areas as program planning, management and leadership skills, accounting, financial planning and management, and information sharing (Newman, 1992). Governments, international aid agencies, and international NGOs alike will need to find ways to provide this critical support.

C. Conclusion

8.74 The experience of Machakos district in Kenya demonstrates that the right policy framework and investments of the kind recommended here will work to address agricultural growth, environmental conservation and human resource development (English *et al.*, 1992). Significant soil degradation and erosion was observed in Machakos as early as 1920. Substantial efforts have been undertaken over the

past 60 years to combat these problems and to prevent further deterioration. By 1990, with nearly five times the population as in 1920, the district's agricultural production had increased more than five-fold -- yet land degradation had not merely been arrested, but reversed. Real incomes and general welfare have increased.

8.75 The ingredients to this success have been those recommended in this chapter. The Government has provided a generally good macroeconomic and agricultural policy environment which has made intensive, market-oriented farming profitable. Relatively good transport infrastructure facilitated the movement of farm inputs and output at affordable costs. Land tenure security, achieved through a combination of respect for traditional land rights and slowly expanding individualized land titling, encouraged farmer investment in land. Rural education and health services have also been relatively good. Agricultural research and extension efforts in the District have been excellent since before Independence and have included emphasis on soil conservation efforts, tree planting and low-cost crop husbandry. In this setting, and particularly because the economic incentives were good, farmers were receptive to good extension advice regarding soil conservation, moisture retention, the intensification of farming and tree planting, and they have applied these measures on a wide scale. Local farmers groups are playing an increasingly important role in planning and implementing community activities. Efforts to slow population growth are only now beginning to show the desired impact, but the combined effect of these various measures has been so positive that photographs taken of the same sites in 1930 and again in 1989/90 show the improvement of the rural environment -- including the increase in the number of trees.

IX. INFRASTRUCTURE DEVELOPMENT, MIGRATION, AND URBANIZATION

A. Infrastructure Development

9.1 The most basic elements of rural physical infrastructure comprise rural roads, markets in rural towns, and rural water supply facilities. In some areas, irrigation and drainage facilities would also be essential to facilitate agricultural production. At a somewhat higher level of development, infrastructure also includes rural electrification as well as telecommunications facilities and access to electronic mass media. Defined more broadly, rural infrastructure also includes educational, health and sanitation facilities. Given the critical importance of such facilities -- or, more importantly, of the services they provide -- for the development and maintenance of "human capital" in rural areas, these are indeed crucial in the context of the Nexus.

9.2 The importance of basic rural infrastructure for agricultural development is well established. Remunerative output prices accelerate the pace of agricultural intensification -- provided they are effectively transmitted to the farm. Incentives to increase production and marketed output are blunted if the physical barriers and, hence, the costs of moving goods to and from local markets are too high. This is equally true of the national transport system linking local markets to cities and to ports. Recent research in Asia found that in villages with better infrastructure, fertilizer costs were 14 percent lower, wages were 12 percent higher, and crop output was 32 percent higher (IFPRI, 1991). No comparable analysis is available for Sub-Saharan Africa as yet, but similar findings would be likely. Research in a number of SSA countries has shown that adequate road links to product markets stimulate agricultural intensification -- even where population densities are comparatively low (Pingali *et al.*, 1987). Farmers with access to roads and transport infrastructure use land more intensively, adopt efficient techniques and modern inputs, produce more for the market, and employ more labor.

9.3 Infrastructure development also has a major effect on the productivity of rural labor and on key determinants of human fertility, such as infant mortality and female education. Roads provide access to health facilities and schools, and water supply schemes and sanitation facilities have significant impact on health and on labor productivity. Education, health, water supply and sanitation facilities and services arec particularly important in terms of their impact on female education and on infant mortality -- both critical determinants of fertility preferences (see Chapters III and VII).

(i) Transport

9.4 Rural transport infrastructure is highly deficient in most countries of Sub-Saharan Africa, and throughout most of the continent distances from villages to major towns and to all-weather roads are substantial. Rural road density has been estimated at about 32 m/km^2 in Western Africa and 36 m/km^2 in Eastern and Southern Africa. Moreover, Nigeria, Cameroon and Côte d'Ivoire account for more than half the rural roads in Western Africa, and Tanzania, Zaïre, Zimbabwe and Madagascar have more than two thirds of the rural roads in Eastern and Southern Africa between them (Riverson, Gaviria, and Thriscutt, 1991, p. 4), so that these average data significantly overstate the true situation in most countries.[1] In Nigeria, with its fairly dense network of rural roads by African standards, rural road density today is about 90 m/km^2, barely equal that of India in 1951; a reasonable target density, based

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[1] Rural road densities also vary considerably within countries, being generally higher in areas with higher population densities and productive natural resource endowments. In Kenya, for example, rural road density ranges from 400-500 m/km^2 to less than 30 m/km^2 (Riverson, Gaviria, and Thriscutt, 1991, p. 4).

on Indian areas with comparable population densities would be 730 m/km^2 (*ibid.*). Where rural roads exist, they often are poorly maintained. Indeed, maintenance standards have deteriorated considerably during the 1980s: 42 percent of unpaved roads in West Africa and 47 percent in East Africa were in poor condition in 1988, compared with 28 percent and 44 percent, respectively, in 1984 (Carapetis, Levy and Wolden, 1991a, p. 12).

9.5 The availability and reliability of transport services is frequently further compromised by restrictive transport sector policies and trucking regulations. Transport monopolies, for example, are often granted to parastatal companies or to well-connected individuals, and entry into the industry is often restricted even where there are no monopolies. Inefficient procurement and distribution of motor fuels by monopolistic parastatals is another impediment in a number of countries. Price controls on motor fuels tend to reduce fuel availability in the countryside because they make it unprofitable to invest in transporting and selling motor fuels in locations distant from the port cities.

9.6 As a result, markets are poorly integrated, inter-regional and inter-seasonal price variations are far greater than they would be with efficient transport facilities, and incentives to switch from subsistence to market production are often weak. Where there is surplus farm produce, it often has to be carried over considerable distances to markets or to roadsides from where vehicles can move it to processing facilities and/or consuming centers. Women bear the brunt of the rural transport burden since much of rural commodity transport (water, fuel, farm inputs and farm produce) is done in the form of headloading by women. Studies throughout Sub-Saharan Africa show that women and older girls carry loads of 10-25 kg (sometimes as much as 40 kg) and can manage 3-5 km per hour, depending on terrain and load weight.

9.7 Rural roads and improved tracks navigable for animal-drawn vehicles are crucial for rural development. Planning, construction and maintenance should involve the local communities as well as local contractors and technicians. This will help ensure that siting is in accordance with local needs, make maximum use of labor-intensive techniques to keep down costs, and provide local off-season employment.

Rural Transport in Ghana

A field study in the Ashanti, Volta and Northern Regions of Ghana (Barwell *et al.*, 1987) found walking and headloading to be the predominant means of rural travel and transport. Transport activities for an average household, numbering 11.4 persons, involved an average of about 4,800 hours (with a range from 3,740 to 6,210 hours) per year and a load-carrying effort averaging 234 ton-km per year (ranging from 185 t-km to 315 t-km). This comprised 54 t-km for water fetching, 20 t-km for firewood gathering, 75 t-km for crop harvesting, 77 t-km for crop marketing, and 8 t-km for carrying produce to and from the local food grinding mill. About three quarters of the load-carrying effort involved and of the time spent concerned transport within and around the village.

Women accounted for about three fourths of the total loads carried. The average adult woman spent 977 hours per year, or 19 hours per week, on transport activities, mainly headloading. This involved water carrying (11.8 t-km per year per woman), crop harvesting (13.1 t-km), crop marketing (14.7 t-km), fuelwood collection (5.0 t-km), and food processing (2.0 t-km). Male involvement in transport was far less, about 346 hours per year per adult male, and was almost entirely crop-related (harvesting, 7.9 t-km; marketing, 2.9 t-km), with little involvement in transporting water (0.8 t-km) and fuelwood (0.5 t-km).

9.8 Major efforts are also needed to promote the use of locally appropriate intermediate means of transport (IMT),[2] especially animal-drawn implements, and off-road transport. Governmental involvement would have to be largely facilitative and promotional. Improvements in off-road transport are essential for rural people's wellbeing and productivity. The extremely poor state of off-road transport

[2] IMT refer to technology intermediate between walking and headloading on the one hand and motor vehicles on the other. They cover a wide range: improved aids for human porterage (shoulder bars, yokes, backpacks), panniers and rigs for pack animals, animal-drawn sleds and wheeled vehicles, wheelbarrows and handcarts, bi- and tricycles and trailers, etc.

in much of Sub-Saharan Africa severely reduces the timeliness and quantities of agricultural inputs and outputs moved to and from motorable roads, thus acting as a strong impediment to agricultural productivity and growth (Riverson, Gaviria, and Thriscutt, 1991; Riverson and Carapetis, 1990). Rural women in particular will benefit very considerably from such improvements -- with significant follow-on benefits in terms of the various Nexus linkages.

9.9 Farmers need information about technical options and market opportunities. Improved communications more generally are required, including not only transportation but also telecommunications and access to electronic mass media. The latter also have significant potential for reaching rural populations with health and educational information, including information concerning family planning and the prevention of sexually transmitted diseases.

(ii) Water Supply

9.10 The rural water supply situation constitutes another key constraint -- and an important link in the Nexus. Less than 20 percent of Nigeria's rural population, for instance, have convenient access to safe water. There is a direct link between safe potable water and the reduction of infant mortality, and efforts to provide safe water and sanitation facilities have been motivated mainly by these and other direct health considerations. Water-borne and water-related pathogens are major causes of seasonally or permanently debilitating diseases which severely effect, *inter alia*, labor productivity, and often especially during periods of peak demand for farm labor (such as land preparation and planting).

9.11 Women's stake in convenient access to safe water and sanitation facilities is particularly high, given their almost exclusive responsibility for collecting, transporting, boiling and storing water for drinking and cooking and for washing household effects and laundry, for disposing of waste water, and for maintaining household sanitation standards and facilities. Women have to determine the water sources that can be used for various purposes (for drinking, washing, cooking, watering domestic animals and home gardens, and so on); collect, transport and store the water; and purify drinking water using simple techniques and locally available materials (Dankelman and Davidson, 1988, p. 32). In rural Kenya, 89 percent of the women over age 14, but only 5 percent of the men, reported fetching water as one of their normal tasks; the same percentages were reported for fetching fuelwood (Republic of Kenya, 1980). Access to sufficient quantities of quality water is an increasingly more time-consuming problem for many rural women. A study in Kirinyaga, Kenya, found that 70 percent of trips that involve carrying a load are for fetching water (Kaira, 1982).

9.12 Assuming a daily requirement of, say, only 10 liters of water per person, a six-member household needs 60 liters of water daily -- almost **22 tons of water each year**. If a women carries 20 liters of water per trip (provided she has the appropriate vessels), this implies that she would have to make three trips daily to the water source -- or have her daughter(s) help her with this chore. If the water source is 20 minutes away from the home, about 2 hours daily will be needed to meet the household's water needs. If young girls are responsible for fetching water, they carry smaller loads and, hence, will need to go more often. The work load increases substantially if water also has to be brought home for watering domestic animals and the home garden, brewing beer, processing cassava, making mud bricks, or other production tasks requiring water. Additional trips to the water source, each with considerable loads to be carried, are required for bathing small children and for washing laundry, pots and kitchen utensils.

9.13 Drastic changes in the rural landscape brought about by deforestation, often exacerbated by prolonged drought, have made water far more difficult to obtain. Springs and streams run dry for long periods, and wells go dry as the water table recedes. The 1976-79 Integrated Rural Surveys of Kenya

found that during the wet season 49 percent and during the dry season 56 percent of all rural households were more than 1 km from their source of water; 14 and 23 percent, respectively, were more than 2 km from their water source (Republic of Kenya, 1980). In some areas, water sources have become polluted or contaminated: in parts of Zimbabwe, for example, women used to get water from wells in the fields where they worked, but these have become contaminated by fertilizer (Nyoni, 1985, p. 55).

9.14 Convenient sources of safe water are of enormous importance for human health and, hence, labor productivity, and contribute substantially to reductions in infant mortality and child morbidity and mortality. A major benefit to women and girls of better access to safe water is that time formerly spent fetching water from distant sources and preparing it for human use can be used instead for other productive activities, attending school or training, tending to children's health and educational needs, or simply rest and recuperation. Water supply projects should be planned and implemented, if not operated, with and by local women.

The Kenya Water for Health Organisation

Good examples of successful water supply projects based on women's groups are those of the Kenya Water for Health Organisation (KWAHO), an NGO consortium supported by the government, UNDP, UNIFEM and the World Bank. In Kwale district, it has organized cooperative handpump installation and maintenance with female extension workers, village decision-making, local materials and labor, backed by training in health, water use, pump maintenance, bookkeeping and group organization (Dankelman and Davidson, 1988).

(iii) Infrastructure and Environmental Conservation

9.15 Infrastructure development is a major determinant of the way people use land as well as of the spatial allocation of people on land. Sound infrastructure policy is therefore a powerful instrument in the two-pronged strategy to intensify agricultural production and to limit further destruction of forest and pasture areas. The development of infrastructure tends to attract and retain people. The many instances of colonists invading forests via abandoned logging roads provide a powerful illustration. Conversely, the absence of infrastructure in areas that are environmentally delicate will tend to induce people to stay out of those areas. Careful locational targeting of infrastructure development can guide spontaneous population movement into environmentally robust/resilient areas with agricultural potential, and into secondary towns and cities, and help keep migrants out of areas that should not be opened up to farming.

9.16 Infrastructure development, and especially road construction, should be focused where the potential for agricultural intensification is highest and/or where settlement is to be encouraged. It should be avoided in forest areas which are to be conserved and in other environmentally fragile areas where an influx of people will lead to environmental degradation and destruction. Concentrating infrastructure development and thereby attracting/retaining people in areas of high production potential and keeping them out of environmentally fragile areas also allows considerable efficiencies in investments and service provision, since the per capita cost of infrastructure development and maintenance is inversely related to population density.

B. Migration and Settlement Policy

9.17 Given the considerable agro-ecological diversity in most countries of Sub-Saharan Africa, the development and adoption of suitable productivity-enhancing and environmentally appropriate agricultural technology will of necessity have to be highly region- and even location-specific. This will, over time, engender significant regional disparities in agricultural production and income growth. Governments will need to resist the urge to correct for this by targeting scarce public resources to the lagging regions. Allowing, facilitating and encouraging migration from the lagging to the thriving regions is the

appropriate policy response. This is particularly important when the lagging regions are likely to be those that have less agricultural potential and are environmentally more fragile.

9.18 In many areas, therefore, part of the solution to the problems of unsustainable agriculture and environmental destruction will have to involve some movement of people. This is the case, for example, in much of the Sahelo-Sudanian Zone where movement should be encouraged to the Sudano-Guinean Zone further south as well as to areas within the Sahelo-Sudanian Zone itself that can still absorb more people. Nigeria's "middle belt", for instance, remains relatively underpopulated, compared with the country's northern and southern regions, and holds considerable untapped potential for agricultural development. The same is true for much of Ghana's Brong-Ahafo and Northern Regions.[3]

9.19 Migration is multisectoral in nature and, in the context of rural Sub-Saharan Africa, closely linked to the problems of rising population pressure, land tenure uncertainties, poor land use and environmental resource degradation. Large scale migration within and between African countries is inevitable in the future, given rapid population growth and the limited absorptive capacity in many rural areas. Without strengthening tenurial arrangements to provide greater security, it will be as difficult to channel migration and settle migrants as it will be to protect and improve their host environments. A sound migration policy must consider the land-use rights of farmers, transhumant pastoralists and forest dwellers. Migration can be used as a positive development tool -- if it is linked to a well conceived settlement program. In many cases, migration can balance resource demand with resource availability. Regional surveys of migration, both quantitative (who, how many, from where, and to where) and qualitative (motivations and aspirations) should be carried out in the most sensitive areas of immigration. Without land rights that are confirmed by both custom and law, migrants have no incentive to protect or restore their land. Neither will the residents be able to protect themselves and their resource base from incoming migrants (Falloux and Mukendi, 1988). This has happened in Côte d'Ivoire, for instance, where massive unplanned immigration of Sahelian farmers into open-access forests has contributed to rapid forest destruction, widespread land disputes, and a lack of incentives to conserve the land.

9.20 Redistributing population -- to reduce pressures on the environment on the one hand and to accelerate the transition to intensive farming on the other -- requires identifying areas of high agricultural and economic potential, improving infrastructure and services (roads, water supply, schools, health facilities, markets) in these areas, and encouraging people to move to the high potential areas and into rural towns and secondary cities. Governments should normally include population distribution as a part of their policy to accommodate population growth. Spontaneous movement of people, in search of a better livelihood, in pursuit of trade, and to find seasonal or permanent employment, has been occurring for a long time, both within countries and across borders. Cross-border movement has helped to ease population pressure in the areas from which people emigrate -- such as the Sahel or Rwanda. But such movements have sometimes been restricted or reversed because of political and ethnic conflicts. Benefits of population migration certainly accrue to the individual migrants and often to the communities from which they migrate. There often also are significant economic benefits for the communities receiving the migrants. The Sahelian farmers settling in Côte d'Ivoire have been a dynamic force for agricultural growth. The benefits and costs need to be realistically assessed, and migration, though better anticipated and prepared for, must be allowed to continue. Such movement of people is also consistent with African aspirations to encourage and promote regional cooperation.

9.21 There are two main types of rural-rural migration: spontaneous and uncontrolled migration, and government-sponsored organized migration and resettlement. Spontaneous migration involves no

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[3] In both cases, as in other countries, ethnic diversity and land tenure issues help explain the uneven population distribution.

direct costs to the public treasury. It is quick for the individuals who move, but in most cases takes place gradually enough to preclude social and economic upheavals in the receiving areas. Unfortunately, it also often tends to lead to poor land use practices, because migrants bring with them only the farming and land use experiences and traditions from the area they left, and these are often inappropriate to their new environment. This is particularly the case where settlers invade forest areas opened up by loggers (see Chapter VIII). Organized migration, on the other hand, usually entails high costs and is characterized by slow implementation.[4] It, too, has often resulted in poor land use, as planning and implementing agencies have tended to promote settlement, resource use and production patterns poorly matched to the settlers' own needs, perceptions and capabilities.

9.22 The required strategy, therefore, lies somewhere between these two. It should channel, train and support migrants, combining incentives for and controls over land use practices with the development of sustainable and viable production systems. It makes far more sense for governments to promote and support spontaneous migration and settlement than to undertake organized colonization schemes. It will be essential to devise and implement enforceable land-use regulations to promote sustainable settlement.

C. An Appropriate Urbanization Policy

9.23 During the past three decades, the urban population of Sub-Saharan Africa has been growing roughly twice as fast as its total population. In a number of countries the rate of urbanization has been considerably faster still. The rate of urbanization has been especially high in west, central and east Africa, comparatively more modest in southern Africa (Montgomery and Brown, 1990, p. 76). The very rapid growth of cities is due not only to the persistent high fertility rates still observed among urban women in Sub-Saharan Africa, but in large part to the very high rate of rural-urban migration. This "land-flight" is caused in part by the strong urban bias inherent in the economic and investment policies of almost all countries of Sub-Saharan Africa.

Urban as Percent of Total Population in Sub-Saharan Africa, 1960-1990

(Data for 41 countries of Sub-Saharan Africa)

9.24 In much of Sub-Saharan Africa, rural out-migration involves predominantly young men (Russell, Jacobsen and Stanley, 1990a). Where policy has a heavy urban bias, this has been particularly pronounced. As women, children and the old stay behind, farm management is increasingly left to women who already have multiple and very heavy responsibilities and work loads and who face far greater constraints in access to resources and services than men (see Chapter V). Many rural areas are today characterized by severely imbalanced gender ratios in their adult population, with women substantially outnumbering men. In addition, if the migrants abandon resilient and productive areas in pursuit of urban employment and in response to anti-agricultural policy biases, this has a negative impact on agricultural production and rural development in the areas which they leave.

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[4] For a good analysis of migration in Rwanda, see Olson (1990).

9.25 Experience throughout the world suggests that urban populations have grown and will continue to grow much faster than rural populations -- even if governments were to pursue policies that do not favor urban over rural dwellers (Cour, 1990). What is needed, therefore, is an urbanization and urban development policy which also promotes agricultural development and preserves the integrity of the environment.

9.26 Where government policy discourages agricultural production and encourages agricultural imports to supply urban needs, there will be no positive impact of urbanization on agriculture. This has tended to be the case in countries where urban development policy has focused heavily on the capital or on a few dominant cities, inevitably more distant from rural hinterlands. Manifestations of such policy and expenditure bias are the subsidization of the consumption of urban populations (often based on imported food), preoccupation with large urban infrastructure projects, and focus of social expenditures in a few cities. The political influence of growing, massed and vocal urban populations results in political pressure to keep food prices low and to target public investments and services disproportionately to the big cities. The result is the extraordinarily low level of public investment in rural roads, water, health, and education observed in much of Sub-Saharan Africa. Where governments have effectively resisted this pressure, the results have been positive for agricultural profitability and growth: Kenya, Togo and Zimbabwe are cases in point.

9.27 Some countries have pursued policies that have led to the emergence of numerous and geographically dispersed secondary cities and rural towns closely linked with their surrounding rural areas (for example, Cameroon, Côte d'Ivoire, Kenya, Nigeria, Togo). They also have a few very large cities (notably Abidjan, Nairobi, Lagos, Ibadan), but urbanization in these countries has also been characterized by the development of many smaller cities and rural towns throughout much of the national territory. This has had important positive effects on agriculture. These towns and cities have created non-agricultural employment opportunities for some of the rural population, but this industrial and service sector development has been much more closely linked to agriculture and to the needs of rural populations. Cash remittances to home villages are an important source of financing of both consumption and investment expenditures in rural areas. Urban growth creates expanding markets for farm products and tends to lead to increased supply and availability of farm inputs and services. This can make agriculture more profitable -- provided there are adequate transport links and marketing arrangements. Where networks of rural towns and secondary cities exist, these links are far more direct, immediate and efficient. Dispersed rural towns and secondary cities tend to be associated with far greater penetration of rural areas with adequate transport links and marketing arrangements than are distant mega-cities. For areas that are approaching the limits of sustainable agricultural land use under existing tenurial, technological and climatic conditions, migration to these secondary towns and cities reduces the population pressure and provides an important safety valve.

9.28 Considered in the context of the Nexus, urbanization is both a result and a cause of environmental resource degradation. People leave rural areas when they can no longer make a living there (or at least not year-round). Urban dwellers, especially the vast numbers of poor, require fuelwood and food. Urbanization concentrates demand at specific locations. The heavy concentration of urban populations in a single capital city (often a seaport, rather than in a central inland location) makes things worse. Huge concentrations of people in a single location, coupled with high transport costs for domestically produced supplies, tend to make it easier and cheaper to import food than to obtaining it from domestic producers. Government policies in most of Sub-Saharan Africa tend to keep food and fuelwood prices low, reducing incentives for intensification of local food and wood production. Food imports, often sold at subsidized prices, further undermine the incentives for domestic producers. Imports can also lead to major changes in consumer preferences that may diminish demand for local products and be nutritionally undesirable. Fuelwood suppliers, responding to the dual opportunities

presented by large concentrations of demand and virtually free access to the raw material base, mine the forests and woodlands around the cities and along roads (see, for instance, Gorse and Steeds, 1987, p. 7).

9.29 Ensuring that urbanization promotes agricultural development and environmental resource conservation requires economic policies that do not discriminate against rural areas (for instance through discriminatory pricing, tax and investment promotion policies). It also requires a better balance between rural and urban areas in public investments in social and physical infrastructure. The more rapid agricultural growth that will occur in the absence of such discrimination is likely to have a positive impact on the economies of Africa's cities and their inhabitants.

9.30 Greater focus on secondary cities and rural towns, in infrastructure investment and urban development generally, and a reduced bias to invest in the mega-cities, will provide a beneficial rural-urban link. Powerful synergies can be tapped here. The examples of Cameroon, Kenya and Togo show that rapid urbanization tends to occur in secondary cities and rural towns (rather than in mega-cities) if governments effectively implement policies to promote agricultural development and rural growth (Becker and Morrison, 1988). Agricultural growth is an essential lever to stimulate non-agricultural investment and growth as well as to influence population distribution. A recent analysis of farm-nonfarm linkages in rural Sub-Saharan Africa found that each monetary unit of increased agricultural income generated an additional increase of half a monetary unit in non-agricultural rural incomes; the direction of causality was largely agricultural growth stimulating growth in services and manufacturing.[5] This is less likely to occur when biased policies retard or prevent the development of secondary towns and cities and instead cut off rural areas and agriculture from the mega-city and make the latter more dependent on imports. Sound urban policy is an important element to assure balanced urban and rural development, favoring rural towns and secondary cities compared to mega-cities.

9.31 A sound urban development policy will involve relatively more public expenditure in secondary towns and cities and less in the few large cities than has generally been the case to date. It will require spatially well distributed infrastructure investment throughout the country (not merely in the largest cities). Market-based petroleum pricing will be essential to promote the development of efficient transport fuel distribution systems throughout each country. Small and medium-scale industry will ned to be promoted -- through industrial extension as well as fiscal and credit policies. It will also require considerable decentralization of decision making to local people and rural communities to avoid undue dominance of the major cities and their populations in national political decision making. And there will have to be greater community control over urban resources: given adequate financial resources and the requisite technical and administrative assistance, local and community governments are far more likely to create and maintain appropriately scaled and sited urban infrastructure facilities than are central governments. Investment in urban development should be responsive to demand for such investment, not driven by political considerations.

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[5] Of this additional rural income, only about 20 percent was attributable to production linkages, but about 80 percent to consumption linkages. These strong consumption linkages are likely to have significant positive effects on the real incomes of the rural poor – given the importance of female-dominated food processing and beverage production and of service and manufacturing activities with low investment requirements. They are also likely to stimulate production of fruits, vegetables and meat and, thus, agricultural intensification and diversification into higher-value products, with positive effects for rural income equity where, if, and as long as these commodities are produced by smallholders and pasturalists. The production linkages of increased agricultural incomes on rural equity depend heavily on the respective rates of growth of demand for agricultural wage labor and for purchased inputs, both of which are currently at very low levels (Haggblade and Hazell, 1988; Haggblade, Hazell and Brown, 1989).

X. MANAGING THE NATURAL RESOURCE BASE

A. Production versus Protection

10.1 The environmental issues that are linked to population and agriculture are primarily those involved with soil, water and vegetation. There are, of course, many other environmental problems facing Sub-Saharan Africa -- such as over-fishing in coastal waters, oil spills, dumping of hazardous wastes, pollution from urban sewage and industrial waste, land devastation from surface mining, and so forth. These problems are not, however, so closely related to rapid population growth and laggard agricultural growth and therefore are not dealt with here.

10.2 Governments must be more determined in developing and implementing environmental policies aimed at: (a) maintaining and restoring, in the face of increasing consumption demands, the soil, water, pasture and forest vegetation on which agriculture will continue to be based, and (b) preserving ecosystems and plant and animal species -- both as repositories of genetic diversity that may underlie future production of many types of products, and as a national and global heritage. Solving the population and agricultural aspects of the problem are crucial to curtailing degradation of the natural environment. Agricultural intensification, farm forestry and fuelwood programs, and sensible land tenure reform are critical factors, as discussed in Chapter VIII. However, moving from the present situation of rapid deforestation, wetland conversion and land degradation to one of stabilizing the area under trees, raising the efficiency of fuelwood use, preserving much of the remaining wilderness areas, and reversing the degradation of soils will require an "affirmative action program" of considerable consequence. It will need to comprise a number of elements beyond those discussed in Chapter VIII.

10.3 An essential first step is to determine which areas should and can be maintained as protected areas, and which should be allowed to be developed for production (agricultural, forest, livestock, fisheries). Criteria for selecting natural ecosystems for preservation and protection include:

- Biological importance, notably richness (diversity, numbers) and uniqueness of species and complexity of the ecosystem: the greater the importance, the more important the need for full protection.

- Provision of "environmental services," such as prevention of soil erosion or of destructive flooding, recharge of aquifers, maintenance of river flow, provision of breeding grounds for marine life: the greater the value of such services, the greater will be the importance of protection.

- Importance for the survival of indigenous peoples and their livelihood systems, especially of forest dwellers: where indigenous peoples depend for physical and/or cultural survival on an area remaining undisturbed, the need for protection becomes imperative.

- Productive potential if converted to other uses such as cropping or livestock production: the greater the productive potential under alternative uses, the less viable the decision to protect fully.

- Current status, i.e., whether or not the ecosystem is already degraded or spatially constricted to an extent where it is no longer stable and wildlife populations are no longer viable: the less viable a particular ecosystem, the less viable would be a decision to protect it fully.

- Likelihood of success of preservation -- which depends on the type and degree of present threats (such as human population pressure) which reduce the likelihood of success versus the potential for supporting non-exploitative economic activities (such as eco-tourism) which increase the likelihood of success.

10.4 These criteria imply trade-offs. In many cases they will involve the need to make difficult choices. If one basic objective is to limit the decline in Sub-Saharan Africa's total wilderness areas (from their present extent of 27 percent of the total land area to not less than 23 percent), these criteria will need to be applied with considerable stringency. Since natural resource systems, including forests, have multiple uses, there can be no substitute for some form of planning. Land use plans should identify conservation areas, parks, areas designated for sustainable logging, farming areas, pasture and range land, as well as areas needed and suitable for human settlements and physical infrastructure. Agricultural technology is location-specific in its applications, and land use plans therefore should identify, in broad terms, the appropriate technologies. Land tenure issues and fuelwood problems also are location-specific -- as are many of the cultural factors that help determine human fertility. Regional plans should define these, with considerably more weight attached to resource conservation than in the past.

10.5 The widespread skepticism concerning the utility of such plans is based on the fact that most past attempts at land use planning and regional planning have not worked well in Sub-Saharan Africa. The reasons included often excessive complexity of such plans, lack of governmental capacity to prepare and implement realistic plans, and frequent lack of incentives to cooperate for the people living in the areas concerned. In most cases, and especially those concerning forest areas, land tenure issues, identification of appropriate agricultural technology in forest areas, participation of local people and of the private sector, and provision of adequate incentives to cooperate for loggers, farmers, hunter-gatherers, livestock owners and forest dwellers were neglected. Instead, nearly universally applied were "engineering solutions", implemented by public sector agencies or donor-supported project management units which sought to manage forest areas independently of people and of companies operating in the forests. A different approach is necessary -- both for planning and management. It must greatly increase the role of local people and the private sector in planning and implementation; it must be evolutionary and adaptive, rather rigid; and it must be simple to execute. If the role of governments is confined primarily to providing the legislative backing and to planning and supervision, land use planning becomes more manageable. And if assistance for carrying out these more limited functions is provided through the collaborative mechanisms established for preparing National Environmental Action Plans (NEAPs) and Tropical Forestry Action Plans (TFAPs), adopting this approach is a realistic strategy.

10.6 It is increasingly recognized that maintenance of protected areas requires the direct involvement of the local and surrounding populations. It is unrealistic to expect local people to conserve forest and wildlife resources unless such conservation provides them with clear benefits. The exclusionary approach so often taken in protected areas in the past is neither workable nor sustainable nor equitable. Governments cannot financially afford and effectively provide the degree of enforcement needed. And the local people, frequently among the poorest, are left to bear the costs of restricted or prohibited access to resources, exposure to marauding wildlife, and other disadvantages associated with living on the edge of a closed off territory.

10.7 The local people therefore must be active participants in both planning and implementation of land and resource use. This requires: (i) appropriate incentives and (ii) collaborative planning and implementation of resource management plans. Incentives are far more likely than governmental regulation, control and enforcement to be effective tools for inducing people to conserve essential stocks of natural resources. The most important incentive to ensure resource conservation is clearly defined and uncontested resource ownership: it entails the certainty that the yield or benefits derived from resources

Integrated Conservation and Development

Reflecting the recognition that effective resource conservation and management must involve strong local participation, the concept of "Integrated Conservation and Development" is being developed. It involves the following key aspects:

- Local people retain the rights to continued traditional utilization of resources inside state-owned protected areas to the extent that this is not detrimental to the ecosystem and are, of course, allowed to continue such activities on all land returned outright to them.
- The local communities are allowed to generate income from protected areas through environmentally compatible activities such as tourism, hunting with traditional weapons, and gathering of non-timber forest products. All of these activities are directly dependent on the protected area. Local communities given exclusive rights to carry out these activities will have an incentive to conserve the forest or wilderness area.
- Commercial logging of protected areas would be entirely excluded. Logging would be allowed and carefully managed only in those areas identified for logging, but on a sustainable basis.
- Buffer zones are established around core protected areas where the land and resource ownership is returned to the local people and which will provide them with forest and agricultural products without overexploiting the protected areas. Buffer zones also serve to keep potentially destructive wildlife away from villages, crops and domestic livestock.
- Agriculture and social development activities can be provided outside protected areas to attract local people away from these areas and as an incentive to avoid encroachment.

Actual experience with implementing this concept is still limited in Sub-Saharan Africa. A number of pilot projects have been initiated, but are at a very early stage. An important concern – and a potential danger to be alert to – is the risk of the "magnet syndrome": the development of buffer (or support) zones around areas to be protected may in fact serve to attract more people to the area if rural social and infrastructure development further away is significantly lagging behind that in the buffer zone.

conserved will continue to accrue to the current owners/users and their descendants, but also that resource degradation will be a cost directly borne by them. This is best accomplished by ensuring people's ownership of the land and of the natural resources on that land -- or, where government ownership is to continue, by providing legally binding and protected long-term use rights. Under the right economic conditions, this provides strong and direct incentives to conserve and to invest in resource conservation or productivity enhancement. Conversely, loss of ownership or exclusive user rights, or ambiguities concerning these, create incentives to exploit without regard to sustainability.

10.8 Appropriate resource management plans should be prepared in a collaborative manner -- involving the concerned communities, technically competent government agency staff and, where they exist and enjoy the local people's confidence, grassroots organizations and NGOs. Participatory rural appraisal (PRA) techniques provide very effective tools to do this.[1]

B. Forests

10.9 About 30 percent of Sub-Saharan Africa's land area are classified as forests or woodlands. But only about 28 percent of this area is closed forest -- compared with about two thirds in Latin America

[1] PRA techniques have been developed and refined in the 1980s, evolving from Rapid Rural Appraisal (RRA) techniques and agroecosystem analyses, to ensure maximum involvement by the local populations in local land use planning (resource inventory, problem diagnosis, resource use planning, action plan formulation, etc.). See, for instance, Chambers, 1991.

and in Asia. About 34 percent are shrubland and 38 percent are savanna woodlands; both are multiple-use resource systems, utilized for meeting local requirements for fuelwood and other tree and forest products as well as for farming and forage.

10.10 As discussed in Chapter II, Sub-Saharan Africa's forest area is diminishing at a rate of about 3.7 million ha per annum, and the rate of decline is accelerating. The most important causes of deforestation are conversion to farmland, infrastructure development in environmentally delicate areas, timber extraction and commercial fuelwood harvesting. Growing and migrating human populations as well as international demand for tropical timber drive these processes. Timber exports from Sub-Saharan Africa amount to about US$700 million per year at present. Crop land is expanding at a rate of 1 million ha annually. A number of agricultural development projects supported by external aid donors have facilitated the conversion of forest and range lands into cropland.

10.11 The most important areas for action to stop the degradation of Sub-Saharan Africa's forest resources lie outside the immediate purview of forestry sector policy. They are: (a) reducing population growth, and (b) intensifying agricultural production at a rate which exceeds population growth, in order to encourage sedentary agriculture and livestock raising and to discourage further invasion of the remaining forests. Rapidly growing numbers of people, barely surviving in land-extensive agricultural systems, have no option than to continue to invade and destroy forests. This points again to the complex mutual dependency of agricultural and non-agricultural activities.

10.12 For the forests which remain, improved management for multiple uses will be vital. These uses range from the provision of critical environmental services to the supply of timber and non-timber products, and from tourism and recreational uses to mining. It is unrealistic to expect that all forests can be conserved in their present state. For almost all of Sub-Saharan Africa's forests the issue is not whether to use them or not to use them -- but how to use them. If people (and governments) feel that there is little benefit from forests, they will continue to be mined for urgently needed export revenue or converted into agricultural land.

10.13 To address these problems effectively, there is no alternative to planning, orchestrated by governments. This can be done within Tropical Forestry Actions Plans (TFAPs), National Environmental Action Plans (NEAPs) or simply forestry master plans. Each will involve some form of land use and natural resource planning. Land use plans for forest areas should identify conservation areas, parks, areas designated for sustainable logging, mining areas, farming and grazing areas, and areas designated for infrastructure development. Farmers have encroached into most forest areas in Sub-Saharan Africa, including into many government-managed "forest reserves". Removing and resettling these people would, in most cases, entail social and economic costs of a magnitude that render this option generally prohibitive. Even if farmers were to be expelled from areas they have invaded for farming, this would not restore the affected areas to their previous forested state. Consequently, areas which have already been largely converted to farm land should be formally relinquished for farming and farmers should be provided with secure use rights. Areas allocated to industrial wood production should be carefully managed in collaboration with logging companies (which should be compelled under their concession agreements to log in a sustainable manner) and with local populations. Areas designated for protection should be managed by government agencies in partnership with the local people. This will require giving these people specific user rights in protected areas and involving them in management decisions.

10.14 A key to improving forest management will be the direct involvement of the local people in both planning and execution of forest resource use plans. As noted above (para. 10.6), the most effective manner to achieve this is to ensure their resource ownership or legally protected long-term use rights and to prepare forest resource management plans in a truly collaborative manner. Where local communities

own the forest, governments should assist them, through forest and extension services, to manage their forests productively and sustainably.[2] Sound forest management plans would allow some logging and artisanal wood harvesting on a sustainable basis (specifying concession fees, taxes, etc.), provide for essential infrastructure development, and identify areas suitable for crop and livestock production. Local people would utilize the forest and woodland resources for fuelwood and artisanal forestry, for hunting and for harvesting of non-wood forest products, the arable land for cropping, and the range and grazing land for livestock production. Royalties paid by "outside" users would accrue to the local communities; governments would share in such royalties through the tax system.

10.15 Where governments retain ownership of forests, the management will be more directly under government control. But even there, management plans will need to be responsive to local people's needs and should, therefore, be developed and implemented with their full participation. Local people will only be induced to cooperate if they are given secure and exclusive user rights: hunting, fishing, collection of non-timber forest products, some wood harvesting. They should also be given a significant share in the royalties received from other users, such as logging concessionaires; the certainty of such long-term sources of income will represent a significant benefit and an incentive to adhere to agreed use plans.

10.16 Governments will need to provide the essential policy and administrative framework: publishing standard concession agreements, establishing and collecting taxes and stumpage fees, and creating conservation areas, based on both land use plans and national forest policy parameters. Implementation would be the responsibility of the local communities, with the requisite technical assistance provided by government agencies and/or NGOs. As these communities acquire experience and management acumen, the need for such outside assistance will decline and government support should be commensurately withdrawn. As emphasized above, strong and lasting incentives (embodied in resource ownership, user rights, revenue sharing, and the like) would need to be provided to ensure appropriate local interest in such an approach to resource management.

10.17 Whether any kind of commercial logging is compatible with sustainable management of primary humid forests is highly contentious. Although the evidence available at present may not be sufficient to make a definitive and categorical statement, there is increasing support among experts for entirely prohibiting logging in intact primary humid forests.[3] Logging certainly should be stopped in ecologically delicate and in environmentally important areas in humid and in savannah forests. There should be no logging where it is not possible to log on a sustainable basis. In secondary forests (i.e., those consisting of regrowth where primary forests have been logged or otherwise significantly disturbed

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[2] Indeed, since government agencies throughout most of Sub-Saharan Africa are stretched far too thin to manage even those forest resources that are legally under government ownership and control, and since in many cases local people and communities continue to consider these resources to be rightfully theirs, governments should consider divesting many (though not all) forest and range areas to local people. The traditional owner/user communities could obtain group title to these resources.

[3] Although considerable interest and optimism are often expressed with respect to sustainable exploitation of natural forests, ITTO has estimated that only one fifth of one percent of the world's natural tropical forest areas are currently being harvested on an ecologically sustainable basis (Goodland, 1991, p. 14; Poore *et al.*, 1989). Even logging systems based on selective removal of certain species and age classes of trees may seriously disrupt the ecological balance of a tropical moist forest and destroy a significant portion of the remaining vegetation during the process of extraction. Recovery of the ecosystem can only be assured if the damaged area is very small and is surrounded by large areas of undamaged forest that can serve as a reservoir of recolonizing species. Thus, even though the area may remain forested, any type of commercial logging in a tropical moist forest may result in a fundamental and quite possibly irreversible degradation of the original ecosystem. This is in contrast to the less diverse and more resilient temperate forests, which can be logged productively on a sustainable basis.

before), and on forest plantations and tree farms, logging must be undertaken in accordance with sustainable management practices. These areas could, in many cases, be specifically designated and managed as permanent sources of timber, pulpwood and woodfuels -- provided the private owners (individuals or groups) agree. Logging companies unable to log in a sustainable manner should not be given concessions and permits, even in secondary forests. This will require governmental regulation of logging, even if it is undertaken on private land.

10.18 Loggers will have to improve their performance and show themselves to be responsible in their logging activities. In order to induce this behavior, concession agreements providing for logging company responsibilities as well as rights will be necessary. Payment of taxes should be the norm -- rather than tax evasion. Sustainable management of secondary growth forests and industrial plantations would then become a more important aspect of the business of logging companies than mining of primary forests. Even where governments choose to continue to allow logging in primary forests, management of secondary growth should be strongly encouraged by levying much lower taxes on trees taken from

A New Forest Policy in Côte d'Ivoire

In Côte d'Ivoire, about 12 million ha of tropical forest land have been lost since the turn of the century. To arrest this destruction, the Government has initiated an effort to implement a number of the recommendations set out here. Wildlife and biodiversity would be conserved in national parks covering 1.9 million ha, of which 600,000 ha are tropical forests. Sustainable wood production would be undertaken through better management of forest reserves for logging (all of which are secondary forests, previously logged), maintenance and expansion of hardwood plantations, and assistance to farmers induced to resettle outside the forests.

This process began with detailed land use plans for existing "gazetted" forest which belong the government. These plans designate specific tracts of land for protection, logging, farming and/or other uses. Park areas have already been delimited and are to be fully protected and managed. In those parts of the gazetted forests which have been previously logged over and are to remain production forests, logging companies are receiving long-term concessions for logging in accordance with detailed forest resource management plans and under governmental supervision. Loggers judged unable or unwilling to participate are not permitted to log. To generate the greatest amount of forestry value for the government, taxes on logs have been increased, and concessions are auctioned to the highest qualified bidders. This is helping to eliminate the least efficient loggers. In effect, forests will no longer be treated as a virtually free good, but as an expensive and valuable resource to the community, requiring high payment by logging companies for exploitation. Intact primary forests are in parks and will not to be logged at all.

Farmers are given incentives to move out of those parts of parks and logging reserves which are environmentally delicate or should be managed for logging. The key incentives are ownership titles for land outside these areas and the provision of access to agricultural inputs. The agricultural extension service will provide technical advice to resettled farmers. No support services will be provided to farmers remaining inside the forests. There will, however, be no coercion to move; the incentives are expected to be sufficiently persuasive to induce voluntary exit from the park and logging areas. Traditional forest dwellers will be allowed to remain in the forests; so would farmers settled in areas already so heavily encroached upon that forests have essentially disappeared. Land tenure reform to eliminate open access to land is being initiated under a separate project. Government institutions in the forest sector will be strengthened to focus more on conservation and resource management, rather than on servicing the logging industry.

This new forestry policy fits into a broader national strategy for natural resource conservation which includes accelerating agricultural intensification and improving land tenure security.

A major issue now is the need for an effective consultative process between farmers, traditional forest dwellers and the government. Such a process has been initiated in the form of local-level forest-farmer commissions for each forest which will decide on resettlement questions as well as other areas of controversy between the government, traditional forest dwellers and farmers who have settled in the forests. A second issue is land ownership. The government would continue to own the land in the gazetted forest areas, but would pay part of the royalties received to local populations to induce their support for the new policy.

replanted areas and industrial plantations than on trees harvested from primary forests. If international prices for tropical wood rise as currently projected, the profitability of forest plantations will increase, making such an approach even more feasible.

10.19 Where logging is still permitted in primary forests, it should be more heavily taxed -- through area-based taxes levied on concessions. Part of the tax should be collected and retained by local communities owning the forests or having user rights in them. Concession agreements should be auctioned to the highest bidder. These measures would serve to return more of the benefit to the community and, in effect, impose a charge on the companies for the resource (the forest) exploited. Taxes should be high enough to reflect the economic and social value of the forest, including the environmental services it provides, and the cost of rehabilitation if the public sector or the local community undertakes that rehabilitation.

10.20 Governments will also need to develop the institutional and human capacity required to manage protected areas and to monitor logging as well as the use of agricultural, pasture and fisheries resources made available for local people's use in forest areas. This is important to ensure that protected areas are in fact protected and that the areas made available for exploitation are used in a productive and sustainable manner. An example of management for sustainability is increasing the availability of wood products to keep pace with population growth -- ensuring, for example, that reforestation exceeds cutting. This could be done by inducing local communities and individual land owners to set aside sufficient land for wood production. The primary instrument to achieve this would be ensuring that price, tax and other incentives make tree production and marketing profitable (and more profitable than other forms of land use on land most suitable for tree production). This requires planning and management capacity in government to help local populations manage natural resources. In parks and protected areas, governments will need the capacity to manage resources directly and effectively.

10.21 On privately and communally held forest land, government forest services can also help local land owners reforest degraded areas, by providing planning assistance, technical advice, training and seedlings. But planting, maintenance and harvesting must be done by the resource owners, the people themselves. NGOs can play an important role in assisting them. Forest services need to move away from their present almost exclusive focus on direct management of forests -- which is all too often coupled with an adversarial relationship with the people living around the forests -- and place far greater emphasis on extension functions targeted at private and community-owned land. Forest research similarly needs to pay greater attention to the issues faced in private and community management of forest resources.

C. Natural Resource Management in Farming Areas

10.22 Since much farming takes place within forest areas, there is not always a clear distinction between forest areas and farming areas. In large areas throughout Sub-Saharan Africa forests have been almost totally replaced by farms. In these areas, the primary role of governments in natural resource management should be effective planning of land and water resource use. Even in areas predominately used for farming, land must still be allocated for various uses such as settlements, service and infrastructure facilities, parks and forests, grazing and crop land, areas to be protected (watershed headlands, wetlands, water bodies), and so forth. Land use planning will need to take into account the important trade-offs between these various uses. Land use and management plans for farming areas should be prepared in a collaborative manner, with the active participation of the local communities. They will need to cover such issues as watershed management, locally appropriate improved farming and livestock husbandry practices, farm tree planting, irrigation and drainage, domestic water supply and use, and the location of physical infrastructure.

10.23 Actual resource management and conservation in such areas will be almost entirely in the hands of the local farmers and livestock owners.[4] It will be essential to ensure tenurial security if there is to be significant private investment in land conservation and productivity enhancement (see paras. 8.52-8.54). The agricultural research and extension systems will be the major governmental instruments for supporting farmers and private industry in managing the natural resources in farming areas.

D. Dryland and Range Areas

10.24 Many dryland and range areas will, like forest areas, require special protection. Actions in the agricultural, livestock, infrastructure, land tenure and population spheres along the lines set out in previous chapters will be necessary, but not sufficient. Since agricultural technology adapted to dryland areas is so marginal, land tenure reform so exceedingly difficult to implement, and carrying capacity so low, sustainable management of dryland areas will be very problematic.

10.25 Land use planning will be important, since there are trade-offs and potential conflicts here as well between the traditionally predominating pastoralists, new settlers who are moving into the better areas to farm, fuelwood gatherers, and the preservation of bio-diversity. Many pastoral areas contain forests and wildlands. Resolving land disputes is an important aspect of the solution to these problems, including that of ensuring adequate fuelwood supplies in drier areas. The management of rangeland by local people, grouped into voluntary and self-governing associations, is the most effective tool for managing these resource systems. But these associations must be provided undisputed ownership of, or assured long-term user rights to, the land and the associated water and vegetation if they are to manage them.

10.26 Two recent reviews of key issues in Sahelian dryland management highlighted a number of essential concerns that should be observed in attempts to ensure sustainable management and development (Nekby, 1990; Shanmugaratnam *et al.*, 1992). These include the research and extension of appropriate crop and livestock technologies which are both soil conserving and more profitable for farmers and herdsmen, land tenure reform to eliminate open access, reduction of population growth through out-migration, and promotion of non-agricultural rural industries to reduce the pressure on land. One of these reviews (Nekby, 1990) also suggested a return to holistic and integrated planning and execution -- in effect, a return to the concept of integrated regional development based on land use plans that allocate land for pasture, cropping, reserves and parks, fuelwood production, forests and other uses. Land ownership would be allocated, including to traditional community or clan owners. Agricultural and livestock technology would be developed to suit each particular agroclimatic situation. The technologies would include considerable soil conservation measures. It is, at present, not possible to envisage an alternative approach in dryland areas.

10.27 Local initiative and management need to be mobilized to manage range, pasture and dryland areas -- in a manner similar to that outlined above for forest areas. Where traditional, community-based authority still exists, group land titles or secure long-term user rights should be provided. As in the case of forests and farmland, it is through the ownership of land and the associated natural resources, or at least the assurance of secure long-term exclusive use rights, that local participation in sustainable resource management can be mobilized and maintained. In better watered grazing areas, individual ownership of livestock farms will be possible (although crop farming may prove to be a more remunerative use of land and labor in many such situations), but this will be rarely feasible on drylands due to the patchy availability of water and the need for seasonal livestock movement. But exclusion of others -- i.e.,

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[4] The viability of this approach is demonstrated by the example of Machakos District in Kenya (see paras. 8.72-8.73).

elimination of open-access conditions -- is essential. At the same time, local communities and individuals need to be supported in planning and managing resource use, particularly in view of the increasing limitations imposed on the geographic mobility of pastoralists' herds. The micro-project funds which some donors have begun to establish are a suitable instrument to provide critically needed funding for this purpose. Technical assistance should come through extension agents, knowledgeable about conservation techniques.

E. Water

10.28 In large parts of Sub-Saharan Africa, water is the critical limiting resource, and conflicts over competing uses are becoming evident. In some areas, groundwater reserves are being drawn down for irrigation much faster than they can be replenished. Damming and diversion of rivers for irrigation or hydro-power development have often created serious problems downstream. These include the spread of water-borne and water-related diseases, intrusion of saltwater into groundwater aquifers in coastal areas, destruction of riverine woodlands and of wetlands of importance as wildlife habitat, destruction of downstream fisheries and of coastal wetlands critical for marine life and migratory birds, and coastal erosion. Water pollution from domestic sources has become a major concern in many areas, particularly around major cities, but also in countless rural areas where lack of safe potable water is the most serious public health problem. In some regions, pollution from agrochemicals is emerging as a problem, as it already is in other parts of the world.

10.29 With the primary exceptions of parts of coastal West Africa and the Congo/Zaïre River basin and adjoining parts of humid Central Africa, most of Sub-Saharan Africa is not endowed with abundant water. Moreover, only a portion of total potentially available water is actually accessible and useable. Geographical distribution of supplies, seasonal and annual variations in flows, topographic conditions and evaporation losses drive a large wedge between potentially available and realistically accessible water. Conflicting demands on water use and environmental considerations pose further constraints on the utilization of water (Falkenmark and Suprapto, 1992, pp. 33-34). In Europe, water management problems began to be encountered when water demand exceeded 20 percent of potential water availability (Falkenmark, 1991, pp. 88-89). Water quality is an important consideration as well. Not all sources of water are suitable for all uses, and water impurities and pollution can severely limit the range of uses to which a particular source of water can be put.

10.30 Demand for water is rising rapidly, driven by population growth and economic development. Except for the humid regions of Central and coastal West Africa noted above, almost all of Sub-Saharan Africa will be facing water shortages or water scarcity early in the next century. In many of the arid regions, this is already the case -- particularly during the dry season. WHO has suggested an average of 30 liters per capita daily (or about 11 m^3 per person annually) as the minimum needed to ensure adequate hygiene for urban populations in developing countries. Industrial water requirements depend very much on the size and type of industries; in industrialized countries, these requirements considerably exceed household consumption, even though the latter surpass the WHO standard cited above five to ten times. Agriculture is, and will continue to be, the largest consumer of water. In dry climates, the photosynthesis process consumes about 1,000 m^3 of water to produce one ton of biomass (Falkenmark and Suprapto, 1992, p. 31). Depending on agro-ecological factors (crops grown, soil characteristics, evapotranspiration rates, etc.) and on technical efficiency, feeding people by means of irrigated agriculture requires anywhere from 500 to 2,500 m^3 of water per capita per year. For many countries in Sub-Saharan Africa, the water that can be utilized at reasonable cost with available technological means will not be more than about 250 m^3 per capita annually by the year 2025, and for some (such as Kenya, Burundi, Rwanda, Malawi) it may be as little as half that amount. This has important implications for the type of agricultural and overall economic development strategies these countries will need to pursue.

It certainly underscores the urgency of initiating effective water resource monitoring and planning and of maximizing efficiency in water use.[5]

10.31 The many different uses of water can be variably grouped, depending on the objective of the analysis. One categorization distinguishes between consumptive, nonconsumptive and polluting uses (Frederiksen, 1992, pp. 24-25). Another differentiates between withdrawal uses and instream uses. Water used by households and industries and for watering livestock and irrigated crops represents withdrawal uses. Instream uses include water flow for fisheries and wetlands, for maintaining downstream water quality, for water transport, and for recreational uses. Power generation may involve instream uses (for hydropower generation) or withdrawal uses (for cooling thermal and nuclear power plants). While some instream uses are compatible with others, most demands for different water uses compete with each other and, in situations of increasing water scarcity, imply important trade-offs and potential conflicts.

10.32 This points to the urgent need for effective hydrological planning and for prudent demand management which involves planning, regulation, technology and pricing. Demand management means allocating among alternative uses, encouraging conservation, and protecting instream flow and water quality. Market mechanisms alone will not be adequate: "... the nature of the resource makes it difficult and in many cases impossible to establish efficient markets" (Frederick, 1993, p. 23). Well defined and transferable property rights are usually missing and very difficult, if at all, to establish. The full benefits and costs of a water transfer are not likely to be borne by the buyer and seller, because there are multiple and important externalities. And rarely will there be multiple and competitive suppliers of water, since the nature of the resource makes water supply a natural monopoly (*ibid.*, pp. 24-25).

10.33 Water must be recognized as the critical and limiting resource it is. It must be carefully allocated, beginning with the development of local and regional water use plans, and it must be protected against pollution. Project-by-project and sector-by-sector planning for water uses (water and sewage services, irrigation, flood control, hydropower, navigation, fisheries, industrial uses, and so forth) is prone to lead to conflicting and inefficient investment decisions. In the absence of prices for water that reflect its scarcity, planning must be based on natural hydrological units such as river basins to ensure that the opportunity costs associated with different water uses are properly considered. Such planning should be integrated with planning for land use and other activities that affect, and are affected by, water development. Water management plans will need to assess water availability against likely demand (taking into account anticipated population growth and urban/industrial development), develop options for water supply (including costs), as well as options for demand management and conservation.

10.34 Given the frequent occurrence of drought, many water sources in semi-arid and arid parts of Sub-Saharan Africa are very vulnerable to wide annual variations in flow volume and, hence, in supply. In these regions, water use plans must allow adequate margins for safety and establish clear priorities among competing uses. In many arid and semi-arid regions, water supply constraints will imply that large-scale irrigation cannot be the primary priority in allocating water among different uses. Where this is not recognized, capital investments designed to abstract surface or groundwater for irrigation and to

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[5] An effort has been underway since 1986 to establish the information base for sound water resource planning in Sub-Saharan Africa. A number of multilateral and bilateral agencies (including the ADB, UNDP, UNDTCD, WMO, the World Bank, the EEC, and France) are collaborating in a multi-year program, *Sub-Saharan Africa Hydrological Assessment*, to assist all SSA countries in creating or improving a sound hydrometric base for the purpose of planning and evaluating water resource development programs and projects. This effort covers surface water resources, hydrometeorology, and groundwater. Initial reports for a number of countries are available from the World Bank's Agriculture and Rural Development Department.

develop land for irrigated farming may later need to be abandoned as the requirements for human and livestock use increase.[6]

10.35 Water resources frequently are shared among countries. This points to the importance of close cooperation in planning for long-term water sharing if riparian disputes are to be avoided.

10.36 The economics of water supply are important. Many irrigation and water supply schemes are excessively costly -- and uneconomic. Conservation efforts on currently used supplies or demand management through more rational water charges can obviate expensive new investments in water supply, especially for irrigation. Water user associations should be given much greater management responsibility in operation and maintenance of water schemes, in rural potable water supply schemes as well as in irrigation systems.

F. Common Elements

10.37 There are a number of common elements to the recommended strategies and approaches for conserving and sustainably managing Africa's natural resources and lessons from the limited experience to date:

(a) The overall policy and legal framework must be consistent with the conservation objective. For example, local communities need to be authorized to participate in the management and benefits of protected areas and the wildlife and other resources they contain. Resistance to this concept remains strong in most of Sub-Saharan Africa, as governments generally believe that benefits reaped from conservation areas should accrue to all citizens. Compromises will have to be made. For example, taxes can be levied on local community receipts from tourism, so that benefits may be shared more widely.

(b) Social and institutional factors constrain implementation of community-based conservation strategies. The major problems are the general weakness of community organizations and the vastly unequal distribution of authority between the national and local levels. Most local communities in forest, range and wilderness areas are poorly organized and difficult to organize. Outside assistance is nearly always necessary.

(c) Only in a small number of cases can protected areas be expected to generate sufficient revenues from non-exploitative uses (such as eco-tourism) to provide significant local income or to support significant rural development. In most cases, external financing will need to be provided on a long-term basis. The national and international communities must contribute to the cost of maintaining the national and global heritage represented by the areas being protected.

(d) Creation of an institutional and management capacity in government is a difficult process. This is rarely, if ever, the highest priority of governments; as a result, government agencies charged with managing natural resources are usually neglected and financially strained. Again, international assistance is essential.

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[6] Climate change is likely to have significant impact on water supplies and regional hydrological systems, particularly in regions already facing water shortages. This makes prudent planning so much more important. Even relatively small changes in precipitation and temperature can have significant effects on the volume and timing of runoff, especially in arid and semi-arid regions (Frederick, 1993, p. 63).

(e) In the absence of agricultural intensification outside the areas to be protected, conservation efforts are bound to fail. Only rapid increases in output per unit of land will induce fast growing populations to stay out of the remaining intact forests and other ecosystems that should remain undisturbed.

10.38 Conservation of biodiversity depends directly upon preservation of natural habitats, particularly tropical moist forests which contain the greatest diversity of species outside of certain marine environments. Habitat destruction is the greatest cause of extinction of species overall. However, for certain species which are acutely endangered by commercial exploitation, additional protection is needed in the form of controls on harvesting and on international trade. Such controls can only be effective if the governments of both "producing" and "consuming" countries are committed to enforcing them.

10.39 While better and more effectively protected area systems are essential, the single most important factor to ensure the preservation of land-based natural ecosystems will be meeting the demand for food, wood and other agricultural and forest products on a sustainable basis. Soil and water resources must be protected by protecting important watersheds -- by maintaining natural forests and, where these are already degraded, by re-planting or allowing natural regeneration to take place. The critical question of meeting the needs for woodfuels and timber must be addressed from both the production and the demand side. While commercial logging of remaining primary moist forests should be greatly reduced (if not banned entirely), because the available evidence indicates that it cannot be sustainable, there must be a major increase in resources for the sustainable production of fuelwood and construction wood. This must come from farm forestry, as well as from industrial plantations and well-managed production forests located in areas where the original forest system has already been substantially altered by logging. At the same time, energy conservation must be promoted, both through economic policy measures (e.g., pricing) and through the development and extension of technical innovations.

10.40 The most important element is agricultural intensification outside the forests and wilderness areas. Without agricultural intensification the forests and wilderness areas of Sub-Saharan Africa stand little, if any, chance of survival in the longer run. The ultimate environmental collapse can be postponed by reducing the rate of population growth. The preferred option combines maximum agricultural intensification with sharply curtailing population growth and far more determined and effective management of environmental resources.

The Role of Governments

10.41 There are important functions to be fulfilled by government agencies, and there is an urgent need to develop the requisite institutional and human capacity to undertake these. They include carrying out resource inventories and mapping, preparing land use plans, managing protected areas, and monitoring logging and the use of agricultural, pasture, wetland and fisheries resources (see also para. 10.20). Governments also need to develop the capacity to undertake environmental assessments of development projects in order to avoid unacceptably negative environmental impact.

10.42 Governments should focus their direct management efforts on a much smaller share of the total national land and forest resources -- i.e., those areas that provide public (and global) benefits and goods. This will consist mainly of parks and other protected conservation areas where there are important externalities that local populations cannot be expected to finance or otherwise support. Even there, local participation will be necessary. The local people should be given incentives to conserve the resource endowment of the protected area through the confirmation of exclusive hunting and gathering rights, the provision of employment opportunities in the various support services required to manage protected areas, and a share of any user fees that are collected from outsiders.

10.43 NGOs can play important roles in assisting local people in managing natural resources. Where they are ready and willing to assume this role, they should be given wide room to do so.

10.44 Governments should also intensify their efforts to provide effective and locally relevant environmental education through the school system and through mass media. Agricultural extension staff should similarly be utilized to spread awareness of environmental issues, and especially of soil, water and tree conservation techniques, among rural populations.

10.45 A problem common to all natural resources is that financial returns to conservation are often lower than economic returns. Individuals and private enterprises will therefore tend to undertake less conservation and more exploitation than is economically optimal. In circumstances where the economic returns to conservation are high, but the financial returns too low to induce adequate conservation by private resource users, taxes on natural resource use (logging fees, mining royalties) and subsidies for conservation (free extension advice to farmers, cost-sharing for soil conservation activities) are likely to be justified to close the gap between economic and financial returns. Making this determination, and imposing the necessary taxes or providing the required subsidies, are functions of Government.

Global Cost-Sharing of Tropical Forest Conservation

The benefits of conserving tropical forests will accrue to the entire world, while the costs will have to be borne almost entirely by the countries in which the forests are located. This has stimulated efforts to compensate the producing countries for income foregone as forests are taken out of production and placed under protection. The first such efforts were *debt-for-nature swaps*. Although not many swaps have been organized in Sub-Saharan Africa, there is considerable potential for them in many parts of the continent. The principle is that governments set aside as a protected reserve large tracts of forest or wildland, usually managed with the help of an NGO, in return for the purchase of some amount of the country's discounted external debt by that NGO (or organized by it).

Another important recent initiative has been the *Global Environmental Facility* (GEF) under which funds have been made available to countries as compensation for reducing activities that are remunerative but that significantly compromise biodiversity (such as logging), contribute to carbon dioxide emissions (such as forest burning), or produce CFCs. Experience with this facility is now under review, before decisions will be made on modalities for a second phase. Setting aside of intact tropical forests as reserves and parks is a good candidate for funding under this facility.

G. National Environmental Action Plans

10.46 The development of national environmental resource management strategies must be a national affair. The main instrument for this process is the National Environmental Action Plan (NEAP). NEAPs are currently being prepared or implemented with World Bank support by most African countries. They should contain strategies for addressing all of the issues of the Nexus. The NEAP concept is multi-sectoral in approach, and oriented to bottom-up participatory planning and implementation. It provides a framework for integrating environmental concerns with social and economic planning within a country. The objective is to identify priority areas and actions, develop institutional awareness and processes and mobilize popular participation through an intensive consultation process with NGOs and community representatives. Donor collaboration can also be effectively mobilized in this manner.

10.47 A successful national approach to environmental concerns involves several important steps:

- Establishing policies and legislation for resource conservation and environmental protection that are integrated into the macroeconomic framework and, if possible, assessing the costs of degradation. These were, for example, estimated to be between 5 and 15 percent of annual GNP in Madagascar and more than 5 percent of GDP in Ghana.

- Setting up the institutional framework, usually involving a ministerial or higher-level environmental policy body, developing mechanisms for coordination between agencies, building concern in these agencies, balancing private and public sector concerns, decentralizing environmental management, and assuring continuous contact with local people. The preparation of regional land use plans could be an important component. The basic framework needed to guide the implementation of land tenure reform, forest policy reform and other elements discussed above can also be included in NEAPs.

- Strengthening national capacity to carry out environmental assessments and establishing environmental information systems. This can be done to some extent by restructuring existing data and making them available to users. Pilot demand-driven information systems should also be initiated to strengthen national capacity to monitor and manage environmental resources. Local and regional research capacity will be crucial to the development of plants and technologies which are truly adapted to local conditions.

- Developing human resources through formal and on-the-job training; introducing environmental concerns into educational curricula and agricultural extension messages; and increasing public awareness through media coverage, general awareness campaigns, and extension services.

Geographic Information Systems

Lack of operationally meaningful and reliable environmental data is major problem. It tends to result in misconceptions about natural resource problems and the consequent risk that policy measures will be misdirected. Urgent needs include assessments of forest cover, soil erosion and soil capability, desertification risks, and the distribution of human and livestock populations. This is clearly an area in which donors can provide support and expertise and governments need to act. It is important to develop national capacity to gather and analyze information in-country: properly designed and operated Geographical Information Systems (GISs) can be extremely helpful in this regard. GISs make use of aerial photography, remote sensing and actual ground inspections and data collection. GISs will be particularly useful not only to monitor the progress of natural resource degradation and destruction, but -- more importantly -- to assess land capability for various uses and, thus, to provide the basis for sound land use planning.

10.48 NEAPs are intended to be evolutionary -- developing policies through field experience as well as national-level analysis. They should lead to the empowerment of the non-governmental sector, not just by providing funds for small-scale community activities through national environmental funds, but also by drawing large numbers of village and district representatives into consultative forums. A non-governmental advisory body was part of the institutional arrangements set up, for example, under the Lesotho NEAP.

10.49 Considerable external support has been provided for the NEAP process, from bilateral and multilateral agencies and NGOs (such as the World Wildlife Fund, the World Resources Institute, and the International Institute for Environment and Development). Donor expertise is made available to the countries undertaking NEAP preparation, and donor policies are coordinated in the process, with the NEAP forming the basis for coordination. Where NEAPs have led to the preparation of national environmental investment plans (as in Madagascar and Mauritius), donors have substantially oversubscribed the programs. An NEAP can therefore become the major preparatory instrument for addressing the issues discussed in this chapter.

XI. CONCLUSION

A. The Problem

11.1 The countries of Sub-Saharan Africa face three important challenges: (a) reducing the rate of population growth, (b) safeguarding their natural resource base, and (c) making agriculture, as quickly as possible, sufficiently productive to ensure rising standards of living for the rapidly increasing population without further endangering the resource base available for this purpose. Because these three challenges are closely interlocking, the ambitious indicative targets set out in Chapter VI are more likely to be achieved if the actions suggested in each specific area are successful.

11.2 Rapid population growth, environmental degradation, and slow agricultural growth in Sub-Saharan Africa are closely linked. The principal problem is that the technologies applied in shifting cultivation and transhumant pastoralist systems, appropriate under low population density conditions on Africa's fragile natural resource base, are environmentally damaging when practiced by rapidly increasing populations. When population densities increase and shifting around on the land becomes impossible, but farming practices do not change, soils degrade and forests are destroyed. Soil degradation and deforestation constrain agricultural growth. Lagging agricultural growth perpetuates rural poverty and food insecurity, which in turn impede the onset of the demographic transition to lower human fertility rates.

11.3 Past efforts have, on the whole, failed to reverse the downward direction of the spiral that is driven by the synergetic forces of this Nexus. The explanation, at least in part, appears to be that past efforts have been pursued too narrowly along traditional sectoral lines -- matching established institutional arrangements and traditional academic disciplines -- while crucial cross-sectoral linkages and synergies have been ignored. Environmental integrity and resource conservation are critical for sustainable long-term growth of agriculture, and of the economy. But this will be very difficult to achieve if present rates of population growth persist. Population growth is unlikely to decelerate unless there is more vigorous growth of agriculture, and of the economies dependent on agriculture. At the same time, agricultural growth based on traditional patterns of resource use and production technologies will be increasingly constrained by rapid population growth and the degradation of the environmental resource base.

11.4 A key conclusion of this study is that far more emphasis needs to be placed on efforts designed to promote effective **demand** for sustainable and environmentally benign farming technologies, for family planning services, for resource conservation. Considerable emphasis has been placed in most past sectoral development efforts on the supply side (efforts to develop and deliver technology and services), while the need to generate demand has remained largely unrecognized -- or at least poorly served. The synergies inherent in the Nexus provide considerable potential for addressing the demand side of these important problems.

11.5 There is low demand for small families, and there is inadequate supply of family planning services. Both are keeping total fertility rates (TFRs) high. Low demand for small families is due to cultural factors, high infant mortality, low education for girls, and limited family planning services. More contentious is the impact of economic incentives. High demand for child labor may be created by systems of shifting cultivation, severely constrained access by rural women to production inputs other than child labor, additional demand for child labor as part of a survival strategy in the face of poor food security and increasing degradation/depletion of soil and water resources. Demand for smaller families is manifesting itself, however, where the density of population on cultivated land is high, infant mortality is low, food security is high, and female school enrollment rates are high. Countries with these

characteristics are entering the demographic transition, and family planning programs are likely to be extremely effective there in responding to the strongly emerging demand for family planning services.

11.6 Forest degradation is stimulated by rapid population growth combined with shifting cultivation (people moving into forests to farm), poorly regulated logging, and "open access" land tenure. "Open access" occurs when there is no effective regulation of land use, either traditional or modern. This allows farmers and others to exploit the land, and the resources on it, in a non-sustainable manner. Fuelwood prices which are too low to cover replanting costs, are constraining fuelwood planting. Fuelwood prices are low because it can be mined, nearly freely, from open access areas. Where there is open access, trees can be cleared for farmland by migrant farmers.

11.7 Women's time is increasingly constrained in rural areas, as fuelwood and water become scarce. Women walk further for water and fuelwood as a result. Women have difficulty maintaining food output with less time available, contributing to food security problems.

11.8 Technological innovation which could permit traditional farming and livestock practices to evolve in an environmentally sustainable manner, is not keeping up with the present rapid rate of population growth. The present gap is enormous.

11.9 Lack of demand by farmers for new agricultural technology is as important as lack of supply of appropriate technology, in explaining slow agricultural growth. Lack of demand is related to several factors:

- Open access land tenure conditions are replacing traditional land tenure systems. In open access, land occupation and use is temporary and there is no incentive for the farmer to invest in farm intensification. Open access also reduces the incentive for farmers to conserve the land (since it is not theirs).

- There is often a lack of capital and financial resources with which farmers (especially women) can invest. This low income trap is operable in much of subsistence agriculture.

- Labor constraints on women often prevent them from adopting those technologies which are labor intensive.

- In much of Sub-Saharan Africa poor agricultural and economic policies, combined with currently low world prices for many agricultural products, have reduced the profitability of farming and hence the incentive to intensify farming. They have often restricted farmers' ability to participate fully in land management, marketing or price setting.

- Appropriate improved agricultural technology for farmers is often locally unavailable or unknown; there can be no effective demand for what does not exist or is not known to exist.

B. Recommendations for Action

11.10 To correct the current disastrous trends, a set of mutually reinforcing actions need to be undertaken by governments and donors. One of the most important will be to promote demand for smaller families and for family planning (FP) services. This needs to be effected through determined action in several areas -- notably expanding primary and secondary education for females, reducing infant mortality, and providing culturally sensitive FP advice and services. Field surveys to identify the determinants of fertility and attitudes to family planning will be essential. Population programs are being

prepared in about half of the countries of Sub-Saharan Africa. Political commitment will be necessary to implement them. Priority in establishing FP programs that emphasize increased supply should be given to countries where demand for fewer children is emerging -- as a consequence of increasing population density on cultivated land, improving female education, declining infant mortality rates, improved food security and better conservation of environmental resources. Where these factors are not satisfactory, demand for children will remain strong and will blunt the effectiveness of programs oriented towards increasing the supply and accessibility of FP services.

11.11 Where AIDS is a serious concern, even in the absence of the elements that appear to spur the onset of the demographic transition, high priority must be placed on providing appropriate information and education regarding the prevention of sexually transmitted diseases as well as condoms through all available channels, such as schools, health facilities, traditional health providers, FP programs, pharmacies, NGOs, etc.

11.12 Strong efforts are also needed to create farmer demand for "environmentally sustainable" agricultural technology. Means to accomplish this include expansion of appropriate research and extension to farmers, the elimination of open-access land tenure systems, and agricultural policy which makes agricultural intensification profitable (and reduces the relative profitability of shifting cultivation). The priority development of rural roads and markets in areas designated for agricultural development will be important in this regard. Agricultural research establishments must be developed to supply the appropriate technology. The recent elaboration of Frameworks for Action under the auspices of the Special Program for African Agricultural Research (SPAAR) merits strong support, as do related efforts to improve other agricultural support services such as extension. Funding is not so much the problem as is organization and management.

11.13 Agricultural services and education must serve women as much as men, to improve women's farming practices, raise their productivity and incomes, and stimulate reduced demand for children. Successful introduction of agro-forestry and fuelwood production on farms would significantly reduce women's work burden in fuelwood gathering. Introduction of appropriate transport improvements and stoves that save both fuel and time would also help. Improving rural water supply will save women's time. It will also reduce infant mortality, thus reducing the demand for more children. Success in these areas will free more of women's time for family management, agricultural production and other economic activities.

11.14 Measures necessary to create a market for fuelwood should be pursued. Fuelwood prices should reflect the scarcity value and replanting costs of trees. Higher prices would stimulate farmers and entrepreneurs to plant trees. This will require land tenure reform to eliminate open access to free fuelwood by farmers and entrepreneurs. It will also require extension advice to farmers on agro-forestry and fuelwood plantations. Eliminating price and taxation disincentives to the marketing of kerosene and other substitute fuels would stimulate the substitution of such fuels for woodfuels over time, particularly in urban areas.

11.15 The rate of degradation and destruction of forests and wildlands can be reduced by determined pursuit of agricultural intensification. This needs to be promoted through the measures indicated above, the elimination of open-access land tenure situations, keeping infrastructure out of environmentally sensitive areas, and more effective regulation and taxation of logging.

11.16 In each country, Environmental Action Plans should be prepared, and they should focus heavily on agricultural and demographic causes of environmental degradation in rural areas. A key instrument to be used in preparing solutions will be land use plans. These define the use, given various

demands, to which various types of land are to be put (forest, protected areas, agriculture, settlements, infrastructure, and so forth). A meaningful National Environmental Action Plan should be based on careful analyses of the issues discussed here and should incorporate an action plan for governments, affected communities and external aid agencies to address these issues and the linkages and synergies among them. In most cases, the action plan will consist of changes to agricultural research, extension and investment policy; increased focus on creating demand for family planning services and increased resources for population policy; greater emphasis on fuelwood and industrial forestry plantations and private tree farming; greater sensitivity to the environmental impact of all investments; more investment in natural resource conservation and protection; and land tenure reform. The role of women must be addressed far more effectively, notably in the areas of agricultural development, natural resource management, and education.

11.17 Infrastructure development in rural areas, particularly roads and water supply, is important for agricultural development and to focus population settlement outside of environmentally sensitive areas. Keeping infrastructure out of environmentally sensitive areas is an important tool for conserving those areas. Infrastructure investment in rural areas and in secondary towns merits considerably higher priority than it has received in most countries in the past. Infrastructure development should be in response to demand. This is likely to result in smaller-scale investments rather than massive engineering efforts which have to date characterized much government and aid agency spending. Demand responsiveness will be stimulated by more community and local control over infrastructure design and siting, by the use of local private contractors, and by funding facilities constructed and maintained by the user communities themselves.

11.18 Urban areas represent outlets for population increases, markets for agricultural products and fuelwood, sources of manufactured inputs and consumer goods for farmers, and centers for the provision of educational, health and other services. Urban development needs to be one component of land use plans. Further, urban policy should be developed in part as a function of likely growth of the urban population, linkages between urban and rural product and labor markets, communications needs in rural areas and environmental constraints. Generally, policies which promote development of secondary cities and rural towns, rather than of a few mega-cities, will be far more conducive to efficient, equitable and sustainable rural development. This requires spatially well distributed public investment which is not biased in favor of mega-cities, sound and substantial investment in infrastructure throughout each country (rather than concentration in mega-cities). It further requires functioning markets and market-based pricing for petroleum and other energy sources, avoidance of transport monopolies to increase the likelihood that the entire country is adequately served by private transport providers, promotion (through industrial extension, investment codes, credit facilities) of small and medium enterprises located in secondary cities and rural towns, and decentralization of political decision making outside capital areas to facilitate greater responsiveness to demand. These are not only crucial elements of sound urbanization policy, but are important for rural development because well functioning secondary towns and cities are more likely to provide services and markets for rural areas than are distant mega-cities which tend to be heavily oriented to overseas suppliers.

11.19 Local communities need to be empowered to participate in all of the above. Without participation, people will not demand smaller families, sustainable agricultural technologies, road maintenance or forest conservation. Participation is more likely to result in development initiatives which respond to felt needs rather than to short-term political imperatives and expediencies. People should become managers of actions conceived in partnership with Governments.

11.20 Multi-sectoral and cross-sectoral analysis is needed to resolve agricultural, population, settlement and environmental problems -- because of the important linkages and synergy between them. Environmental protection will be very difficult to achieve if present rates of population growth continue. Population growth is unlikely to decelerate unless agriculture, and the economies dependent on agriculture, grow more rapidly. Agriculture will be increasingly constrained by rapid population growth. Settlement and urban development policies are important factors influencing population growth and movement, agriculture and environmental resource use. In this regard, the analysis suggests that spatial planning is desirable and that action plans covering the various sectors should be integrated at the regional level. In particular, land use plans should be developed with a spatial and regional focus. These should identify conservation areas, logging areas, farming areas, and locations for settlements and infrastructure development. Appropriate farming technologies vary from one micro-agro-climatic zone to the next. Infrastructure development is location-specific. Land tenure systems, fuelwood problems, gender responsibilities in farming, and cultural factors affecting attitudes towards human fertility vary among regions, and often from place to place, within the same country. There is therefore merit to developing integrated action plans for regions within countries. Such plans would address the wide range of issues and concerns applicable within that region -- appropriate land uses, demographic trends, likely migration patterns, natural resource management, the development of transport and other infrastructure, agricultural technology, land tenure reform and land ownership, fuelwood demand and supply, forestry development and utilization, likely development of markets, towns and cities, and so forth.

11.21 Far greater community involvement in the preparation and the execution of these location-specific plans will be essential. Communities and individuals must be given ownership of natural resources as an incentive for them to manage and conserve these resources. Better planning, particularly spatial planning, community and individual ownership of assets, and community management of implementation are the main directions in which donors and governments must move.

11.22 Because such multi-sectoral action plans will be complex and difficult to implement, they should in most cases not be implemented through integrated multi-component projects. Conservation and land use plans specified by location would be one cluster of projects. Appropriate agricultural technology for each micro-region could be developed and extended through national research and extension programs, with regional implementing divisions. Regionally specific land tenure reform could be implemented under national tenure reform programs. FP programs adapted to particular communities would be implemented through national population and family planning programs. Urban and infrastructure development will constitute separate projects. But there needs to be a sensible fit between these separate projects and investments, given the synergies and complementarities between them.

11.23 Several other important recommendations emerge from this study concerning analytical work that should precede the formulation of action plans and, particularly, of developmental interventions -- be they investment projects or institutional and policy reforms.

- Far greater attention needs to be paid to the social organization of production and consumption, of decision-making and resource allocation, of access to resources and services. These systems and structures can be very complex and often differ substantially among communities (and certainly among countries) throughout Sub-Saharan Africa.

- This implies the need to use relevant "units of analysis". The casual and often indiscriminate use, for example, of the "household", the "family" and the "family farm" may not be appropriate if these terms are simply assumed to convey concepts of social and economic arrangements familiar to 20th-century industrialized economies. Most African societies are characterized by complex systems of resource-allocation and -pooling arrangements for both

production and consumption purposes, based on lineage, kinship, gender and age-groups -- often with multiple overlaps. It is imperative to be cognizant of, and sensitive to, these and to analyze the impact of development interventions on individuals in this context.

- Gender issues are critical, especially in terms of gender-specific divisions of responsibilities, tasks, and budgets, as well as in terms of access to resources, information and markets. Interventions and incentives do not necessarily work in the same direction or with the same intensity for men and women.

- More input is needed from sociologists and anthropologists to understand socio-economic systems and relationships. Social scientists should collaborate closely with agricultural scientists and economists in researching farming systems, cultures and socio-economic institutions into which new varieties and technologies are to be introduced. Agriculturalists and economists in turn should receive special training to raise awareness of these issues. Local expertise needs to be much more drawn upon to improve our understanding of how things operate, why they operate this way, and what may work under these conditions.

- Extremely important is the need to take into account the risk perception of the local people -- their absolute requirement for ensuring survival in the short term even under worst-case scenarios.

C. Status of Implementation

11.24 The above recommendations are broad and need adapting to each country's special circumstances. In some countries, these ideas are already being pursued:

(a) Many countries in Sub-Saharan Africa are pursuing macro-economic and agricultural policy reform programs designed in part to improve the profitability of agriculture; this will stimulate the needed agricultural intensification. Other countries do not yet pursue policies which would make agriculture profitable. Also, many donor countries maintain a combination of import barriers and agricultural subsidies to assist their own farmers, and this harms African producers of these commodities. These policies need to be changed.

(b) An increasing number of countries in Sub-Saharan Africa are now developing environmental action plans. For these countries, implementation is the watchword. In the others, the process should be launched. Donor support should be intensified.

(c) Agricultural research and extension systems in a number of countries are slowly shifting to a greater focus on "sustainable" agricultural technology and responsiveness to varying farmer demand. Collaborating within SPAAR, countries in the Sahel and SADCC regions are planning the improvement of their agricultural research systems. Others should follow suit, and donors should collaborate in implementing SPAAR's "Frameworks for Action".

(d) At least four Sub-Saharan African countries (Botswana, Kenya, Mauritius and Zimbabwe) have, with considerable effort, succeeded in bringing down fertility rates. Much more needs to be done here in all SSA countries, but these four provide relatively successful models. Several others countries are now developing promising population and family planning programs. Genuine and sustained political commitment will be essential. Donor support should be channelled through the ongoing African Population Action Plans.

Kenya: The Nexus Synergies at Work

In Kenya, population density on cultivated land is high. Education is relatively good, and females participate. Infant mortality has declined due to relatively good health care, food security and women's education. Agricultural policy has been quite good, smallholder commercial farming is profitable, and private sector participation in all aspects of agricultural production, marketing and processing is high. Land tenure security is assured (although there have been problems with land grabbing by influential elites as well as with the land rights of livestock herders and of women). Women are receiving attention from the agricultural extension service. Family planning programs are in place. Popular sensitivity to the costs of environmental degradation is high, and there has been successful environmental conservation action in the form of a national soil conservation program, the maintenance of sizeable national parks, and the widespread tree planting under the Greenbelt Movement promoted by a national NGO working almost entirely with women. Urban bias in economic policy is less pronounced than elsewhere in Sub-Saharan Africa, and the development of secondary towns and cities characterizes Kenya's urbanization policy. Relatively good infrastructure, including a country-wide network of roods, has been developed.

The combination of these (and other) factors has had a number of desirable results. Agricultural growth has been averaging between 3 and 5 percent per annum. Tree farming and other agro-forestry activities have increased, and the area under trees may now in fact be expanding. There is at least marginally effective protection of national parks and of wildlife. Farmers participate in marketing decisions, with farmer-managed cooperatives playing a significant role. Kenya's urban markets are stocked with Kenyan farm products, assembled in rural markets and secondary towns and brought to market largely by private traders. And the TFR has begun to decline measurably in recent years.

(e) Improved health programs, including health education and the distribution of condoms, to address the AIDS problem are starting up in several countries.

(f) The empowerment of local communities to manage development in each of the above areas is now beginning to be accepted in some countries; it requires much more effort.

(g) Slow land tenure reform, inappropriate fuelwood pricing, and feeble rural infrastructure programs are major weak points everywhere.

11.25 In many countries of Sub-Saharan Africa, major deficiencies remain to be addressed in rural health care and education (and particularly female education), rural infrastructure, promoting greater participation of local communities in development efforts, forest and conservation policy, land tenure reform, sound urbanization policy, and effective family planning programs.

11.26 Several SSA countries are pursuing many of the policies suggested here. By bringing much of this together, they are obtaining positive synergies between agricultural growth, environmental protection and reduction in human fertility rates. Kenya, Zimbabwe, Botswana and Mauritius are examples. They strongly suggest that the type of measures recommended here are likely to be effective. Others, such as Ghana and Tanzania, are moving in the right direction.

D. Issues and Follow-Up

11.27 Many issues touched upon here require more focused and detailed research and analysis. Among them are the following:

(a) There is a need for further research to ascertain the relative importance of the various factors that influence human fertility decisions and trends. Gender-specific analysis is particularly essential in this area.

(b) The expected impact of AIDS on population growth has been incorporated in the most recent population projections used here. However, given the difficulty of predicting its impact, the

possible margin of error is considerable. More research is needed. Should AIDS turn out to have even more devastating impact on demographics than currently anticipated, improved health care, FP services and education focused on preventing sexually transmitted diseases and increasing the use of condoms could become the single most important intervention to be undertaken in Sub-Saharan Africa.

(c) More analysis is needed concerning the productivity potential of the environmentally benign and "sustainable" agricultural technologies identified. The environmental effects of "green revolution" technologies also need careful study.

(d) Work is needed to determine and test the degree to which communities and community groups will be conservation-minded if and when natural resource management is turned over to them by governments.

(e) Urbanization and the urban-rural link are important determinants of key aspects of the agriculture-population-environment Nexus. More research is required in this direction.

(f) There is some argument with the contention of this study that, although multi-sector planning is necessary, multi-sectoral projects to implement such plans may be undesirable. Some writers suggest that regional development plans could in many cases be implemented in an integrated fashion. Although this makes conceptual sense, the disappointing past experience with integrated rural development projects suggests that such programs are too complex to be managed as integrated wholes. How best to implement integrated location-specific plans through manageable components remains an issue to be explored.

(g) The equity impact of these recommendations needs further scrutiny. Reducing open access to land, expanding the areas under protection, raising the price of woodfuels will have negative effects on some of the poor. However, improved agricultural technology successful family planning, better access to rural health and education facilities and services, improved rural infrastructure, sound urban development will have positive impact on the poor.

11.28 The follow-up to this study has been launched. It includes the preparation of country-specific population, agriculture and environment nexus studies in Côte d'Ivoire, Ethiopia, Malawi, Kenya's Machakos District, Nigeria, Rwanda, and the Sahelian countries as a group. These studies will help firm up the analytical framework and will be instrumental in adapting the analysis to the situation of specific countries. The study was the most important input for a revised agricultural development strategy for Sub-Saharan Africa recently prepared by the World Bank's Africa Region (Cleaver, 1993). Follow-up also includes widespread incorporation of Nexus issues in environmental action plans and in investment projects. Concurrent monitoring is underway regarding the progress of preparation and implementation of national environmental action plans and of national population programs. The institutional locus for the former is the "Club of Dublin", comprising representatives of African governments and donor agencies. The institutional arrangement for deepening the population agenda for SSA and for monitoring its progress is the African Population Advisory Committee, with similar membership. It is hoped that a similar African Agricultural Advisory Committee, managed by prominent Africans, will also be established.

Annex: Statistical Tests of Key Hypotheses

I. Pooled Cross-Country Time Series Analysis

A. Methodology

1. Statistical analysis was undertaken to test some of the hypotheses discussed in this study. The statistical tests were imperfect because of lack of data and/or poor quality of some of the available data. Reliable data on environmental resources and their degradation or destruction are particularly difficult to obtain, but agricultural statistics are also often of limited reliability. Nevertheless, considerable effort was devoted to collecting data and verifying their validity by comparing different sources.

2. This section describes the methodology and data used in the pooled cross-country time series analysis referred to at the end of Chapters III and IV. Section II describes a separate analysis of the same hypotheses, using a different data set with single observations for each variable for each country. These two separate analyses were undertaken to determine how robust the results are.

3. In general the most complete data set currently available was used. Data are too voluminous to be reproduced here, but the sources are listed. Data were collected for 41 countries in Sub-Saharan Africa. (Cape Verde, the Comoros, Mauritius, Sao Tome and Principe, and the Seychelles were excluded because of their special features as small islands.) The inclusion of countries in any specific statistical test was based solely on the availability of data. The same is true for the length of the time series: the largest common denominator of available data was used. There is a trade-off between the number of countries that can be used and the length of the available time series. In some cases, several sets of regression were conducted -- some with more countries and shorter time series, and vice versa. This allows for additional insights in terms of analyzing the stability of results with changing samples.

4. Many of the relationships hypothesized and discussed in the study could not be analyzed -- either because data were not available, or because they simply cannot be investigated statistically using aggregated data. In some cases independent variables, such as the role of women in society or the influence of different land tenure systems, could not be quantified and therefore had to be excluded. However, limited testing may establish the plausibility of several of the hypotheses.

5. The methodology used was pooling cross-sectional and time series data (panel data) and estimating a fixed effects model. The fixed effects model allows for differences in the means of the observed variables in different countries. This is particularly important, because there clearly are differences among countries which cannot be explained by the independent variables considered. However, the assumption is that the independent variables influence the dependent variable in the same manner. Technically, this assumes that there is a common vector of slope coefficients. For example, if there is an increase in primary education for women and a decreasing TFR (or vice versa), the result would be a negative coefficient for female primary education.

B. Statistical Analysis to Explain Inter-Country Variations in Total Fertility Rates (TFRs)

6. The available data were used to test several of the findings from the country-level analysis concerning the determinants of TFRs in Sub-Saharan Africa.[1] In general, first differences of the time

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[1] A list of all abbreviations used in the annex is provided at the end of the annex.

series were used to minimize the problem of autocorrelation.[2]

7. Unfortunately not all data are available in time series form. Important factors like "use of contraceptives" and "strength of family planning programs" therefore had to be excluded from the analysis. In the case of the latter, a purely cross-sectional estimation was attempted, but the results appeared to be insignificant, presumably because the inter-country differences outweigh the influence of the independent variables when no intra-country time series are used.

8. For the statistical test, TFRs are hypothesized to be related to the independent variables as follows:

- positively to infant mortality (the higher the expected loss of infants, the more births per woman to ensure a "sufficient" number of surviving children);

- negatively to food security (the greater the food security, the lower the need for children to provide labor for food production since sufficient other factors of production are available);

- negatively to urbanization (the higher the degree of urbanization the lower the TFR);

- negatively to female school enrollment, both at the primary and the secondary level (better educated women want and have fewer children);

- positively to the cultivable land per person (the more cultivable land per person, the greater the need for family labor, or, in other words, the higher the marginal productivity of child labor); and

- positively to the rate of deforestation (the higher the rate of deforestation, the greater the need for child labor to help with wood gathering and water fetching).

9. Because important data were not available, a number of countries were excluded from the analysis: Botswana (missing: area under permanent crops); Djibouti (missing: calories, area under permanent and temporary crops, education); Equatorial Guinea (missing: calorie intake, education data from 1984 onwards); The Gambia (missing: area under permanent crops); Lesotho (missing: area under permanent crops and under forest); Namibia (missing: education); and Niger (missing: area under permanent crops).

10. Lack of data on education constrained the length of the time series used. Education data were not (continuously) available before 1970 or after 1989. In addition, depending on the length of the time series considered, more countries had to be omitted because of missing education data for recent years.[3] This lack of data had the additional effect of necessitating the use of a different sample depending on the length of the time series -- providing some insight about the stability of the results with changing samples.

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[2] To determine the autocorrelation coefficient, a method similar to the Hildreth-Lu operation was used, which entails maximizing the likelihood function by taking quasi-differences of the time series. The standard Hildreth-Lu command in most statistical packages is not applicable for panel data, as it also takes quasi-differences for the country dummies. The likelihood function was maximized at an autocorrelation coefficient (rho) close to one (at least 0.98, depending on which dependent variables entered the regression), with results similar to using rho = 1, which is equivalent to using first differences of the time series.

[3] Missing were: 1989: Benin, Ethiopia, Guinea Bissau, Kenya, Malawi, Mauritania, Sierra Leone, Togo, Uganda, Zambia; 1988-89: Gabon, Mozambique, Zaire; 1987-89: Liberia, Sudan; 1986-89: Côte d'Ivoire, Somalia.

11. The lag structure on the independent variables is to some extent arbitrary. Given the lack of an underlying definite theory about the length of time which has to elapse until an independent variable affects the TFR, a very simplistic lag structure was chosen: in all cases the independent variables were lagged by one year.

Conclusions for Total Fertility Rates

12. Education. Both primary and secondary female education have a significant negative impact on the TFR. The level of significance of these results is fairly high (from 0.7% to 3.3%). This significance level, derived from the T statistic, indicates with a probability of between 99.3% and 96.7% that the coefficient is not zero.[4] These results confirm that the higher the level of female education, the lower the total fertility rate.[5]

13. Calorie Intake. Calorie intake as percent of the minimal requirement is not significant at the 10% level. In addition, the sign of the coefficient is positive and not -- as had been expected -- negative.

14. Infant Mortality Rate. As hypothesized, the IMR is a significantly negatively correlated with the TFR. The level of significance is very high, in all panels even at the 0.005 level, with very high t-statistics.

15. Urbanization. The degree of urbanization has a negative impact on the TFR as hypothesized. However, this result is not stable regarding the panel of data used. The coefficient is significant when a panel with long time series (16, 17 and 18 years) is used (significance 0.4% to 6.4%). However, if shorter time series are used, the coefficient turns insignificant.[6] This supports findings of other studies that the impact of urbanization in Sub-Saharan Africa on key determinants of the TFR has been slower to materialize than in other regions, and short time series therefore do not pick up the long-term trend. The case of Côte d'Ivoire is curious, in that certain specific features of the country (high immigration from the Sahel countries, TFR substantially higher than average, urbanization higher than average) are enough to change the coefficient from negative to positive when this country is included in the panel.

16. Cultivable Area. The hypothesis is confirmed that the TFR is higher the greater the potentially cultivable area per person.[7] The coefficient on per capita cultivable area turned out to be positive -- as hypothesized -- and highly significant.

17. Deforestation. If cultivated area per person (per capita land under annual and permanent crops) instead of cultivable area is used in the regression, the coefficient on deforestation is highly significant (at the 5% level) and positive -- suggesting that the higher the rate of deforestation, the higher the TFR. However, if cultivable area per capita (adding per capita forest area) is included in the equation, the rate of deforestation turns insignificant (but still positive). This is probably because the two variables are correlated and should not be included in the same equation.

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[4] In some cases different lag structures were investigated. For instance, for primary education a lag of 5 years leads to even stronger results.

[5] Some studies suggest that the first three years of female education actually increase the TFR and that the TFR only declines with further education. This hypothesis could not be tested because of lack of data.

[6] Regressions were also run with different groups of countries, numbering from 27 to 32, and with a truncated time series of only 15 years. Omitting three years was enough to lose the significance of the coefficient on urbanization.

[7] The sum of the area under annual and permanent crops plus the area under forest, divided by the rural population.

Model: D1TFR = α*country dummies + β1*D1ED1FF(-1) + β2*D1ED2FF(-1) + β3*CALPCT(-1) + β4*IMR(-1) + β5*URBPCT(-1) + β6*DP1PCFOR(-1) + β7*PCCULTIVABLE(-1) + Error Term
All independent variables lagged by one year.

Variable:	Primary Education (Female)	Secondary Education (Female)	Calorie Intake (Percent)	Infant Mortality Rate	Degree of Urbanization (Percent)	Deforestation	Cultivable Area	Adj. R^2
486 Observations 27 countries, 18 years: 1972-89	**negative** -2.30 [2.2%]	negative -1.96 [5.1%]	positive 0.88 [38.0%]	**positive** 4.55 [0.0%]	**negative** -2.90 [0.4%]	positive 1.17 [24.5%]	**positive** 2.01 [4.5%]	0.4315
510 Observations 30 countries, 17 years: 1972-88	**negative** -2.34 [1.9%]	**negative** -2.06 [4.0%]	positive 1.39 [16.6%]	**positive** 4.88 [0.0%]	**negative** -2.42 [1.6%]	positive 1.25 [21.1%]	**positive** 3.74 [0.0%]	0.4536
512 Observations 32 countries, 16 years: 1972-87	**negative** -2.43 [1.5%]	**negative** -2.07 [3.9%]	positive 1.14 [25.6%]	**positive** 4.69 [0.0%]	negative -1.86 [6.4%]	positive 0.67 [50.4%]	**positive** 4.68 [0.0%]	0.4604
495 Observations 33 countries, 15 years: 1972-86	**negative** -2.76 [0.6%]	**negative** -2.10 [3.6%]	positive 1.12 [26.5%]	**positive** 4.61 [0.0%]	negative -0.53 [59.5%]	positive 0.23 [82.0%]	**positive** 4.39 [0.0%]	0.4459
510 Observations 34 countries, 15 years: 1972-86	**negative** -2.77 [0.6%]	**negative** -2.03 [4.3%]	positive 1.33 [18.5%]	**positive** 4.64 [0.0%]	positive 1.87 [6.2%]	positive 0.24 [81.3%]	**positive** 3.93 [0.0%]	0.4409

Note: Since the value of the coefficient cannot readily be interpreted, only sign, T-statistic, and level of significance (in square brackets) are displayed. For more details see the appendix. Whenever coefficients were significant at the 10% level they are underlined, when they were also significant at the 5% level they are also bold.

The following countries were included in the regressions: 27 countries: ago ben hvo bdi cmr caf tcd cog eth gha gin gnb ken mdg mwi mli mrt nga rwa sen sle swz tza tgo uga zmb zwe; 30 countries: included also gab moz zar;
32 countries: included also lbr sdn; 33 countries: included also som; 34 countries: included also civ

C. Variations in Crop Yields Among Countries

18. Many of the relationships hypothesized and discussed in this study cannot be investigated statistically using aggregated data. Especially regrettable was the lack of time series data on fertilizer used on specific food crops and of data on road density (also as a proxy for access to markets). However, limited testing may establish the plausibility of several of the hypotheses:

- Countries with a policy environment more conducive to profitable market-oriented farming should have higher crop yields than countries with less conducive policies.

- Crop yields should be higher where population is growing most rapidly relative to cultivated land. People begin to intensify agriculture as cultivable area per person declines. Hence, statistical analysis should show an inverse relationship between area cultivated per person and crop yields (other things equal). However, the hypothesis of the study suggests that the rate of growth in yields stimulated by declining availability of cultivable land per person will be significantly lower than the rate of population growth.

- Schooling, especially at the primary level, of both men and women, should facilitate the adoption of intensive farming techniques and therefore be associated with higher crop yields.

- Ceteris paribus, countries with more rapid degradation of their natural resource endowment, as reflected in higher rates of deforestation, should have lower crop yields.

- Efforts to stimulate intensification (through the promotion of fertilizer use, for example) will significantly accelerate the increase in crop yields beyond the rate stimulated by rising population density alone. This should be observed as higher yields in countries with higher intensities of fertilizer use (all other things equal). Unfortunately no data were available on the use of fertilizer on specific crops.

Data Limitations

19. One major limitation of the data was the availability of information on drought. As droughts affect crop yields, no matter how conducive all other factors are for generating high yields, the observation period had to be limited to the decade of the 1980s for which drought data were available.

20. Another shortcoming was the availability of data indicating whether the policy environment in a country is conducive to stimulating agricultural output or not. The cross-sectional technique used in the study complicates matters. Using indices, which are more meaningful in a single-country study, is not a good procedure in a cross sectional study,[8] unless these indices can be scaled to a common denominator. Thus, nominal protection coefficients (NPC) for traded food crops, as collected by Jaeger, were used to measure the distorting effects of policy (Jaeger, 1992, p. 53). An NPC greater than 1 reflects a subsidy to producers, an NPC less than one indicates a tax on producers. This implies that the natural log of the NPC (LNNPC) is positive if producers are subsidized and negative if they are taxed. Thus, we would expect the coefficient on the LNNPC to be positive, reflecting that producers intensify production under a favorable policy and diminish production under an unfavorable policy. Unfortunately,

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[8] The choice of the base year for constructing an index does not affect results when only one country enters the analysis, as the only effect is a change of the magnitude of that single coefficient, not the sign nor the T-stat or the level of significance. In a cross-sectional study, indexing per country (for instance, real producer price relative to a base year) leads to severe problems as the mere choice of the base year affects all coefficients.

NPCs were not available beyond 1987, and even until then not for all countries. Because the data set for NPCs was limited, two sets of regressions were conducted. One included the NPC (thereby restricting the number of observations which could be used and diminishing the statistical power of the test), and one omitted the NPC. This procedure is problematic, because the omission of the NPC (if it belongs into the estimated model) causes results to be biased. Results from these regressions should therefore be interpreted with caution.

21. In all cases a lag of 5 years on both the NPC and primary education was used, in order to take into account the "lead time" aspects of agricultural policy as well as of education. Choosing this lag structure is, however, somewhat arbitrary. Unfortunately, the sample of usable observations was very limited. In the cases of cereals, rice and cassava it comprised 10 countries, for maize and sorghum 9, and for wheat only 6 countries.

Results

22. The table on the following page displays the results of the analysis.

- As expected, the coefficient on drought is negative and in all cases (except for rice) significant at the 10% level or better.

- As hypothesized, the coefficient on the NPC is positive -- except for cassava, where it is highly insignificant (65%). In the case of cereals and sorghum, it is significant at the 10% level.

- As hypothesized, the coefficient on primary education is positive -- except for cassava and maize, where it is highly insignificant (85% to 96%).[9] In the cases of rice and sorghum, it is significant at the 10% level.

- As hypothesized, the coefficient on per capita land under annual and permanent crops is negative, except for cassava, where it is highly insignificant (86%). In the cases of rice and maize, it is significant at the 10% level.

23. The results on cassava are strikingly different from all other results. Neither the NPC, nor primary education, nor per capita farm size seem to affect cassava yields. Several of the specific features of cassava might lead to these differences. Cassava is a subsistence crop and rarely traded on international markets. It is therefore understandable that cassava yields are not influenced by agricultural policy, as "measured" by the NPC. Also, cassava production is not necessarily from the same year as it is planted, as cassava can be "stored" in the ground for up to two years.

24. In all but the cases mentioned above, the coefficients have the expected sign:

- Drought has a significant negative effect on agricultural output.[10]

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[9] The apparent lack of impact of primary education on maize yields is somewhat surprising, given the importance of education for rice and sorghum production.

[10] Except for rice with a level of significance of only 14.8%. This might be due to the fact that much rice is grown with irrigation and thus not as much affected by drought as other crops.

Dependent Variables: Crop Yields. Small sample including NPC
Model: Yield (natural log) = α*countries + β1*LNNPC(-5) + β2*LNED1MF(-5) + β3*LNPCARCR(-1) + Error Term

Dependent Variable:	Drought	Agricult. Policy Variable	Primary Education	Cultivated Area per Capita	Adj. R^2
Cereals 100 Observations 10 countries, 10 years: 1980-89	**-0.32** (-7.01) [0.0%]	**0.14** (2.37) [2.0%]	0.03 (0.23) [81.5%]	-0.30 (-1.01) [31.2%]	0.8758
Rice 100 Observations 10 countries, 10 years: 1980-89	-0.15 (-1.46) [14.8%]	0.75 (0.59) [55.7%]	**1.23** (3.88) [0.0%]	-1.11 (-1.72) [8.9%]	0.6839
Cassava 100 Observations 10 countries, 10 years: 1980-89	**-0.14** (-2.56) [1.2%]	-0.31 (-0.46) [64.8%]	-0.78 (-0.05) [96.4%]	0.06 (0.18) [86.1%]	0.8578
Maize 90 Observations 9 countries, 10 years: 1980-89	**-0.23** (-4.14) [0.0%]	0.11 (1.44) [15.4%]	-0.03 (-0.19) [84.8%]	**-0.85** (-2.38) [2.0%]	0.8080
Sorghum 90 Observations 9 countries, 10 years: 1980-89	**-0.30** (-4.10) [0.0%]	0.17 (1.73) [8.8%]	0.43 (1.83) [7.1%]	-0.45 (-0.95) [34.3%]	0.5813
Wheat 60 Observations 6 countries, 10 years: 1980-89	-0.10 (-1.91) [6.2%]	0.14 (1.12) [27%]	0.38 (0.25) [80.2%]	-0.30 (-0.08) [93.8%]	0.9552

Note: Displayed are the value of the coefficient (which, except in the case of drought, represents elasticity), the T-statistic (in parentheses), and the level of significance (in square brackets). Whenever coefficients were significant at the 10% level they are underlined; when they are also significant at the 5% level they are also bolded.

The following countries entered the regression:
10 countries (cereal, rice, cassava): civ gha lbr ken mdg rwa sdn tgo zmb zwe
9 countries (maize, sorghum): excluded lbr
6 countries (wheat): excluded also civ gha tgo

- The NPC has a positive effect on yields (i.e., if producers are 'subsidized' by a favorable agricultural policy, reflected by a NPC greater than 1, yields are increased and if producers are 'taxed' yields are diminished). The level of significance is especially high in the case of cereals. This is probably picking up some of the impact of higher fertilizer use, since higher NPCs lead to more intensive agriculture.[11]

- Primary education has a positive impact on yields. The level of significance is especially high in rice yields.

Conclusions for Crop Yields

25. Agricultural Policy. Conducive agricultural policy, represented by the proxy nominal protection coefficient, shows a positive effect on agricultural yields (except for cassava). This relationship is significant in the case of cereals generally and of sorghum. Producers respond to incentives, largely by using higher levels of inputs, and therefore "taxing" producers hampers agricultural production. The interpretation of the coefficient -- if we take the case of cereals -- is, that a 1% increase in the NPC is associated with an increase in cereal yields of 0.14%. This, given the quality of the data, should be interpreted as an illustrative example rather than as an exact relationship, especially since the assumption that the elasticity is constant along the entire production function seems to be far-fetched.

26. Cultivated Area. As hypothesized, area cultivated per person and crop yields were found to be inversely related, if the special case of cassava is excluded. However, this relationship is only significant in 2 cases: for rice and maize. It is interesting to note that in the case of rice, the inverse relationship between crop yields and area cultivated is even greater than hypothesized. A decrease in the area cultivated per person is more than offset by an increase in yields (a 1% decrease in cultivated area leads to a 1.11% increase in yields, thus augmenting total production). However, as noted above, this result should be interpreted with caution. In all other cases however the coefficient is less than one, as hypothesized.

27. Education. Primary education enhances agricultural productivity. The effect of increasing yields is more likely to be attributable to an environment of learning and being open to new farming techniques and opportunities. The interpretation of the results, taking the case of rice as an example, is that a 1% increase in the primary gross enrollment ratio leads to a 1.23% increase in rice yields.

28. Environmental Degradation. Percentage change in per capita forest area was tested for its impact on yields and was found to be insignificant. This result does not necessarily imply that environmental degradation does not influence crop yields. It might be due to the fact that either the quality of the data on deforestation is not good enough or that deforestation is not good enough a proxy to reflect all the complex and important impacts of environmental degradation.

29. Fertilizer Use. The use of fertilizer could not be effectively tested since fertilizer data were available only in the form of total fertilizer use per country and not fertilizer used for specific crops. The majority of fertilizer used is put on export crops (like cotton, coffee, cocoa) and not only on a few cereal crops. In addition, the effects of fertilizer use are captured to some extent in the coefficient for the NPC, since fertilizer use will vary directly with relative input and output prices.

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[11] Use of modern farm inputs is a function of the policy environment (and relative prices), farmer education, and input availability.

Dependent Variables: Crop Yields. Extended sample without NPC.
Model: Yield (natural log) = α*countries + β1*LNED1MF(-5) + β2*LNPCARCR(-1) + [β3*DP1PCFOR(-1)] + Error Term

Dependent Variable:	Drought	Primary Education	Cultivated Area per Capita	Deforestation	Adj. R^2
Cereals 300 Observations 30 countries, 10 years: 1980-89	**-0.19** (-6.02) [0.0%]	**0.32** (4.16) [0.0%]	0.09 (0.43) [66.4%]		0.8242
Rice 290 Observations 29 countries, 10 years: 1980-89	**-0.20** (-2.93) [0.4%]	**0.38** (2.29) [2.3%]	**-1.31** (-3.11) [0.2%]		0.7275
Cassava 260 Observations 26 countries, 10 years: 1980-89	0.001 (0.02) [98.1%]	-0.06 (-0.66) [50.8%]	0.13 (0.55) [58.4%]	0.44 (1.85) [6.6%]	0.8549
Maize 300 Observations 30 countries, 10 years: 1980-89	**-0.19** (-5.07) [0.0%]	0.09 (1.05) [29.4%]	-0.80 (-0.34) [73.5%]		0.7656
Sorghum 270 Observations 27 countries, 10 years: 1980-89	**-0.15** (-3.08) [0.2%]	**0.46** (3.84) [0.0%]	0.03 (0.09) [93.0%]	**0.04** (2.11) [3.6%]	0.6770
Wheat 190 Observations 19 countries, 10 years: 1980-89	-0.02 (-0.42) [67.6%]	**0.25** (2.15) [3.3%]	-0.28 (0.84) [40.0%]		0.8576

Note: Displayed are the value of the coefficient (which, except in the case of drought, represents elasticity), the T-statistic (in parentheses), and the level of significance (in square brackets). Whenever coefficients are significant at the 10% level, they are underlined; when they are also significant at the 5% level, they are also bolded.

The following countries were included in the regressions:
30 countries (cereal, maize): ago ben hvo bdi cmr caf tcd cog eth gab gha gin gnb ken mdg mwi mli mrt moz nga rwa sen sle swz tza tgo uga zar zmb zwe;
29 countries (rice): excluded eth; 27 countries (sorghum): excluded ago cog gab;
26 countries (cassava): excluded eth gnb mrt swz; 19 countries (wheat): excluded ben hvo caf cog gab gha gin gnb sen sle

Increasing the Sample Size by Omitting the Nominal Protection Coefficient (NPC)

30. Given the limited availability of data on the NPC, a second set of regressions were conducted in order to see how increasing the sample size changes the results. However, the results have to be interpreted with caution because of an omitted variable bias.[12] The expected results would be a higher level of significance of the coefficients on the independent variables because of the larger sample, if the relations proposed earlier hold. The results are displayed in the table on the following page.

31. The coefficient on drought remains negative (except for cassava where it is highly insignificant and very close to zero) and in all cases, except for wheat, significant even at the 1% level.

32. With the increased sample size the result that primary education enhances agricultural production appears even stronger. In four cases (cereals, rice, sorghum and wheat) the coefficient is significant even at the 5% level; only in the case of cassava it is negative, but highly insignificant (50%).

33. The coefficient on per capita land under annual and permanent crops is significant only in the case of rice, where it is negative as expected. For other crops it is highly insignificant (at least 50%). Contrary to the hypothesis, the coefficient -- i.e., the elasticity -- is greater than one, implying that a decrease in the area cultivated per person is more than compensated by an increase in yields (a 1% decrease in the cultivated area leads to a 1.31% increase in yields, thus augmenting total production). However, as noted above, the result should be interpreted with caution.

34. In two cases, namely sorghum and cassava, the rate of deforestation turned out to be significant, but not in the expected direction. The coefficient turned out to be positive, suggesting that a higher rate of deforestation increases yields for sorghum and cassava. However, when a longer lag on deforestation is used (for example 5 years) it ceases to be significant. In our case a lag of 1 year was used, suggesting that right after deforestation the yields for sorghum and cassava increase, a result that is, however, not sustainable. Deforestation may be significant in the case of sorghum and cassava because they are often planted right after forest clearing and benefit from higher soil fertility. After 5 years, fertility declines and there is no yield benefit.

D. Variations in the Rate of Deforestation Among Countries

35. The analysis in chapter IV suggests that deforestation is related positively to population pressure on cultivated area (the lower the cultivated area per person, the higher the rate of deforestation), to the rate of population growth (the higher the rate of population growth, the higher the rate of deforestation due to land clearing and fuelwood gathering), and with policies favorable to agriculture (the more profitable agriculture and logging, the more rapid the clearing of forests). Deforestation is also hypothesized to be positively related to drought. It is hypothesized to be negatively related to the use of modern farm inputs such as fertilizer (the greater the use of modern farm inputs, the lower the need to clear more forest land for farming). Open-access land tenure situations were also hypothesized to stimulate deforestation, but this variable could not be quantified.

36. Policies favorable to agriculture. As for the crop yields, the nominal protection coefficient (NPC) was used as a proxy for agricultural policy. Unfortunately, using the NPC limits the sample of usable observations to 10 countries: Côte d'Ivoire, Ghana, Kenya, Liberia, Madagascar, Rwanda, Sudan, Togo, Zambia, and Zimbabwe. Presumably due to the low power of a test with so few observations,

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[12] Especially in the case of cereals as a group and of sorghum, where the NPC was significant.

none of the coefficients turned out to be significant. The coefficient on the log of the NPC was positive supporting -- to some extent -- the hypothesis that a policy conducive to agriculture leads to more rapid deforestation. However, the significance level was only 33.4%. Consequently, in further regressions the NPC was omitted, which permitted inclusion of 36 countries in the analysis.

37. Per capita cultivated area. The hypothesis that population pressure on cultivated area (the lower the cultivated area per person, the higher the rate of deforestation) increases the rate deforestation could not be confirmed with the available data. In both the large and small sample (the latter including the NPC), the coefficient is insignificant.

38. Rate of population growth. The hypothesis that the rate of population growth increases the rate of deforestation (the higher the rate of population growth, the higher the rate of deforestation due to land clearing and fuelwood gathering) could not be confirmed with the available data. In both samples (with and without NPC) the coefficient is negative, contrary to the hypothesis, but in both cases it is insignificant.

39. Drought. The hypothesis that drought increases the rate of deforestation was confirmed. In both samples, the coefficient is positive. In the large sample (without NPC), it is highly significant (1.5%).

40. Fertilizer Use. As hypothesized, the use of modern farm inputs such as fertilizer is negatively related to the rate of deforestation. It suggests that intensifying agriculture would slow the rate of deforestation.

Model: DP1FOAREA = α*country dummies + β1*LNNPC(-5) + β2*PCARCR + β3*DP1POP + β4*DROUGHT + β5*FERTPARC + Error Term
The log of the nominal protection coefficient was lagged by 5 years.

Variable:	Agricult. Policy Variable	Cultivated Area per Capita	Population Growth Rate	Drought	Fertilizer use per cultivated	Adj. R^2
Sample with NPC: 10 countries, 10 years: 1980-89	0.19 (0.97) [33.4%]	0.22 (0.13) [0.90%]	-0.20 (-0.81) [42.2%]	0.33 (0.22) [82.7%]	-0.24 (-0.02) [99%]	0.64 18
Sample without NPC: 36 countries, 10 years: 1980-89		-0.38 (-0.31) [76%]	-0.14 (-1.07) [28.7%]	**0.29** (2.43) [1.5%]	**-0.21** (-3.50) [0.1%]	0.52 53

Note: Displayed are the coefficient, the T-statistic, and the level of significance (in square brackets). Whenever coefficients are significant at the 5% level, they are underlined and bolded.

The following countries were included in the regressions:
10 countries: civ gha ken lbr mdg rwa sdn tgo zmb zwe;
36 countries: included also ago ben hvo bdi cmr caf tcd cog gnq eth gab gin gnb mwi mli mrt moz

41. The following abbreviations were used:

TFR:	Total Fertility Rate
IMR:	Infant Mortality Rate
ED1FF:	Female Primary Education: Gross Enrollment Ratio. It is the female primary school enrollment as percentage of the female primary schooling population. Note that gross enrollment ratios of more than 100% are possible, if women who are older or younger than the schooling population attend school.
ED1MF:	Primary Education (Male and Female): Gross Enrollment Ratio.
ED2FF:	Female Secondary Education: Gross Enrollment Ratio.
ED2MF:	Secondary Education (Male and Female): Gross Enrollment Ratio
CALPCT:	Calorie intake as percent of the requirement (CALPCT=CALIN/CALREQ)
URBPCT:	Percentage of Urban Population
CERE:	Cereal Yield in thousands of hectograms per hectare
MAIZE:	Maize Yield in thousands of hectograms per hectare
WHEAT:	Wheat Yield in thousands of hectograms per hectare
RICE:	Rice Yield in thousands of hectograms per hectare
SORGH:	Sorghum Yield in thousands of hectograms per hectare
CASSA:	Cassava Yield in thousands of hectograms per hectare
NPC:	Nominal Protection Coefficient

The prefix PC denotes per capita rural population. Rural population was defined as non-urban population; i.e., rural population equals total population of a country multiplied by (1 - percentage of urban population).[13]

PCARAB:	Area under temporary crops (arable land) per capita rural population.
PCCROP:	Area under permanent crops per capita rural population.
PCARCR:	Sum of PCARAB and PCCROP.
PCFOR:	Area under forest per capita rural population.
PCCULTIVABLE:	Sum of PCARCR and PCFOR

In addition, the following general prefixes were used:
D1 denotes a first difference of the time series; i.e., D1X equals variable X at time t minus X in the previous year (at time t-1): $D1X = X_t - X_{t-1}$.
DP1 denotes the percentage change over the previous year; i.e., $DP1X = ((X_t - X_{t-1})/X_t)*100$.
LN denotes the natural log of a variable; i.e., LNX is the natural log of variable X.

[13] Thus, PCX = X/[(1-URBPCT)*Total Population].

II. Simple Cross-Country Analysis

A. Methodology

42. Similar tests to those described above were undertaken on a second simpler data set consisting of single observations on each variable for each of the 38 countries in Sub-Saharan Africa. The hypotheses were tested by assuming that statistical associations in the variations in variables across countries will similarly reflect associations between changes in these variables over time within countries. If, for example, cereal yields are significantly higher in countries with less cultivated area per capita, the assumption implied here is that a decline in cultivated area per capita in a given country will provide a stimulus for farmers in that country to intensify their farming practices and thereby increase crop yields. This assumption is not necessarily true. Cross-country data at a given point in time are obviously not the same as data depicting developments in the same setting over a long period of time. Moreover, a good explanatory model is not necessarily a good predictive model. For these reasons, this second series of tests was useful for determining the degree to which the results reported above are robust.

B. Variations in Total Population Fertility Rates Among Countries

43. The same tests as described in the pooled cross-country series analysis was run, with the following results. The total fertility rate is the dependent variable, and the statistical method was ordinary least square regression:

Independent Variable	Coefficient	T-statistic	2-Tail Significance Test
Constant	6.5	4.2	1%
Female primary school enrollment rate	-0.005	0.9	37%
Cultivated ha per person (a)	0.16 (b)	0.6	53%
Infant mortality rate	0.01	2.0	6%
Calorie supply as % of requirement	-0.02	1.2	25%
Deforestation rate	0.29	2.4	2%

Adjusted R squared = 0.4
F statistic = 5.5

(a) Converted to natural logarithm.
(b) Represents elasticity.

44. The coefficients are consistent with the hypothesis, but only infant mortality, the rate of deforestation, and the constant term are statistically significant at the 90 percent level or better (i.e., with a two-tailed significance test of 10 percent or lower). The relatively poor fit of the equation and some of the variables may be explained by the poor data, as well as the fact that there is considerably more behind the explanation of TFRs than is explained here, such as age at first marriage for women, cultural links between female fecundity and social status, and so forth.

45. Most interesting is the consistency of results with the pooled cross-country time series data reported previously. In that test infant mortality rate, deforestation, as well as female education, cultivable area, and urbanization are significant, consistent with the hypothesis. In both analysis,

calorie supply was insignificant. Urbanization was tested only in the pooled cross-country time series analysis and was a significant explanatory variable. The pooled cross-country time series data provide considerably better, and more interesting results.

C. Variations in Crop Yields Among Countries

46. A statistical relationship was tested with cereal yields (average over 1984-86) as the dependent variable, using as independent variables: average cultivated area per person (average 1965-1987), fertilizer use per ha in 1987/88 (fertilizer use remained fairly stable in the 1980s), the percentage of the school-age population in primary school (average 1965-1987), the rate of deforestation in the 1980s, and the general "appropriateness" of agricultural policy during the period 1980 to 1987. Except for the rate of deforestation and the dummy variable for policy "appropriateness", the values for each variable were converted to their natural logarithm and a regression equation was fit to these data; the coefficients reported below therefore represent elasticities. Policy appropriateness is represented by a dummy variable having the value 1 for countries where policy is judged to have been conducive to profitable agriculture, and 0 where it is judged to have been inappropriate. Of the 38 countries considered, 24 were judged to have pursued inappropriate policies, 14 appropriate; these judgements are highly subjective.

47. The equation is as follows, where the dependent variable is average cereal yields in 1984/86 (natural logarithm):

Independent Variable	Coefficient	T-statistic	2-Tail Significance Test [1]
Constant	5.45	10.1	1%
Cultivated area (ha) per person (a)	-0.33 (b)	2.5	2%
Fertilizer use per ha (a)	0.10 (b)	1.7	10%
Primary school enrollment rate (a)	0.17 (b)	1.2	24%
Deforestation rate	-0.05	0.9	39%
Agricultural policy dummy	0.30	1.9	7%

Adjusted R squared = 0.45
F Statistic = 7.0

(a) Converted to natural logarithm.
(b) Represents elasticity.

48. The equation explains about 45 percent of the differences in cereal yields among the 38 countries. The unexplained portion of 55 percent is due to rainfall differences between countries, differences in land tenure problems (as hypothesized in the text), differences in soil degradation and soil fertility, and data problems. Each of the variables, except deforestation and primary school enrollment, is statistically significant at the 90 percent level or better in explaining variations in cereal yields across countries (i.e., a 10 percent probability or less that the coefficient is actually zero). The results are consistent with those obtained from the pooled cross-country time series data.

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[1] The 2-tail test indicates the probability of the coefficient actually being zero. In the present example, there is, thus, a 2 percent probability of there being no significant relationship between cultivated area per person and cereal yields.

49. Consistent with the Boserup hypothesis, and with the hypotheses advanced in this study, the lower the cultivated area per person, the higher are cereal yields, all other things being equal. The statistical relationship is highly significant. This suggests that as more people squeeze onto cultivated land, the pressure mounts for them to innovate and intensify production; it is true even when the use of fertilizer and other modern inputs, the policy environment and primary school enrollment rates are held constant. This reflects farmers' ability to respond to rising population density with simple innovations.

50. But, also consistent with the hypotheses, the coefficient is less than 1. This suggests that a 3.1 percent annual decline in cultivated area per person (due to population growth at this rate) will only stimulate people to intensify farming at a rate of about 1 percent per year -- i.e., much slower than the rate of population growth itself. Without additional effort and support to promote more rapid intensification of farming, people -- responding to population pressure alone -- will be unable, or unwilling, to raise crop yields fast enough. Historically, this is indeed what has happened. Crop land expanded at a rate of somewhat less than 1 percent per annum, and yields increased on average by slightly more than 1 percent per annum, giving an agricultural output growth of slightly less than 2 percent per year for Sub-Saharan Africa as a whole for the 1965-1990 period.

51. A increase of 1 percent in fertilizer use is associated with a 0.1 percent increase in cereal yields. The coefficient is significant statistically. Since fertilizer use is extremely low in Sub-Saharan Africa (averaging 85 grams per ha in 1987/88, compared to China, for example, where it is 2,360 g/ha), there is vast scope for increasing its use. This is also true for other modern tools and inputs (such as seeds of higher-yielding varieties), with which fertilizer use is highly correlated. Fertilizer use can therefore be considered a proxy for adoption of "modern" farming technology, and the coefficient linking fertilizer use to cereal yields picks up the effect of the use of other modern inputs as well. Growth rates of fertilizer use (and other modern inputs) of 10-15 percent per year during the next decade are feasible. This would stimulate growth of cereal yields, according to this equation, by between 1.0 and 1.5 percent per year.

52. A 1 percent increase in the proportion of primary school-age children enrolled in school is associated with an 0.17 percent increase in cereal yields, although the statistical significance is below the normal 90 percent threshold level. Similar tests using the more extensive pooled cross-country time series data reported above, confirmed the significance of this variable. A more literate and knowledgeable people make better farmers. A better educated population as a whole may have a positive impact on farm productivity. This makes sense, since in most African countries the majority of the adult population is either working in agriculture, in farm input supply, agricultural marketing and processing, or in agricultural support services.

53. The dummy variable representing the adequacy of agricultural policy is statistically significant in explaining cereal yield variation among countries. A better policy environment is associated with higher yields, all other things being equal. The categorization of countries into those with acceptable and unacceptable policies during 1980-1987 (to coincide with cereal yields in 1984-1986) is consistent with the categorization by the World Bank; it is, however, highly subjective.

54. Consistent with the hypothesis, countries experiencing the most rapid deforestation have lower cereal yields, all other things equal, but the statistical relationship is not significant. The rate of deforestation is an instrument variable intended to reflect the rate of natural resource degradation (soil, water, and forests) on land not yet directly within the farming cycle. The low degree of statistical significance of the association between this indicator and cereal yields may be due to the fact that deforestation itself is related to population density, population growth, fertilizer use,

education levels, and agricultural policy, as indicated below. The impact of deforestation on cereal yields is then picked up directly by these other variables. These results are exactly consistent with those using the pooled cross-country time series data. However, the pooled data also showed the explanatory power of drought.

D. Variations in the Rate of Deforestation Among Countries

55. The analysis in Chapter IV suggests that deforestation is related positively to population pressure on cultivated area (the lower the cultivated area per person, the higher the rate of deforestation), to the rate of population growth (the higher the rate of population growth, the higher the rate of deforestation due to land clearing and fuelwood gathering), and with policies favorable to agriculture (the more profitable agriculture and logging, the more rapid the clearing of forests). It is negatively related with the use of modern farm inputs such as fertilizer (the greater the use of modern farm inputs, the lower the need to clear more forest land for farming). Open access land tenure situations were also hypothesized to stimulate deforestation, but this cannot be measured.

56. To test this hypothesis, regression analysis was undertaken with the rate of deforestation 1980-1988 as the dependent variable. Independent variables include the number of hectares cultivated per person (average 1965-1987), fertilizer use per hectare (1987/88), the population growth rate (1965-1990), and the agricultural policy dummy variable. The resulting equation is as follows:

Independent Variable	Coefficient	T-statistic	2-Tail Significance Test
Constant	-0.54	0.41	69%
Cultivated ha per person (a)	-0.60 (b)	1.50	15%
Fertilizer use per ha (a)	-0.19 (b)	1.17	25%
Population growth rate	0.56	1.40	17%
Agricultural policy dummy	0.76	1.65	11%

Adjusted R squared = 0.09
F statistic = 1.92

(a) Converted to natural logarithm.
(b) Represents elasticity.

57. None of the variables is statistically significant at the 90 percent level or above, in its association with deforestation, although the agricultural policy dummy, cultivated hectares per person, and population growth are close enough to suggest further testing. All of the coefficients have signs consistent with the hypothesis. The overall equation does not explain well the variation among countries in the rate of deforestation. Evidently, a number of other unquantifiable factors are at play, such as the land tenure situation, climate, and logging policies. No doubt, the poverty of the data also reduces the tightness of the fit.

58. The equation is primarily interesting as a comparison with the pooled cross-country time series analysis which established the significant inverse relationship of deforestation and fertilizer use, and the positive relationship of drought to deforestation. The relationship with agricultural policy is not significant, but the sign in the two equations is as hypothesized.

Appendix I:
Data Used for the Pooled Cross-Country Time Series Analyses

The actual data are used are too voluminous to be reproduced here. Sources were as follows:

Total Population

Years:	1961-1989
Database:	SOCIND
Measuring:	Population in thousands
Indicator:	POP
Definition:	POP. Interpolated estimates using annual and quinquennial estimates.
Sources:	POP; (same as for the Total Fertility Rate).
Missing data:	None (data are complete for the specified time series).

Urban Population

Years:	1961-1989
Database:	SOCIND
Measuring:	Urban population as percentage of total population
Indicator:	POP_URB_PCT
Definition:	POP.URB.PCT. Five-year and interpolated estimates of urban population as a percentage of the total population.
Sources:	POP; (same as for the Total Fertility Rate).
Missing data:	None.

Total Fertility Rate

Years:	1961-1989
Database:	SOCIND
Measuring:	Total Fertility Rate
Indicator:	POP_TFR
Definition:	POP.TFR. The average number of children that would be born alive to a woman during her lifetime, if she were to bear children at each age in accordance with age-specific fertility rates (see also note on Crude Birth Rate [POP.CBR.] -- The number of births per 1000 population in a given year. Note that the data are a combination of observed values based on censuses or surveys and interpolated and extrapolated estimates based on projection models.)
Sources:	POP; UN DIESA. Various Years. Population and Vital Statistical Report; New York. 1980: Patterns of Urban and Rural Population Growth; New York. 1984: Recent Levels and Trends of Contraceptive Use as Assessed in 1983; New York. 1989: Prospects of World Urbanization; New York. 1989: World Population Prospects: 1988; New York. Mauldin, W. Parker, and Sheldon J. Segal. 1988. "Prevalence of Contraceptive Use: Trends and Issues." Studies in Family Planning, Vol. 19, No. 6, pp. 335-353.

	Demographic and Health Surveys, various countries.
	World Bank Data.
Missing data:	Mauritania (1988, 1989).
	Senegal (1988, 1989).
	Togo (1988, 1989).
	Zimbabwe (1985, 1986)
Replaced:	1988: interpolated (Mauritania, Senegal, Togo).
	1989: extracted from "African Development Indicators":
	Mauritania = 6.8; Senegal = 6.5; Togo = 6.6.
	1985: extracted from "African Development Indicators", Table XIII:
	Zimbabwe = 5.9.
	1986: interpolated (Zimbabwe).

Infant Mortality Rate

Years:	1961-1989
Database:	SOCIND
Measuring:	Infant Mortality Rate
Indicator:	POP_IMR
Definition:	POP.IMR.
	The number of deaths of infants under one year of age per 1000 live births.
Sources:	POP; (same as for Total Fertility Rate).
Missing data:	Zimbabwe (1985 and 1986).
Replaced:	1985: extracted from "African Development Indicators."
	1986: interpolated.

Male and Female Primary Schooling Population (UN Projections)

Years:	1965; 1970-1989
Database:	UNESCOMS
Measuring:	Schooling population in thousands
Indicator:	113001
Definition:	UNESCOMS (Unesco Miscellaneous Statistics).
	This presents demographic data in general as well as demographic data on the student population (enrollment by age and sex and by level and by area of specialization); and data on library collections, borrowers and employees.
Sources:	The data are drawn primarily from official periodic reports to Unesco by its Member States. For definitions, refer to Unesco, Statistical Yearbook.
Missing data:	See computer printout.

Male and Female Secondary Schooling Population (UN Projections)

Years:	1965; 1970-1989
Database:	UNESCOMS
Measuring:	Schooling population in thousands
Indicator:	113002
Definition:	UNESCOMS (Unesco Miscellaneous Statistics).
	This file presents demographic data in general as well as demographic data on the student population (enrollment by age and sex and by level and by area of specialization); and data on library collections, borrowers and employees.

Sources: The data are drawn primarily from official periodic reports to Unesco by its Member States. For definitions, refer to Unesco, Statistical Yearbook.
Missing data: See computer printout.

Female Primary Schooling Population (UN Projections)
Years: 1965; 1970-1989
Database: UNESCOMS
Measuring: Schooling population in thousands
Indicator: 114001
Definition: UNESCOMS (Unesco Miscellaneous Statistics).
This file presents demographic data in general as well as demographic data on the student population (enrollment by age and sex and by level and by area of specialization); and data on library collections, borrowers and employees.
Sources: The data are drawn primarily from official periodic reports to Unesco by its Member States. For definitions, refer to Unesco, Statistical Yearbook.
Missing data: See computer printout.

Female Secondary Schooling Population (UN Projections)
Years: 1965; 1970-1989
Database: UNESCOMS
Measuring: Schooling population in thousands
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Definition: UNESCOMS (Unesco Miscellaneous Statistics).
This presents demographic data in general as well as demographic data on the student population (enrollment by age and sex and by level and by area of specialization); and data on library collections, borrowers and employees.
Sources: The data are drawn primarily from official periodic reports to Unesco by its Member States. For definitions, refer to Unesco, Statistical Yearbook.
Missing data: See computer printout.

Male and Female Primary Gross Enrollment Ratio
Years: 1965; 1970; 1975-1989
Database: SOCIND
Measuring: Gross primary school enrollment as percentage of total primary school age population
Indicator: ED_GER1_MF
Definition: ED.GER1.
Gross enrollment by sex of all ages at the primary level as a percentage of school-age children as defined by each country and reported to Unesco. Although many countries consider primary school-age to be 6-11 years, others use different age groups. Gross enrollment may be reported in excess of 100 percent if some pupils are younger or older than the country's standard range of primary school.
Sources: ED; Unesco. 1988.
Compendium of Statistics on Illiteracy. Paris. Various Years.
Statistical Yearbook. Paris.
Missing data: See computer printout.

Female Primary Gross Enrollment Ratio

Years: 1965; 1970; 1975-1989
Database: SOCIND
Measuring: Gross primary school enrollment as percentage of total primary school age population
Indicator: ED_GER1_F
Definition: ED.GER1.
Gross enrollment by sex of all ages at the primary level as a percentage of school-age children as defined by each country and reported to Unesco. Although many countries consider primary school-age to be 6-11 years, others use different age groups. Gross enrollment may be reported in excess of 100 percent if some pupils are younger or older than the country's standard range of primary school.
Sources: ED; Unesco. 1988.
Compendium of Statistics on Illiteracy. Paris. Various Years.
Statistical Yearbook. Paris.
Missing data: See computer printout.

Male Primary School Enrollment - All Ages

Years: 1965; 1970-1989
Database: UNESCOED
Measuring: Enrollment in thousands
Indicator: 251010
Definition: UNESCOED (Unesco Education Statistics)
This file contains detailed information on numbers of enrolled students, graduates and teachers by level and grade, sex, age and subject area, as well as similar information on institutions.
Sources: The data are drawn primarily from official periodic reports to Unesco by its Member States. For definitions, refer to Unesco, Statistical Yearbook.
Missing data: See computer printout.

Female Primary School Enrollment - All Ages

Years: 1965; 1970-1989
Database: UNESCOED
Measuring: Enrollment in thousands
Indicator: 251020
Definition: UNESCOED (Unesco Education Statistics)
This file contains detailed information on numbers of enrolled students, graduates and teachers by level and grade, sex, age and subject area, as well as similar information on institutions.
Sources: The data are drawn primarily from official periodic reports to Unesco by its Member States. For definitions, refer to Unesco, Statistical Yearbook.
Missing data: See computer printout.

Male and Female Primary School Enrollment by Grade - Total

Years: 1965; 1970-1989
Database: UNESCOED
Measuring: Enrollment in thousands

Indicator: 221100
Definition: UNESCOED (Unesco Education Statistics)
This file contains detailed information on numbers of enrolled students, graduates and teachers by level and grade, sex, age and subject area, as well as similar information on institutions.
Sources: The data are drawn primarily from official periodic reports to Unesco by its Member States. For definitions, refer to Unesco, Statistical Yearbook.
Missing data: See computer printout.

Female Primary School Enrollment by Grade - Total
Years: 1965; 1970-1989
Database: UNESCOED
Measuring: Enrollment in thousands
Indicator: 221200
Definition: UNESCOED (Unesco Education Statistics)
This file contains detailed information on numbers of enrolled students, graduates and teachers by level and grade, sex, age and subject area, as well as similar information on institutions.
Sources: The data are drawn primarily from official periodic reports to Unesco by its Member States. For definitions, refer to Unesco, Statistical Yearbook.
Missing data: See computer printout.

Male and Female Secondary Gross Enrollment Ratio
Years: 1965; 1970; 1975-1989
Database: SOCIND
Measuring: Gross enrollment in secondary school as percentage of age group
Indicator: ED_GER2_MF
Definition: ED.GER2.
Computed in the same manner as the primary school enrollment ratio, and is based on enrollment in all streams (general, vocational and teacher training). The age group again varies but is usually between 12-17 years of age.
Sources: ED; Unesco. 1988.
Compendium of Statistics on Illiteracy. Paris. Various Years.
Statistical Yearbook. Paris.
Unesco data.

Female Secondary Gross Enrollment Ratio
Years: 1965; 1970; 1975-1989
Database: SOCIND
Measuring: Gross enrollment in secondary school as percentage of age group
Indicator: ED_GER2_F
Definition: ED.GER2.
Computed in the same manner as the primary school enrollment ratio, and is based on enrollment in all streams (general, vocational and teacher training). The age group again varies but is usually between 12-17 years of age.
Sources: ED; Unesco. 1988. Compendium of Statistics on Illiteracy.
Various Years. Statistical Yearbook.

Unesco data.

Male Secondary School Enrollment - All Ages

Years: 1965; 1970-1989
Database: UNESCOED
Measuring: Enrollment in thousands
Indicator: 252010
Definition: UNESCOED (Unesco Education Statistics)
This file contains detailed information on numbers of enrolled students, graduates and teachers by level and grade, sex, age and subject area, as well as similar information on institutions.
Sources: The data are drawn primarily from official periodic reports to Unesco by its Member States. For definitions, refer to Unesco, Statistical Yearbook.
Missing data: See computer printout.

Female Secondary School Enrollment - All Ages

Years: 1965; 1970-1989
Database: UNESCOED
Measuring: Enrollment in thousands
Indicator: 252020
Definition: UNESCOED (Unesco Education Statistics)
This file contains detailed information on numbers of enrolled students, graduates and teachers by level and grade, sex, age and subject area, as well as similar information on institutions.
Sources: The data are drawn primarily from official periodic reports to Unesco by its Member States. For definitions, refer to Unesco, Statistical Yearbook.
Missing data: See computer printout.

Male and Female Secondary Education - All Types

Years: 1965; 1970-1989
Database: UNESCOED
Measuring: Enrollment in thousands
Indicator: 230600
Definition: UNESCOED (Unesco Education Statistics)
This file contains detailed information on numbers of enrolled students, graduates and teachers by level and grade, sex, age and subject area, as well as similar information on institutions.
Sources: The data are drawn primarily from official periodic reports to Unesco by its Member States. For definitions, refer to Unesco, Statistical Yearbook.
Missing data: See computer printout.

Female Secondary Education - All types

Years: 1965; 1970-1989
Database: UNESCOED
Measuring: Enrollment in thousands
Indicator: 230700

Definition: UNESCOED (Unesco Education Statistics)
This file contains detailed information on numbers of enrolled students, graduates and teachers by level and grade, sex, age and subject area, as well as similar information on institutions.
Sources: The data are drawn primarily from official periodic reports to Unesco by its Member States. For definitions, refer to Unesco, Statistical Yearbook.
Missing data: See computer printout.

Daily Calorie Intake
Years: 1961-1989
Database: SOCIND
Measuring: Daily calorie intake
Indicator: FOOD_CALIN
Definition: FOOD.CALIN
The daily calorie supply per capita, computed from energy equivalent of net food supplies in a country. Available supplies comprise domestic production, imports less exports, and changes in stocks. Net supplies exclude animal feed, seeds for use in agriculture and food lost due to processing.
Sources: FOOD; FAO data.
1983. Food Aid in Figures. December; Rome.
Missing data: Djibouti; Equatorial Guinea.

Daily Calorie Requirement
Years: 1970
Database: SOCIND
Measuring: Daily Calorie Requirement
Indicator: FOOD_CALREQ
Definition: FOOD.CALREQ
The daily calorie requirement per capita refers to the calories needed to sustain a person at normal levels of activity and health, taking into account age and sex distributions, average body weights, and environmental temperatures. The estimates are from FAO and are available for 1977 only.
Sources: FOOD; FAO data.
1983. Food Aid in Figures. December; Rome.
Missing data: Djibouti; Equatorial Guinea.

Total Agricultural Area
Years: 1961-1989
Database: SOCIND
Measuring: Area in thousands of square kilometers
Indicator: AREA_AGR
Definition: AREA.AGR.
The sum of arable land, land under permanent crops, and permanent meadows and pasture land.
Sources: AREA: FAO data.
Missing data: None.

Arable Land

Years:	1961-1989
Database:	SOCIND
Measuring:	Area in thousands of square kilometers
Indicator:	AREA_AR
Definition:	AREA.AR Represents land under temporary crops, temporary meadows for mowing or pasture, land under marker and kitchen gardens, and land temporarily fallow or lying idle.
Sources:	AREA: FAO data.
Missing data:	Djibouti.

Permanent Cropland Area

Years:	1961-1989
Database:	SOCIND
Measuring:	Area in thousands of square kilometers
Indicator:	AREA_CP
Definition:	AREA.CP. Represents land cultivated with crops that occupy the land for long periods and need not be replanted after each harvest, such as cocoa, rubber; it includes land under shrubs, fruit trees, nut trees and vines, but excludes land under trees grown for wood or timber.
Sources:	AREA: FAO data.
Missing data:	Botswana; Djibouti; The Gambia; Niger.

Area Under Forest

Years:	1961-1989
Database:	SOCIND
Measuring:	Area in thousands of square kilometers
Indicator:	AREA_FOREST
Definition:	AREA.FOREST. Represents land under natural or planted stands of trees, whether productive or not, including land from which forests have been cleared but that will be reforested in the foreseeable future.
Sources:	AREA: FAO data.
Missing data:	Lesotho.

Consumption of Fertilizers

Years:	1961-1989
Database:	FAOFERT
Measuring:	CONSUMPTION VOLUME IN METRIC TONS
Definition:	FAOFERT contains information on fertilizers, pesticides and land use. Note that the fertilizer data are generally in fertilizer years, with 1984/85 appearing under the year 1984.
Indicator:	FERTILIZR_POTASH (Consumption of Potash Fertilizers). FERTILIZR_NITROG (Consumption of Nitrogenous Fertilizers). FERTILIZR_PHOSPHAT (Consumption of Phosphate Fertilizers).

Sources:	FAO Fertilizer Yearbook. Various Years. Rome. (Note: According to the explanatory notes of the FAO Fertilizer Yearbook, blanks or "NA" indicate none or negligible quantities.)
Missing data:	Namibia.

Crop Yields

Years:	1961-1989	
Database:	FAOPROD	
Measuring:	Thousands of hectogram/hectare	
Definition:	FAOPROD covers data on domestic production and international trade.	
Indicator:	MAIZEYIELD_VOL	(Maize Yield).
	WHEATYIELD_VOL	(Wheat Yield).
	RICE_PADDYYIELD_VOL	(Rice Paddy Yield).
	SORGHYIELD_VOL	(Sorghum Yield).
Sources:	FAO Production Yearbook. Various Years. Rome.	

Nominal Protection Coefficient

Years:	1970-1987
Database:	William K. Jaeger, "The Effects of Economic Policies on African Agriculture," World Bank Discussion Paper 147, pg. 53.
Indicator:	NPC (Nominal Protection Coefficient for Traded Food Crops)

Appendix II:
Data Used for the Simple Cross-Country Analyses

The data used in this statistical analysis are reproduced in the tables on the following pages. Each variable is identified with a code, given below, along with a definition of the variable and the source of the data used. The data in the statistical tables at the end of the book are the most recent available, in May 1993. The data used in the statistical analysis pre-dated this.

POPG Population growth rate, annual average 1965-1990: World Bank (1991c) and the 1991 revision of World Bank demographic estimates and projections.

TOTFR Total fertility rate 1985-1989: World Bank (1991c) and 1991 revision of World Bank demographic estimates and projections.

INFM Infant mortality per 1000 live births, 1965-1990 average: World Bank (1991c).

PRISC Primary school enrollment, percentage of age group, average 1965-1987: World Bank (1991c).

PRIF Primary school enrollment of females, average 1965-1988, percentage of age group: World Bank (1991c).

FDSEC Average daily calorie intake per capita, 1988: World Bank (1991c).

CAL% Average daily calorie supply per capita as percentage of minimum requirement, 1988.

POL Agricultural policy appropriateness 1980-1987 (dummy variable); based on judgement by World Bank staff (1 = appropriate policy, 0 = inappropriate policy).

DEFORS Average annual rate of deforestation in the 1980s: World Bank (1989d).

WILDLS Total percentage wilderness destruction, 1900 to present: WRI/IIED (1988).

PCLD65 Per capita arable land actually cultivated, 1965, ha/person: Table 17.

PCLD87 Per capita arable land actually cultivated, 1987, ha/person: Table 17.

PCLDA Average per capita arable land actually cultivated, 1965-1987, ha/person: Table 17.

FERT Intensity of fertilizer use, 100 g/ha, 1987/89: World Bank (1991c).

CERY Cereal yields, kg/ha, 1984-1986: FAO Production Series.

MZ Maize yields, hundred kg/ha, 1989: FAO Production Series.

RIC Rice yields, hundred kg/ha, 1989: FAO Production Series.

SOR Sorghum yields, hundred kg/ha, 1989: FAO Production Series.

CAS Cassava yields, hundred kg/ha, 1989: FAO Production Series.

	FDSEC	CAL%	POL	PCLDA
Benin	2184.000	95.00000	1.000000	0.500000
Burkina Faso	2139.000	90.00000	0.000000	0.450000
Burundi	2343.000	101.0000	1.000000	0.300000
CAR	1949.000	86.00000	0.000000	0.850000
Chad	1717.000	72.00000	0.000000	0.750000
Ethiopia	1749.000	75.00000	0.000000	0.400000
The Gambia	2517.000	106.0000	1.000000	0.250000
Ghana	1759.000	76.00000	0.000000	0.250000
Guinea	1776.000	77.00000	0.000000	0.300000
Guinea Bissau	2186.000	95.00000	0.000000	0.450000
Kenya	2068.000	89.00000	1.000000	0.150000
Lesotho	2303.000	101.0000	0.000000	0.300000
Liberia	2381.000	103.0000	1.000000	0.250000
Madagascar	2440.000	107.0000	0.000000	0.350000
Malawi	2310.000	100.0000	1.000000	0.400000
Mali	2073.000	88.00000	0.000000	0.350000
Mauritania	2322.000	101.0000	0.000000	0.150000
Niger	2432.000	103.0000	0.000000	0.550000
Nigeria	2149.000	91.00000	0.000000	0.400000
Rwanda	1830.000	79.00000	1.000000	0.200000
Sierra Leone	1854.000	81.00000	1.000000	0.550000
Somalia	2138.000	93.00000	0.000000	0.250000
Sudan	2208.000	94.00000	0.000000	0.700000
Tanzania	2192.000	94.00000	0.000000	0.250000
Togo	2207.000	96.00000	1.000000	0.550000
Uganda	2344.000	101.0000	0.000000	0.500000
Zaire	2163.000	97.00000	0.000000	0.250000
Zambia	2026.000	97.00000	0.000000	1.000000
Angola	1880.000	80.00000	0.000000	0.500000
Botswana	2201.000	95.00000	0.000000	1.550000
Cameroon	2028.000	87.00000	1.000000	0.800000
Congo	2619.000	118.0000	0.000000	0.450000
RCI	2562.000	111.0000	1.000000	0.450000
Gabon	2521.000	108.0000	0.000000	0.400000
Mauritius	2748.000	121.0000	1.000000	0.100000
Senegal	2350.000	99.00000	0.000000	0.950000
Swaziland	2578.000	111.0000	1.000000	0.300000
Zimbabwe	2132.000	89.00000	1.000000	0.400000

	obs	DEFORS	WILDLS	FERT	PRIF
Benin	1	1.700000	60.00000	49.00000	32.00000
Burkina Faso	2	1.700000	80.00000	57.00000	16.00000
Burundi	3	2.700000	86.00000	20.00000	33.00000
CAR	4	0.200000	56.00000	4.000000	40.00000
Chad	5	0.600000	76.00000	17.00000	21.00000
Ethiopia	6	0.300000	70.00000	39.00000	17.00000
The Gambia	7	2.400000	89.00000	40.00000	NA
Ghana	8	0.800000	80.00000	38.00000	62.00000
Guinea	9	0.800000	70.00000	6.000000	19.00000
Guinea Bissau	10	2.700000	78.00000	6.000000	NA
Kenya	11	1.700000	48.00000	421.0000	66.00000
Lesotho	12	2.500000	68.00000	125.0000	119.0000
Liberia	13	2.300000	87.00000	94.00000	23.00000
Madagascar	14	1.200000	75.00000	21.00000	77.00000
Malawi	15	3.500000	57.00000	203.0000	49.00000
Mali	16	0.500000	79.00000	59.00000	17.00000
Mauritania	17	2.400000	81.00000	55.00000	25.00000
Niger	18	2.600000	77.00000	8.000000	14.00000
Nigeria	19	2.700000	75.00000	94.00000	36.00000
Rwanda	20	2.300000	87.00000	20.00000	55.00000
Sierra Leone	21	0.300000	85.00000	22.00000	31.00000
Somalia	22	0.100000	41.00000	40.00000	9.000000
Sudan	23	0.200000	70.00000	40.00000	21.00000
Tanzania	24	0.300000	43.00000	92.00000	46.00000
Togo	25	0.700000	66.00000	76.00000	55.00000
Uganda	26	0.800000	78.00000	2.000000	36.00000
Zaire	27	0.200000	55.00000	15.00000	55.00000
Zambia	28	0.300000	29.00000	183.0000	69.00000
Angola	29	0.200000	39.00000	29.00000	26.00000
Botswana	30	0.100000	56.00000	7.000000	95.00000
Cameroon	31	0.400000	59.00000	71.00000	89.00000
Congo	32	0.100000	49.00000	25.00000	94.00000
RCI	33	5.200000	79.00000	90.00000	41.00000
Gabon	34	0.100000	35.00000	46.00000	122.0000
Mauritius	35	0.000000	95.00000	3075.000	101.0000
Senegal	36	0.500000	82.00000	40.00000	39.00000
Swaziland	37	0.000000	56.00000	125.0000	34.00000
Zimbabwe	38	0.400000	56.00000	505.0000	109.0000

	obs	CERY	MZ	RIC	SOR	CAS
Benin	1	825.0000	9.500000	12.90000	7.900000	83.20000
Burkina Faso	2	690.0000	11.60000	20.50000	7.200000	53.30000
Burundi	3	1101.000	11.20000	35.00000	12.40000	114.5000
CAR	4	513.0000	10.30000	14.00000	11.10000	32.90000
Chad	5	531.0000	4.600000	28.50000	5.800000	45.80000
Ethiopia	6	1081.000	17.80000	NA	11.50000	NA
The Gambia	7	1207.000	13.80000	14.30000	10.40000	30.00000
Ghana	8	969.0000	13.20000	10.30000	8.600000	80.20000
Guinea	9	728.0000	11.50000	9.000000	14.20000	50.00000
Guinea Bissau	10	848.0000	8.000000	13.70000	5.800000	NA
Kenya	11	1611.000	18.80000	44.20000	9.800000	95.40000
Lesotho	12	683.0000	7.500000	NA	5.600000	NA
Liberia	13	1302.000	NA	11.90000	NA	80.00000
Madagascar	14	1731.000	10.60000	20.80000	6.000000	66.50000
Malawi	15	1162.000	11.90000	17.90000	6.700000	21.30000
Mali	16	807.0000	12.90000	15.40000	9.400000	91.30000
Mauritania	17	431.0000	6.700000	40.30000	7.600000	NA
Niger	18	366.0000	16.00000	22.60000	3.000000	76.40000
Nigeria	19	1121.000	10.70000	20.00000	10.90000	126.9000
Rwanda	20	1289.000	11.80000	26.70000	9.500000	72.00000
Sierra Leone	21	1431.000	7.100000	13.00000	23.80000	33.10000
Somalia	22	725.0000	10.40000	31.00000	5.300000	104.7000
Sudan	23	508.0000	5.700000	10.00000	4.000000	15.00000
Tanzania	24	1109.000	16.00000	16.30000	9.800000	90.00000
Togo	25	865.0000	10.70000	14.20000	7.800000	74.30000
Uganda	26	949.0000	10.00000	11.10000	14.40000	73.50000
Zaire	27	851.0000	9.000000	9.100000	9.100000	73.80000
Zambia	28	1747.000	20.60000	9.300000	7.100000	36.00000
Angola	29	461.0000	2.900000	10.00000	NA	38.40000
Botswana	30	178.0000	3.000000	NA	4.100000	NA
Cameroon	31	935.0000	10.20000	52.80000	11.90000	25.50000
Congo	32	622.0000	9.100000	2.500000	NA	72.60000
RCI	33	981.0000	6.900000	12.00000	6.600000	56.50000
Gabon	34	1481.000	17.10000	20.00000	NA	61.10000
Mauritius	35	3200.000	36.60000	40.00000	NA	150.0000
Senegal	36	709.0000	14.10000	21.20000	9.700000	36.50000
Swaziland	37	1528.000	16.90000	75.00000	8.000000	NA
Zimbabwe	38	1468.000	16.20000	28.00000	5.100000	39.10000

	POPG	INFM	PRISC	TOTFR
Benin	3.000000	139.0000	49.00000	6.400000
Burkina Faso	2.500000	164.0000	22.00000	6.500000
Burundi	2.600000	106.0000	47.00000	6.800000
CAR	2.500000	133.0000	61.00000	5.800000
Chad	2.300000	155.0000	43.00000	6.000000
Ethiopia	3.000000	148.0000	24.00000	7.500000
The Gambia	3.100000	168.0000	48.00000	6.500000
Ghana	2.900000	102.0000	70.00000	6.300000
Guinea	2.200000	168.0000	30.00000	6.500000
Guinea Bissau	2.300000	168.0000	43.00000	6.000000
Kenya	3.700000	90.00000	75.00000	6.900000
Lesotho	2.600000	119.0000	104.0000	5.700000
Liberia	3.100000	132.0000	38.00000	6.400000
Madagascar	2.800000	159.0000	93.00000	6.500000
Malawi	3.200000	174.0000	55.00000	7.600000
Mali	2.400000	187.0000	23.00000	7.000000
Mauritania	2.500000	150.0000	33.00000	6.800000
Niger	3.000000	155.0000	20.00000	7.100000
Nigeria	3.000000	138.0000	55.00000	6.600000
Rwanda	3.200000	129.0000	60.00000	8.300000
Sierra Leone	2.300000	179.0000	44.00000	6.500000
Somalia	2.900000	146.0000	13.00000	6.800000
Sudan	2.900000	132.0000	39.00000	6.300000
Tanzania	3.500000	120.0000	49.00000	7.100000
Togo	3.400000	121.0000	78.00000	6.700000
Uganda	3.200000	109.0000	69.00000	7.300000
Zaire	3.000000	117.0000	73.00000	6.100000
Zambia	3.500000	98.00000	75.00000	6.700000
Angola	2.700000	131.0000	66.00000	6.500000
Botswana	3.300000	75.00000	90.00000	4.800000
Cameroon	3.100000	116.0000	102.0000	6.500000
Congo	3.200000	116.0000	114.0000	6.600000
RCI	4.100000	121.0000	65.00000	7.300000
Gabon	3.400000	125.0000	130.0000	5.700000
Mauritius	1.200000	43.00000	104.0000	1.900000
Senegal	3.000000	123.0000	50.00000	6.500000
Swaziland	3.200000	131.0000	92.00000	6.400000
Zimbabwe	3.200000	74.00000	123.0000	5.000000

	obs	PCLD87	PCLD65
Benin	1	0.400000	0.600000
Burkina Faso	2	0.400000	0.500000
Burundi	3	0.300000	0.300000
CAR	4	0.700000	1.000000
Chad	5	0.600000	0.900000
Ethiopia	6	0.300000	0.500000
The Gambia	7	0.200000	0.300000
Ghana	8	0.200000	0.300000
Guinea	9	0.200000	0.400000
Guinea Bissau	10	0.400000	0.500000
Kenya	11	0.100000	0.200000
Lesotho	12	0.200000	0.400000
Liberia	13	0.200000	0.300000
Madagascar	14	0.300000	0.400000
Malawi	15	0.300000	0.500000
Mali	16	0.300000	0.400000
Mauritania	17	0.100000	0.200000
Niger	18	0.500000	0.600000
Nigeria	19	0.300000	0.500000
Rwanda	20	0.200000	0.200000
Sierra Leone	21	0.500000	0.600000
Somalia	22	0.200000	0.300000
Sudan	23	0.500000	0.900000
Tanzania	24	0.200000	0.300000
Togo	25	0.400000	0.700000
Uganda	26	0.400000	0.600000
Zaire	27	0.200000	0.300000
Zambia	28	0.700000	1.300000
Angola	29	0.400000	0.600000
Botswana	30	1.200000	1.900000
Cameroon	31	0.600000	1.000000
Congo	32	0.300000	0.600000
RCI	33	0.300000	0.600000
Gabon	34	0.400000	0.400000
Mauritius	35	0.100000	0.100000
Senegal	36	0.800000	1.100000
Swaziland	37	0.200000	0.400000
Zimbabwe	38	0.300000	0.500000

Statistical Appendix

Table 1: Basic indicators

Country	Population (millions)	Area (thous. sq. km)	GNP per capita (US$)	Life Expectancy (years)		Primary School enrollment (percentage) of age group)		Adult illiteracy (age 15+)
	Mid-1990		1990	1965	1990	1965	1989	1990
Sub-Saharan Africa	495.2		340	43	51	44	69	50
Angola	10.0	1,247	..	35	46	39	94	58
Benin	4.7	113	360	42	50	34	65	77
Botswana	1.3	582	2,040	48	67	65	111	26
Burkina Faso	9.0	274	330	38	48	12	35	82
Burundi	5.4	28	210	44	47	26	71	50
Cameroon	11.7	475	960	46	57	94	101	46
Cape Verde	..	..	..	..	..	..	..	..
Central African Rep.	3.0	623	390	40	49	56	64	62
Chad	5.7	1,284	190	46	47	34	57	70
Comoros	..	..	..	..	..	..	..	..
Congo	2.3	342	1,010	49	53	114	..	43
Cote d'Ivoire	11.9	322	750	42	55	60	..	46
Djibouti	..	..	..	..	..	..	..	..
Equatorial Guinea	..	..	..	..	..	..	..	..
Ethiopia	51.2	1,222	120	43	48	11	38	..
Gabon	1.1	268	3,330	42	53	134	..	39
Gambia, The	..	..	..	..	..	..	..	..
Ghana	14.9	239	390	48	55	69	75	40
Guinea	5.7	246	440	35	43	31	34	76
Guinea-Bissau	..	..	..	..	..	..	..	..
Kenya	24.2	580	370	48	59	54	94	31
Lesotho	1.8	30	530	48	56	94	110	..
Liberia	2.6	111	..	44	54	41	..	61
Madagascar	11.7	587	230	43	51	65	92	20
Malawi	8.5	118	200	39	46	44	67	..
Mali	8.5	1,240	270	38	48	24	23	68
Mauritania	2.0	1,026	500	37	47	13	51	66
Mauritius	1.1	2	2,250	61	70	101	103	..
Mozambique	15.7	802	80	38	47	37	68	67
Niger	7.7	1,267	310	37	45	11	28	72
Nigeria	115.5	924	290	42	52	32	70	49
Rwanda	7.1	26	310	49	48	53	69	50
Sao Tome and Principe	..	..	..	..	..	..	..	..
Senegal	7.4	197	710	41	47	40	58	62
Seychelles	..	..	..	..	..	..	..	..
Sierra Leone	4.1	72	240	33	42	29	53	79
Somalia	7.8	638	120	38	48	10	..	76
Sudan	25.1	2,506	..	40	50	29	..	73
Swaziland	..	..	..	..	..	..	..	..
Tanzania	24.5	945	110	43	48	32	63	..
Togo	3.6	57	410	42	54	55	103	57
Uganda	16.3	236	220	45	47	67	77	52
Zaire	37.3	2,345	220	43	52	70	78	28
Zambia	8.1	753	420	44	50	53	95	27
Zimbabwe	9.8	391	640	48	61	110	125	33
India	849.5	3,288	350	45	59	74	98	52
China	1,133.7	9,561	370	53	70	89	135	27

Note: Excludes Namibia, South Africa, Réunion, Ascension, St. Helena, and Tristan da Cunha.
Source: World Bank, World Indicators, 1992.

Table 2: Sub-Saharan Africa: population growth rates and fertility rates

Country	Average Annual Growth of Population (percent)			Total Fertility Rate 2/	
	1965-80	1980-90	Projected 1990-2000 1/	1965	1990
Sub-Sahara Africa	2.7	3.1	3.0	6.6	6.5
Angola	2.8	2.5	3.0	6.4	6.5
Benin	2.7	3.2	2.9	6.8	6.3
Botswana	3.5	3.4	2.5	6.9	4.7
Burkina Faso	2.1	2.6	2.9	6.4	6.5
Burundi	1.9	2.8	3.1	6.4	6.8
Cameroon	2.7	3.2	2.9	5.2	5.8
Cape Verde	1.6	2.4	2.8	-	-
CAR	1.9	2.7	2.5	4.5	5.8
Chad	2.0	2.4	2.7	6.0	6.0
Comoros	2.2	3.5	-	-	-
Congo	2.8	3.5	3.3	5.7	6.6
Cote d'Ivoire	4.1	4.0	3.5	7.4	6.7
Djibouti	-	3.3	-	-	-
Eq. Guinea	1.7	1.9	2.3	-	-
Ethiopia	2.7	2.9	3.4	5.8	7.5
Gabon	3.6	3.9	2.8	4.1	5.7
The Gambia	3.0	3.3	3.1	-	-
Ghana	2.2	3.4	3.0	6.8	6.2
Guinea	1.5	2.4	2.8	5.9	6.5
Guinea-Bissau	2.9	1.9	-	-	-
Kenya	3.6	3.8	3.5	8.0	6.5
Lesotho	2.3	2.7	2.6	5.8	5.6
Liberia	3.0	3.2	2.6	-	-
Madagascar	2.5	2.8	2.8	6.6	6.3
Malawi	2.9	3.4	3.4	7.8	7.6
Mali	2.1	2.4	3.0	6.5	7.1
Mauritania	2.3	2.6	2.8	6.5	6.8
Mauritius	1.6	1.0	0.9	4.8	1.9
Mozambique	2.5	2.7	3.0	6.8	6.4
Niger	2.6	3.5	3.3	7.1	7.2
Nigeria	2.5	3.3	2.8	6.9	6.0
Rwanda	3.3	3.3	3.9	7.5	8.3
Sao Tome & Principe	2.1	2.7	-	-	-
Senegal	2.9	3.0	3.1	6.4	6.5
Seychelles	1.9	0.7	1.0	-	-
Sierra Leone	2.0	2.4	2.6	6.4	6.5
Somalia	2.7	3.0	3.1	6.7	6.8
Sudan	2.8	3.1	2.8	6.7	6.3
Swaziland	2.8	3.3	3.5	-	-
Tanzania	3.3	3.5	3.1	6.6	6.6
Togo	3.0	3.5	3.2	6.5	6.6
Uganda	2.9	3.2	3.3	7.0	7.3
Zaire	2.8	3.1	3.0	6.0	6.2
Zambia	3.0	3.9	3.1	6.6	6.7
Zimbabwe	3.1	3.7	2.4	8.0	4.9
India	2.3	2.2	2.0	6.2	4.0
China	2.1	1.4	1.7	6.4	2.5

1/ Projections are based on present trends. Hence the slight decline in growth rate results only from the slightly declining trend in a few countries. The projections include the position impact of HIV. They do not include the impact of more successful population programs.

2/ Total fertility rate (TFR) is the average number of children who would be born alive to a woman (or group of women) during her lifetime if she were to pass through her childbearing years confirming to the age-specific fertility rates of a given year.

Table 3: crude birth and death rates, infant and child mortality rates, 1965 and 1990

Country	Crude birth rate per 1,000 population		Crude death rate per 1,000 population		Infant mortality per 1,000 live births		Child mortality (under age 5) per 1,000 live births	
	1965	1990	1965	1990	1965	1990	1965	1990
Sub-Saharan Africa	48	46	23	16	157	107	..	..
Angola	49	47	29	19	..	130	312	209
Benin	49	46	23	15	166	113	261	154
Botswana	53	35	19	6	112	38	160	43
Burkina Faso	48	47	26	18	193	134	320	193
Burundi	47	49	24	18	142	107	237	98
Cameroun	40	41	20	12	143	88	230	118
Cape Verde	..	..	..	..	..	..	176	47
Central African Rep.	34	42	24	16	157	101	270	152
Chad	45	44	28	18	183	125	302	201
Comoros	..	..	..	..	..	..	193	124
Congo	42	48	18	15	129	116	184	165
Cote d'Ivoire	52	45	22	12	149	95	260	140
Djibouti	..	..	..	..	..	..	..	183
Equatorial Guinea	..	..	..	..	..	..	291	193
Ethiopia	43	51	20	18	165	132	273	186
Gabon	31	42	22	15	153	97	250	149
Gambia	..	..	..	..	..	..	350	221
Ghana	47	44	18	13	120	85	197	129
Guinea	46	48	29	21	191	138	321	219
Guinea-Bissau	..	..	..	..	..	..	291	227
Kenya	52	45	20	10	112	67	179	96
Lesotho	42	40	18	12	142	93	194	127
Liberia	46	44	20	14	176	136	282	174
Madagascar	47	45	22	15	201	116	153	164
Malawi	56	54	26	20	200	147	347	235
Mali	50	50	27	19	207	166	363	220
Mauritania	47	48	26	19	178	122	281	196
Mauritius	36	17	8	6	65	21	93	23
Mozambique	49	46	27	18	179	137	294	194
Niger	48	51	29	20	180	128	296	207
Nigeria	51	43	23	14	162	98	290	152
Rwanda	52	54	17	18	141	120	237	188
Sao Tome and Principe	..	..	..	..	..	..	..	47
Senegal	47	45	23	17	160	81	290	110
Seychelles	..	..	..	7	..	..	..	21
Sierra Leone	48	47	31	22	208	147	385	231
Somalia	50	48	26	18	165	126	273	204
Sudan	47	44	24	15	160	102	263	160
Swaziland	..	..	..	..	..	..	220	140
Tanzania	49	48	23	18	138	115	228	138
Togo	50	48	22	14	153	88	238	134
Uganda	49	51	19	19	119	117	197	149
Zaire	47	45	21	14	141	94	232	140
Zambia	49	49	20	15	121	82	192	109
Zimbabwe	55	37	17	8	103	49	165	50
India	45	30	20	11	150	92	239	113
China	38	22	10	7	90	29	113	2

Source: World Bank, World Development Indicators, 1992

Table 4. Sub-Saharan Africa: population estimates and projections based on targeted decline of 50 percent in total fertility rate by 2030

Country	Population size (millions)				Hypothetical size of stationary population[a] (millions)	Annual population growth (percent)			Total fertility rate			Assumed year of reaching Net Reproduction Rate = 1[c]
	1980	1990	2020	2030		1990-95	2020-25	2025-30	1990-95	2020-25	2025-2030	
Sub-Saharan Africa[b]	**350.8**	**494.4**	**1,169.1**	**1,470.8**	**3,040**	**3.02**	**2.24**	**1.99**	**6.24**	**3.60**	**3.10**	**2055**
Angola	7.1	10.0	23.9	30.4	69	2.85	2.54	2.22	6.56	4.34	3.59	2045
Benin	3.4	4.7	10.3	12.1	21	2.91	1.85	1.59	5.99	3.00	2.53	2035
Botswana	..	1.3	2.3	2.6	4	2.79	1.37	1.24	4.33	2.07	2.06	2015
Burkina Faso	6.1	9.0	20.6	25.6	52	2.82	2.33	1.96	6.50	3.95	3.20	2045
Burundi	4.1	5.5	13.0	18.1	33	3.05	2.39	2.28	6.80	3.74	3.50	2045
Cameroon	8.4	11.9	29.6	36.4	75	3.06	2.43	2.02	6.24	3.67	2.91	2040
Cape Verde	..	0.4	0.7	0.9	1	2.85	1.61	1.52	4.66	2.17	2.07	2025
Central African Rep.	2.3	3.0	6.2	7.3	13	2.56	1.81	1.57	5.54	3.10	2.59	2035
Chad	4.5	5.7	12.2	14.9	30	2.56	2.16	1.86	6.03	3.75	3.09	2040
Comoros	..	0.5	1.2	1.4	3	3.40	2.33	1.81	6.49	3.43	2.65	2035
Congo, People's Rep.	1.6	2.3	5.9	7.5	17	3.21	2.72	2.23	6.40	4.17	3.24	2045
Côte d'Ivoire	8.3	12.2	32.9	41.2	95	3.69	2.65	2.16	7.01	4.17	3.24	2045
Djibouti	..	0.4	1.0	1.2	2	3.20	2.11	1.76	6.60	3.54	2.90	2040
Equatorial Guinea	..	0.4	0.7	0.9	1	2.24	1.63	1.43	5.50	3.01	2.61	2035
Ethiopia	31.1	50.5	134.5	180.9	474	3.17	2.98	2.65	7.50	4.95	4.20	2050
Gabon	..	1.1	2.6	3.2	7	2.64	2.46	2.01	5.71	4.08	3.15	2045
Gambia, The	..	0.9	2.0	2.5	5	2.90	2.40	2.14	6.50	4.46	3.80	2045
Ghana	11.7	14.9	32.4	37.7	67	2.98	1.86	1.43	5.89	2.92	2.27	2030
Guinea	5.4	5.7	12.3	16.6	34	2.50	2.36	2.16	6.50	4.46	3.80	2045
Guinea-Bissau	..	1.0	1.9	2.3	4	2.06	1.94	1.69	6.00	3.96	3.37	2040
Kenya	15.9	24.1	56.4	78.7	113	3.40	1.85	2.04	6.32	2.58	2.80	2040
Lesotho	1.3	1.8	3.4	3.9	6	2.59	1.54	1.26	5.29	2.52	2.12	2025
Liberia	1.9	2.5	5.4	6.6	11	2.76	1.82	1.56	5.99	2.98	2.49	2035
Madagascar	8.7	11.5	22.7	31.0	42	2.60	1.52	1.46	5.59	2.69	2.42	2030
Malawi	6.1	8.5	22.9	30.2	79	3.49	2.94	2.63	7.60	5.05	4.30	2050
Mali	7.0	8.5	20.8	26.9	63	2.88	2.73	2.41	7.06	4.62	3.87	2050
Mauritania	1.5	2.0	4.7	6.2	14	2.64	2.57	2.48	6.50	4.46	4.10	2050
Mauritius	..	1.1	1.3	1.4	2	0.81	0.45	0.48	1.75	2.01	2.05	2030
Mozambique	12.1	15.8	36.9	45.4	93	3.06	2.33	1.95	6.52	3.90	3.13	2040
Namibia	..	1.3	2.9	3.4	6	2.94	1.70	1.43	5.58	2.59	2.20	2030
Niger	5.3	7.7	20.7	27.8	83	3.14	3.07	2.84	7.19	5.32	4.65	2055
Nigeria	84.7	117.2	271.7	324.0	622	3.06	2.09	1.70	6.25	3.30	2.62	2035
Reunion	..	0.6	0.8	0.9	1	1.50	0.82	0.75	2.16	2.05	2.04	1995
Rwanda	5.2	7.1	20.0	28.2	71	3.85	3.03	2.83	8.00	4.94	4.39	2055
São Tomé and Principe	..	0.1	0.2	0.3	.	2.50	1.36	1.19	4.74	2.17	2.06	2025
Senegal	5.7	7.4	18.1	22.7	48	3.13	2.48	2.09	6.50	3.95	3.20	2045
Seychelles	..	0.1	0.1	0.1	.	1.06	0.96	0.90	2.83	2.09	2.07	2005
Sierra Leone	3.5	4.1	9.1	11.4	25	2.51	2.38	2.13	6.50	4.46	3.80	2045
Somalia	3.9	6.3	14.9	18.8	41	2.96	2.47	2.13	6.77	4.22	3.47	2045
Sudan	18.7	25.1	52.3	61.7	108	2.74	1.82	1.55	6.01	3.13	2.62	2035
Swaziland	..	0.8	1.8	2.2	4	3.15	1.97	1.67	5.99	2.97	2.49	2035
Tanzania	18.7	24.9	63.6	86.9	189	3.31	2.33	2.55	6.40	3.56	4.03	2050
Togo	2.5	3.6	8.5	10.2	19	3.23	2.12	1.74	6.29	3.23	2.61	2035
Uganda	12.6	17.4	44.8	56.8	129	3.49	2.65	2.22	7.30	4.24	3.40	2045
Zaire	28.3	35.6	79.0	93.8	175	2.91	1.97	1.65	5.80	3.18	2.60	2035
Zambia	5.8	8.1	21.2	26.4	57	3.47	2.56	2.10	6.46	3.84	3.02	2040
Zimbabwe	7.4	9.8	18.4	20.9	29	2.88	1.37	1.25	4.55	2.07	2.06	2015
South Africa	29.3	35.9	61.6	68.8	96	2.33	1.16	1.09	4.08	2.08	2.06	2020
India	673.2	849.7	1286.8	1,412.1	1,870	1.82	0.97	0.87	3.74	2.15	2.12	2015
China	976.7	1,122.0	1,512.4	1,614.4	1,839	1.37	0.70	0.61	2.28	2.08	2.08	2000

. indicates less than 500,000.

a. Projection assumes that a 50 percent decline in the total fertility rate from the 1985 level will be attained during 2025-30. These projections assume that the pace of decline in the future will be significantly higher than has hitherto been observed.

b. Excluding South Africa.

c. Even when the Net Reproduction Rate (NRR) reaches one, the age structure is such that the number of women in, or yet to enter, their childbearing years gives rise to total births exceeding the total number of deaths. The population, therefore, will increase for a further considerable period before reaching its hypothetical stationary level. All countries are projected to reach stationary population near the end of the 22d century.

Source: World Bank, preliminary 1991 revision of demographic estimates and projections.

Table 5. Sub-Saharan Africa: required contraceptive prevalence rates for achieving population projections in Table 4.

Country	Estimated contraceptive prevalence rates (percent) [a]			
	1990	2020	2025	2030
Angola	4.0	30.9	34.9	38.8
Botswana	35.8	63.5	68.1	72.8
Burkina Faso	7.0	36.2	41.0	45.7
Burundi	12.5	46.9	52.1	57.2
Cameroon	7.9	42.4	47.6	52.6
Chad	6.1	35.2	39.9	44.4
Cote d'Ivoire	7.8	41.7	46.8	51.7
Ethiopia	4.6	27.6	31.9	36.4
Ghana	16.8	53.8	59.7	65.7
Guinea	7.4	48.7	55.2	61.6
Kenya	28.1	63.6	72.1	78.8
Liberia	11.3	49.8	56.5	63.4
Madagascar	6.7	49.2	56.3	63.4
Malawi	4.9	30.7	34.6	38.5
Mali	7.0	29.6	33.4	37.2
Mozambique	4.6	36.4	41.2	45.8
Niger	5.0	24.1	27.2	30.1
Nigeria	9.2	49.5	56.0	62.4
Rwanda	13.5	39.7	44.4	49.1
Senegal	14.2	42.0	46.5	50.9
Somalia	5.7	33.4	38.3	43.2
Sudan	10.6	47.8	54.2	60.7
Tanzania	11.9	47.6	53.1	58.5
Togo	36.9	63.3	67.2	71.0
Uganda	7.2	40.1	45.7	51.4
Zaire	5.3	41.4	47.8	54.5
Zambia	8.2	41.7	47.6	53.5
Zimbabwe	45.8	72.8	77.3	81.9
All Sub-Saharan African countries	**10.8**	**45.3**	**50.5**	**55.5**
India	37.7	64.2	61.4	64.8
China	81.2	85.0	82.6	82.8

a. The estimated contraceptive prevalence rates (CPR) were derived by applying Bongaarts' model to available country-specific information including data on CPR, contraceptive mix, and proportion married, with assumptions on likely changes. (For countries without such information, proxy data from countries with a similar socio-cultural background were utilized.) The CPR estimates refer to the percentage of women aged 14-49 using contraception (both modern and traditional). For India and China, they refer to married women aged 15-44. Countries in the above table are selected on the basis of the size of population (over 5 million) and/or availability of Demographic and Health Surveys information, Phase I (Oct. 1984-Sept. 1989).

Source: World Bank Estimates; Demographic and Health Surveys of Resource Development/ Macro System, Inc., Columbia, MD.

Table 6. Demand for contraception and its components among currently married women

Countries	Demand for contraception			Unmet needs			Current use			Percent of demand satisfied		
	Total	For spacing	For limiting	Total	For spacing	For limiting	Total	For spacing	For limiting	Total	For spacing	For limiting
Sub-Saharan Africa												
Botswana	61.6	38.6	23.0	26.9	19.4	7.4	33.0	17.9	15.1	53.6	46.4	65.7
Burundi	33.8	23.5	10.3	25.1	17.7	7.4	8.7	5.8	2.9	25.8	24.7	28.2
Ghana	48.1	34.2	13.9	35.2	26.2	9.0	12.9	8.0	4.9	26.8	23.4	35.3
Kenya	64.9	31.0	33.9	38.0	22.4	15.5	26.9	8.6	18.3	41.5	27.7	54.0
Liberia	39.3	23.4	15.8	32.8	19.8	13.0	6.4	3.6	2.9	16.4	15.4	18.4
Mali	27.6	21.2	6.4	22.9	17.2	5.7	4.7	4.0	0.7	17.0	18.9	10.9
Togo	52.2	36.4	15.8	40.1	28.5	11.7	12.1	8.0	4.1	23.2	22.0	25.9
Uganda	32.1	22.0	10.1	27.2	19.9	7.3	4.9	2.1	2.8	15.2	9.5	27.7
Zimbabwe	64.8	37.6	27.2	21.7	10.1	11.6	43.1	27.5	15.6	66.5	73.1	57.4
North Africa												
Egypt	64.8	16.5	48.3	25.2	10.1	15.0	37.8	5.9	31.9	58.4	35.8	66.0
Morocco	60.8	26.4	34.4	22.1	12.5	9.6	35.9	12.7	23.2	59.1	48.1	67.4
Tunisia	71.1	24.9	46.2	19.7	10.6	9.1	49.8	13.5	36.3	70.0	54.2	78.6
Asia												
Indonesia	64.7	28.5	36.1	16.0	10.1	6.0	47.8	17.8	29.9	73.8	62.5	82.8
Sri Lanka	73.9	21.5	54.4	12.3	7.2	5.1	61.7	13.1	48.6	81.3	60.9	89.3
Thailand	77.1	21.8	55.3	11.1	5.6	5.5	65.5	15.9	49.6	85.0	72.9	89.7
Latin American and the Carribean												
Bolivia	69.8	17.5	52.3	35.7	9.5	26.2	30.3	6.5	23.8	43.4	37.1	45.5
Brazil	81.1	24.2	56.9	12.8	4.8	8.0	66.2	17.9	48.3	81.6	74.0	84.9
Colombia	80.9	22.1	58.9	13.5	5.1	8.3	64.8	15.4	49.4	80.1	69.7	83.9
Dominican Rep.	71.2	20.8	50.4	19.4	10.0	9.4	49.8	9.6	40.1	69.9	46.2	79.6
Ecuador	70.8	23.8	47.0	24.2	10.8	13.4	44.3	11.6	32.7	62.5	48.7	69.6
Guatemala	53.4	22.1	31.4	29.4	16.4	13.0	23.2	5.1	18.1	43.3	23.1	57.6
Mexico	79.0	25.9	53.1	24.1	11.0	13.1	52.7	13.5	39.2	66.7	52.1	73.8
Peru	77.8	21.7	56.1	27.7	8.1	19.6	45.8	11.2	34.6	58.8	51.6	61.7
El Salvador	73.8	22.3	51.5	26.0	13.9	12.1	47.3	8.1	39.2	64.1	36.3	76.1
Trinidad and Tobago	71.1	28.6	42.5	16.1	8.3	7.9	52.7	18.9	33.8	74.2	66.1	79.5

Note: All figures except the last column with selected countries are percent of currently married women. Total demand includes method failures, current use, and unmet need. Unmet needs include non-use among women who would like to regulate their fertility. Percent of demand satisfied is the proportion of current use to total demand.

Source: Charles F. Westoff, and Luis H. Ochoa. 1991. Unmet Need and the Demand for Family Planning. DHS Comparative Studies No. 5, Columbia, MD: Institute for Resource Development.

Table 7. Developing countries by strength of family planning programs, 1989

	Strong	*Moderate*	*Weak*	*Very weak or none*
1	Bangladesh	Algeria	Afghanistan	Argentina
2	Botswana *	Chile	Angola *	Bhutan
3	China	Colombia	Benin *	Cambodia
4	El Salvador	Costa Rica	Bolivia	Chad *
5	India	Cuba	Brazil	Gabon *
6	Indonesia	Dominican Rep.	Burkina Faso *	Iraq
7	Korea, Rep.	Ecuador	Burundi *	Côte d'Ivoire *
8	Mexico	Egypt	Cameroon *	Kuwait
9	Sri Lanka	Ghana *	Central African Rep. *	Lao, PDR
10	Taiwan	Guatemala	Congo *	Liberia *
11	Thailand	Guyana	Ethiopia *	Libya
12	Tunisia	Honduras	Guinea *	Malawi *
13	Vietnam	Iran	Guinea-Bissau *	Myanmar
14		Jamaica	Haiti	Namibia
15		Kenya *	Jordan	Oman
16		Korea, PDR	Lesotho *	Saudi Arab
17		Lebanon	Madagascar *	Somalia *
18		Malaysia	Mali *	Sudan *
19		Mauritius *	Mauritania *	U.A.E.
20		Morocco	Mozambique *	
21		Nepal	Niger *	
22		Pakistan	Nigeria *	
23		Panama	Papua New Guinea	
24		Peru	Paraguay	
25		Philippines	Rwanda *	
26		South Africa	Senegal *	
27		Singapore	Sierra Leone *	
28		Trin. & Tobago	Syria	
29		Venezuela	Tanzania *	
30		Zambia *	Togo *	
31		Zimbabwe *	Turkey	
32			Uganda *	
33			Uruguay	
34			Yemen	
35			Zaire *	
Average score		53		
Maximum possible score		120		

Note: Program effort scores were divided into four groups: strong: 80+; moderate: 55-79; weak: 25-54; very weak or none: 0-24.
* Sub-Saharan African countries
Source: W. Parker Mauldin and John A. Ross. "Family Planning Programs: Efforts and Results, 1982-1989" (1991).

Table 8. Total fertility rates, desired number of children, infant and child mortality rates, and contraceptive prevalence rates

Country	DHS survey year	Total fertility rates[b]	Desired number of children[a]: Mean, all women	Desired number of children[a]: Mean, women in union	Infant mortality rate[c]	Child mortality rate[c,d]	Contraceptive prevalence rates (% of currently married women)[a]: Currently using any method[e]	Contraceptive prevalence rates (% of currently married women)[a]: Currently using any modern method[f]
Botswana	1988	4.7	4.7	5.4	37	53	33	32
Burundi	1987	6.5	5.3	5.5	75	152	7	1
Ghana	1988	6.1	5.3	5.5	77	155	13	5
Kenya	1989	6.5	4.4	4.8	60	89	27	18
Liberia	1986	6.4	6.0	6.5	144	220	6	6
Mali	1987	6.9	6.9	6.9	108	250	3	1
Nigeria	1990	5.7	..	..	87	192	6	4
Nigeria-Ondo State	1986/87	5.7	5.7	6.1	56	108	6	4
Senegal	1986	6.2	6.8	7.2	86	191	5	2
Sudan	1989/90	4.6	..	..	70	123	9	6
Togo	1988	6.1	5.3	5.6	81	158	12	3
Uganda	1988/89	7.2	6.5	6.8	101	180	5	3
Zimbabwe	1988/89	5.3	4.9	5.4	53	75	43	36

a. Women aged 15–49.
b. Based on 3 years preceding the survey; women aged 15–44.
c. Based on 5 years preceding the survey; per thousand.
d. Children under 5 years of age.
e. Excluding prolonged sexual abstinence.
f. Excluding periodic abstinence, withdrawal, and "other" methods.
Source: Demographic and Health Surveys, Institute of Resource Development/Macro International., Columbia, Maryland.

Table 9. Sub-Saharan Africa: performance of the agricultural sector

Country	Agricultural GDP average annual growth (percent)		Agriculture's percentage share in GDP	
	1965-80	1980-90 1/	1965	1990 2/
Sub-Saharan Africa	2.0	2.1	40	32
Angola	..	-0.5	..	13
Benin	..	3.6	59	37
Botswana	9.7	-4.0	34	3
Burkina Faso	..	3.3	37	32
Burundi	6.6	3.1	..	56
Cameroon	4.2	1.6	33	27
Cape Verde	..	..	..	..
Central African Rep.	2.1	2.2	46	42
Chad	-0.3	2.7	42	38
Comoros	..	..	..	..
Congo	3.1	3.6	19	13
Cote d'Ivoire	3.3	1.0	47	47
Djibouti	..	..	..	..
Equatorial Guinea	..	..	..	..
Ethiopia	1.2	-0.1	58	41
Gabon	..	..	26	9
Gambia, The	..	7.1	..	..
Ghana	1.6	1.0	44	48
Guinea	..	..	..	28
Guinea-Bissau	..	5.7	..	..
Kenya	5.0	3.3	35	28
Lesotho	..	-0.7	65	24
Liberia	..	..	27	..
Madagascar	..	2.4	25	33
Malawi	4.1	2.0	50	33
Mali	2.8	2.3	65	46
Mauritania	-2.0	0.7	32	26
Mauritius	..	2.6	16	12
Mozambique	..	1.3	..	65
Niger	-3.4	..	68	36
Nigeria	1.7	3.3	55	36
Rwanda	..	-1.5	75	38
Sao Tome and Principe	..	-1.3	..	..
Senegal	1.4	3.1	25	21
Seychelles	..	-2.9	..	..
Sierra Leone	3.9	2.6	34	32
Somalia	..	3.3	71	65
Sudan	2.9	2.7	54	..
Swaziland	..	3.9	..	..
Tanzania	1.6	4.1	46	59
Togo	1.9	5.7	45	33
Uganda	1.2	2.5	52	67
Zaïre	..	2.5	20	30
Zambia	2.2	3.7	14	17
Zimbabwe	..	2.4	18	3
India	2.5	3.1	44	31
China	2.8	6.1	38	27

1/ 1980-1988 for the Gambia, Seychelles, Swaziland, Guinea Bissau, Liberia, Sao Tome & Principe, Sudan.
2/ 1988 for Comoros, The Gambia, Guinea Bissau, Sao Tome & Principe, Sudan, Cape Verde, Seychelles, Swaziland

Source: World Development Indicators 1992, Board Draft, March 2, 1992. World Bank

Table 10. Sub-Saharan Africa: food security

Country	Population facing food insecurity (millions)	Percentage of population facing food insecurity	Per capita daily calorie supply (calories)		Average supply as percentage of minimum requirement a/	Average annual cereal import (thousands of tons)		Index of per capita food production (1979-81 = 100)	
	1980/82	1980/81	1965	Average 1986-89	1988	1974	1990	1964-66	1988-90
Sub-Saharan Africa	98	28	2,074	2,027	87	4,209	7,838	..	94
Angola	..	..	1,907	1,742	74	149	272	127	81
Benin	1	18	2,019	2,115	92	8	126	94	112
Botswana	..	..	2,025	2,251	97	21	87	134	113
Burkina Faso	2	32	1,882	2,002	84	99	145	113	114
Burundi	1	26	2,131	2,320	100	7	17	100	92
Cameroon	1	9	2,011	2,142	92	81	398	89	89
Cap Verde	..	..	..	2,500	107	..	..	163	..
Central African Rep.	1	29	2,055	1,965	87	7	37	94	91
Chad	2	54	2,395	1,821	76	37	36	124	85
Comoros	..	..	..	2,059	88	..	..	114	..
Congo	0	27	2,260	2,519	114	34	94	110	94
Cote d'Ivoire	1	8	2,352	2,405	104	172	502	73	101
Djibouti	..	..	..	..	..	..	..	..	..
Equatorial Guinea	..	..	..	..	..	..	..	..	..
Ethiopia	15	46	1,853	1,684	72	118	687	111	84
Gabon	0	7	1,955	2,398	103	24	57	110	84
Gambia, The	0	19	..	2,339	98	..	..	152	..
Ghana	4	36	1,937	2,167	94	177	337	120	97
Guinea	..	..	2,187	2,007	87	63	210	106	87
Guinea-Bissau	..	..	..	2,437	106	..	..	140	..
Kenya	6	37	2,208	2,016	87	15	188	119	106
Lesotho	..	..	2,049	2,275	100	48	97	120	86
Liberia	1	30	2,158	2,344	101	42	70	95	84
Madagascar	1	13	2,447	2,174	95	114	183	105	88
Malawi	1	24	2,259	2,057	89	17	115	87	83
Mali	3	35	1,938	2,114	90	281	61	100	97
Mauritania	0	25	1,903	2,465	107	116	85	143	86
Mauritius	0	9	2,269	2,690	118	160	210	111	100
Mozambique	6	49	1,712	1,604	68	62	416	132	81
Niger	2	28	1,996	2,321	98	155	86	105	71
Nigeria	14	17	2,185	2,083	88	389	502	125	106
Rwanda	1	24	1,856	1,817	78	3	21	78	77
Sao Tome and Principe	..	..	..	2,529	108	..	..	..	..
Senegal	1	21	2,372	2,162	91	341	534	156	102
Seychelles	..	..	..	2,117	91	..	..	..	..
Sierra Leone	1	23	2,014	1,813	79	72	146	99	89
Somalia	2	50	1,718	1,781	77	42	194	144	94
Sudan	3	18	1,938	1,981	84	125	186	89	71
Swaziland	..	..	..	2,554	110	..	..	68	..
Tanzania	7	35	1,831	2,186	94	431	73	87	88
Togo	1	29	2,454	2,110	92	6	111	118	88
Uganda	6	46	2,361	2,034	88	36	7	110	95
Zaire	12	42	2,187	2,079	93	343	336	110	97
Zambia	3	48	2,072	2,028	87	93	100	98	103
Zimbabwe	..	..	2,075	2,193	92	56	83	96	94

a/ Average per capita daily calorie supply data for 1986-1989 divided by requirement established by the WHO for each country.

Note: Food security is defined as access to enough food for an active and healthy life. The minimum daily calorie requirement to meet the energy needs of an average healthy person, as calculated by the World Health Organization of each country, is taken into account. Index of food production, cereal imports, per capita calories supply 1965: World Development Indicators 1992, except for Guinea-Bissau, The Gambia, Comoros, Sao Tome and Principe, Cape Verde, Seychelles, Swaziland for which the source is the World Bank, Sub-Saharan Africa: Crisis to Sustainable Growth, 1989. Per capita calorie supply 1986-1989; African Development Indicators, 1992; World Bank/UNDP p. 322.

Table 11. Sub-Saharan Africa: crop yields

Country	Cereals		Roots and tubers	
	kg/ha 1984-86	Percentage change compared to 1964-66	kg/ha 1984-86	Percentage change compared to 1964-66
Sub-Saharan Africa	..	..	..	..
Angola	461	-47	14,088	22
Benin	825	54	8,241	34
Botswana	178	-52	5,385	35
Burkina Faso	690	33	6,568	96
Burundi	1,101	12	7,538	-3
Cameroon	935	18	2,455	10
Cape Verde	551	-11	3,007	-27
Central African Rep.	513	-31	3,882	10
Chad	531	-13	5,182	14
Comoros	1,116	-15	3,259	-4
Congo	622	-43	6,457	31
Cote d'Ivoire	981	23	6,282	70
Djibouti	..	..	..	..
Equatorial Guinea	..	..	2,395	-33
Ethiopia	1,081	39	2,827	-7
Gabon	1,481	-6	6,393	0
Gambia, The	1,207	15	3,000	-32
Ghana	969	7	8,641	5
Guinea	728	-10	7,089	-5
Guinea-Bissa	848	19	6,154	0
Kenya	1,611	31	8,929	21
Lesotho	683	-12	15,000	3
Liberia	1,302	107	4,014	-3
Madagascar	1,731	1	5,926	-7
Malawi	1,162	24	4,231	-13
Mali	807	3	9,240	12
Mauritania	431	20	1,903	-24
Mauritius	3,200	59	25,939	108
Mozambique	660	-29	5,783	20
Niger	366	-30	8,877	10
Nigeria	1,121	67	11,260	43
Rwanda	1,289	2	7,780	42
Sao Tome and Principe	..	..	..	..
Senegal	709	24	4,232	2
Seychelles	..	..	..	..
Sierra Leone	1,431	8	3,425	-6
Somalia	725	47	10,792	8
Sudan	508	-27	3,408	-1
Swaziland	1,528	225	1,815	-53
Tanzania	1,109	41	11,075	109
Togo	865	83	10,498	-12
Uganda	949	5	6,432	64
Zaïre	851	24	7,016	4
Zambia	1,747	106	3,687	13
Zimbabwe	1,460	63	4,907	22
India	1,590	76	14,268	61
China	3,891	122	15,614	81

Source: World Bank, World Development Report 1991

Table 12: Sub-Saharan Africa: growth rates of cereal and major export crop yields

Country	Average Annual Percentage Growth					
	Cereals			Major Export Crop		
	1975-80	1980-85	1986-MR	1975-80	1980-85	1986-MR
Angola (maize,coffee)	-6.1	-4.5	-6.9	-21.4	-19.7	-14.3
Benin (maize, cotton)	1.2	3.8	7.0	-2.0	13.6	-0.8
Botswana (maize, n.a.)	-28.7	-11.9	-16.2	..	..	..
Burkina Faso (maize, cotton)	7.4	-1.9	7.7	5.5	7.3	-5.3
Burundi (maize, coffee)	-1.3	0.6	-0.8	4.2	9.6	-1.3
Cameroon (maize, coffee)	-7.3	0.3	4.0	2.8	0.6	-10.3
CAR (maize, coffee)	-2.4	16.9	-4.6	-1.0	1.6	4.4
Chad (sorghum, cotton)	-0.8	-1.8	0.0	2.0	6.9	-4.8
Congo (maize, coffee)	3.7	-4.5	7.4	18.7	1.0	16.2
Cote d'Ivoire (maize, coffee)	6.3	1.8	-1.2	-6.5	-10.8	-8.4
Eq. Guinea (cassava, coffee)	-0.4	-1.7	-0.3	0.8	1.4	0.0
Ethiopia (maize, coffee)	-2.5	-5.1	1.2	3.7	1.0	3.2
Gabon (maize, coffee)	4.1	-3.0	7.6	1.6	9.9	2.9
The Gambia (maize, cotton)	11.8	3.0	-3.1	..	-5.5	0.6
Ghana (maize, cocoa)	-2.9	-0.5	5.9	-3.6	-1.0	11.2
Guinea (maize, coffee)	-3.3	2.4	-0.1	-0.1	-3.7	-2.2
Guinea-Bissau (maize, groundnuts)	-1.2	3.6	-11.4	-3.5	5.1	2.5
Kenya (maize, coffee)	-7.2	4.0	-1.3	3.9	-5.9	-0.6
Lesotho (maize, wheat)	11.4	-4.6	6.3	3.8	-12.3	3.5
Liberia (rice, coffee)	0.5	0.0	-1.0	7.5	3.9	-23.2
Madagascar (rice, coffee)	-1.4	1.5	3.3	-1.7	-1.1	0.6
Malawi (maize, tea)	3.5	-0.1	4.3	1.6	1.1	1.8
Mali (maize, cotton)	12.9	2.9	5.2	1.2	2.6	-3.1
Mauritania (maize, rice)	11.6	-9.6	-4.2	-2.1	7.0	-1.6
Mauritius (potatoes, sugarcane)	1.7	8.7	0.3	1.1	2.1	-3.7
Mozambique (maize, cotton)	4.7	-2.7	0.0	1.3	-7.4	-11.8
Namibia (maize, wheat)	-0.9	0.6	2.9	0.0	4.3	-5.3
Niger (sorghum, groundnuts)	6.3	-10.2	-0.2	28.7	-11.5	9.2
Nigeria (maize, cocoa)	-1.3	-5.2	1.5	-4.5	-6.7	15.9
Rwanda (maize, coffee)	1.4	0.5	0.4	3.3	2.2	7.9
Senegal (maize, cotton)	-6.5	9.7	6.4	-3.7	-1.4	7.6
Sierra Leone (rice, coffee)	-3.8	2.5	-4.3	13.7	-11.2	-17.8
Somalia (maize, bananas)	-1.41	8.5	-6.7	1.0	-0.1	-0.8
Sudan (sorghum, cotton)	-2.7	-9.1	-4.8	-4.5	20.0	5.3
Swaziland (maize, cotton)	-3.6	-0.8	7.7	6.4	-1.5	0.0
Tanzania (maize, coffee)	1.0	1.1	9.7	-1.8	-0.4	-8.3
Togo (maize, coffee)	-0.8	-1.5	20.9	-5.7	-13.1	4.6
Uganda (maize, coffee)	1.1	-3.1	2.7	-8.3	4.9	10.2
Zaire (maize, coffee)	2.1	1.0	2.4	-4.3	-0.2	0.4
Zambia (maize, cotton)	3.3	0.9	3.9	-5.4	11.5	-2.5
Zimbabwe (maize, cotton)	-6.0	-1.5	1.1	0.8	3.3	-15.0

MR: Most Recent Year

Source: UNDP/World Bank Africa Development Indicators, 1992.

Table 13. Sub-Saharan Africa: agricultural exports - value and volume

Country	Average Annual Percentage Growth					
	Value			Volume		
	1975-80	1980-85	1986-MR	1975-80	1980-85	1986-MR
Sub-Sahara Africa	9.6	- 2.4	- 3.1	- 0.8	- 2.9	- 2.5
Angola	- 2.4	-13.0	-36.5	-19.1	-14.2	-12.3
Benin	12.9	17.6	5.4	1.6	5.9	2.8
Botswana	3.2	0.8	3.5	-10.0	10.4	-28.0
Burkina Faso	10.9	- 5.1	17.5	- 0.8	- 8.1	0.9
Burundi	13.2	9.5	-15.9	-14.4	10.0	10.2
Cameroon	17.7	- 5.2	- 1.2	- 1.2	0.0	1.5
Cape Verde	43.5	-23.3	18.6	-12.0	- 6.7	-11.5
CAR	13.2	- 0.9	- 5.0	- 5.6	- 0.3	1.8
Chad	14.2	6.1	9.0	3.2	- 6.6	- 4.2
Comoros	9.7	0.9	- 5.9	- 1.6	8.5	-32.3
Congo	6.6	4.1	- 3.5	-24.8	34.2	1.6
Cote d'Ivoire	19.9	1.5	- 8.6	2.3	3.6	- 4.0
Eq. Guinea	2.5	8.7	-16.4	- 7.2	7.7	4.4
Ethiopia	13.7	- 2.9	-11.2	-14.5	8.1	11.2
Gabon	48.9	-10.0	-19.3	13.5	- 3.0	-11.5
The Gambia	- 9.1	- 1.6	3.1	-11.6	- 3.6	23.2
Ghana	7.2	-10.6	- 7.4	- 13.4	- 5.1	8.6
Guinea	13.3	-10.4	0.2	3.4	- 8.2	- 1.3
Guinea-Bissau	7.8	8.1	11.5	0.6	0.2	- 3.8
Kenya	15.2	1.7	- 4.6	1.8	0.5	- 1.7
Lesotho	12.2	4.2	16.2	- 3.8	- 5.6	-56.9
Liberia	21.4	- 2.5	- 5.0	0.9	2.3	- 2.5
Madagascar	9.8	- 6.1	-10.4	- 5.5	- 3.4	1.6
Malawi	13.5	0.7	10.0	11.3	5.0	-11.7
Mali	20.7	- 2.1	9.6	13.0	- 0.5	- 6.0
Mauritania	15.9	- 3.9	1.5	0.1	- 6.7	- 6.0
Mauritius	4.5	- 4.8	4.9	4.4	- 0.7	1.7
Mozambique	7.0	-26.7	- 1.1	- 6.8	-23.9	17.0
Namibia	7.9	- 3.8	9.5	-	- 2.1	10.0
Niger	18.6	- 6.6	- 7.2	5.5	- 3.3	-14.0
Nigeria	3.2	- 6.1	- 7.4	- 3.5	-17.2	1.8
Rwanda	10.3	1.6	-11.4	-19.7	6.0	- 0.3
Sao Tome & Principe	24.7	-14.8	-10.4	6.2	-12.5	- 3.1
Senegal	-12.4	6.7	22.0	-18.1	- 3.0	33.2
Seychelles	13.4	-14.9	-19.4	- 4.7	- 7.9	-37.2
Sierra Leone	18.7	- 1.7	-24.2	- 7.3	- 2.4	- 0.4
Somalia	11.2	-14.3	- 7.8	6.4	- 10.6	- 21.7
Sudan	4.2	- 4.1	13.4	6.6	- 6.9	24.2
Swaziland	14.0	-12.7	6.2	- 7.0	2.3	- 8.0
Tanzania	4.2	-10.0	- 3.1	- 4.6	-10.4	7.0
Togo	18.3	1.3	- 4.8	0.9	0.6	- 8.9
Uganda	4.8	5.1	-18.8	-15.3	8.2	2.1
Zaire	0.3	2.8	-19.3	- 6.5	- 2.7	-12.6
Zambia	- 2.6	4.9	2.7	-18.7	31.0	-31.6
Zimbabwe	2.4	- 1.2	8.3	-11.8	3.6	-10.7

MR: Most Recent Year

Source: UNDP/World Bank; African Development Indicators, 1992

Table 14. Sub-Saharan Africa: producer price shares

Ratio of Official Producers Price to International Reference Price				
		Average		
		1975/79	1980/85	1986-MR
Angola	Coffee	.22	.45	.96
Benin	Cotton Lint	.45	.41	.54
Botswana	Groundnut	-	.61	-
Burkina Faso	Cotton	.42	.34	.56
Burundi	Coffee	.51	.60	.60
Cameroon	Cotton	.42	.37	.40
CAR	Coffee	.29	.18	.34
Chad	Cotton	.75	.51	.54
Comoros	Vanilla	.43	.32	.42
Congo	Coffee	.21	.26	1.09
Cote d'Ivoire	Cocoa Beans	.40	.51	.79
Eq. Guinea	Cocoa	-	.79	.90
Ethiopia	Coffee	.45	.39	.42
Gabon	Cocoa	.57	.49	.63
The Gambia	Groundnut	.54	.62	.71
Ghana	Cocoa	.30	.87	.25
Guinea	Palm Kennels	1.08	.86	.62
Guinea-Bissau	Groundnut	.63	.51	.34
Kenya	Coffee	.82	.88	.95
Lesotho	Wheat	-	1.40	1.26
Liberia	Coffee	.42	.64	.79
Madagascar	Coffee	.40	.29	.38
Malawi	Groundnut	.47	.65	1.01
Mali	Cotton	.34	.39	.50
Mauritius	Sugar	.90	.61	.52
Mozambique	Tea	.64	.56	.33
Niger	Cotton	.35	.45	1.13
Nigeria	Cocoa	.53	1.12	.49
Rwanda	Coffee	.58	.89	.81
Sao Tome & Principe	Cocoa	.36	.99	-
Senegal	Groundnut	.42	.42	.81
Sierra Leone	Cocoa	.47	.66	.42
Somalia	Bananas	-	.43	.33
Sudan	Groundnut	.55	.40	.96
Swaziland	Cotton	.46	.29	.27
Tanzania	Coffee	.39	.55	.36
Togo	Coffee	.24	.31	.54
Uganda	Coffee	.13	.22	.14
Zaire	Coffee	.18	.45	-
Zambia	Tobacco	.75	.87	.36
Zimbabwe	Tobacco	.66	.62	.58

MR: Most Recent Year

Source: UNDP, World Bank, African Development Indicators, 1992 (Table 8-2)

Table 15. Sub-Saharan Africa: irrigation and fertilizer use

Country	Percentage of irrigated land a/	Fertilizer consumption (100g/ha) b/	
	1985-87	1970-71	1989-90
Sub-Saharan Africa	4	33	89
Angola	0	33	74
Benin	0	36	18
Botswana	0	15	7
Burkina Faso	0	3	58
Burundi	5	5	35
Cameroon	0	34	41
Cape Verde	5	..	..
Central African Rep.	..	12	4
Chad	0	7	15
Comoros	0	..	..
Congo	1	525	32
Cote D'Ivoire	2	74	113
Djibouti	..	..	..
Equatorial Guinea	..	..	..
Ethiopia	1	4	70
Gabon	..	..	27
Gambia, The	7	..	..
Ghana	0	11	31
Guinea	4	44	11
Guinea-Bissau	..	..	..
Kenya	2	238	481
Lesotho	..	10	144
Liberia	1	63	107
Madagascar	28	61	36
Malawi	1	52	227
Mali	9	31	54
Mauritania	6	11	116
Mauritius	16	2095	3302
Mozambique	3	22	8
Niger	1	1	8
Nigeria	3	2	121
Rwanda	0	3	14
Sao Tome and Principe	..	..	..
Senegal	3	17	55
Seychelles	..	..	..
Sierra Leone	2	17	3
Somalia	12	27	26
Sudan	15	28	39
Swaziland	38	..	..
Tanzania	3	31	93
Togo	0	3	83
Uganda	0	14	1
Zaïre	0	6	10
Zambia	0	73	166
Zimbabwe	7	446	604
India	26	137	687
China	44	410	2619

a/ Irrigated land as percentage of arable and permanent crop land; World Resources Institute.
b/ Fertilizer consumption in terms of hundreds of grams of plant nutrients per hectare of arable land; World Bank, World Indicators 1992.

Table 16. Sub-Saharan Africa: land use

Country	Land use as a percentage of total land												Total land area (000 ha)	Wilderness Area as percent of total land area a/
	Cropland			Pasture			Forest			Other				
	1965	1980	1987	1965	1980	1987	1965	1980	1987	1965	1980	1987	1987	1985
Sub-Saharan Africa	6	7	7	27	27	27	33	31	30	34	35	36	2,158,466	28
Angola	3	3	3	23	23	23	44	43	43	30	31	31	124,670	26
Benin	13	16	17	4	4	4	44	36	33	39	44	47	11,062	15
Botswana	2	2	2	74	78	78	2	2	2	23	18	18	56,673	63
Burkina Faso	8	10	11	37	37	37	30	26	25	26	27	27	27,380	3
Burundi	39	51	52	24	35	36	2	2	3	35	11	10	2,565	0
Cameroon	12	15	15	19	18	18	59	55	53	10	12	14	46,540	3
Cape Verde	10	10	10	6	6	6	0	0	0	84	84	84	403	42
Central African Rep.	3	3	3	5	5	5	58	58	58	34	34	34	62,298	39
Chad	2	3	3	36	36	36	12	11	10	50	51	51	125,920	52
Comoros	38	41	44	7	7	7	16	16	16	39	37	34	223	..
Congo	2	2	2	29	29	29	64	63	62	5	6	7	34,150	16
Cote d'Ivoire	8	10	11	9	9	9	60	31	20	22	50	59	31,800	0
Djibouti	..	..	..	9	9	9	0	0	0	91	91	91	2,318	35
Equatorial Guinea	8	8	8	4	4	4	46	46	46	42	42	42	2,805	0
Ethiopia	11	13	13	42	41	41	27	26	25	20	21	22	110,100	22
Gabon	1	2	2	20	18	18	78	78	78	2	2	2	25,767	..
Gambia, The	13	16	17	9	9	9	30	22	17	48	54	57	1,000	0
Ghana	12	12	12	16	15	15	43	38	36	31	35	37	23,002	0
Guinea	6	6	6	12	12	12	49	43	41	33	38	41	24,586	0
Guinea-Bissau	9	10	12	38	38	38	39	38	38	13	13	12	2,812	0
Kenya	3	4	4	7	7	7	8	7	6	82	83	83	56,697	25
Lesotho	13	10	11	73	66	66	..	..	..	15	24	24	3,035	80
Liberia	4	4	4	2	2	2	22	22	22	72	72	72	9,632	17
Madagascar	4	5	5	58	58	58	31	27	25	7	9	11	58,154	2
Malawi	21	25	25	20	20	20	54	54	46	5	2	9	9,408	10
Mali	1	2	2	25	25	25	8	7	7	66	67	67	122,019	49
Mauritania	0	0	0	38	38	38	15	15	15	47	47	47	102,522	74
Mauritius	51	58	58	4	4	4	34	31	31	12	7	7	185	11
Mozambique	3	4	4	56	56	56	22	20	19	18	20	21	78,409	9
Niger	2	3	3	8	8	7	3	2	2	87	87	88	126,670	53
Nigeria	32	33	34	21	23	23	23	18	16	24	26	27	91,077	2
Rwanda	26	41	45	34	19	16	23	21	20	17	20	19	2,495	0
Sao Tome & Principe	35	38	39	1	1	1	..	..	..	64	61	60	96	..
Senegal	23	27	27	30	30	30	35	31	31	12	12	12	19,253	..
Seychelles	19	19	22	..	..	..	19	19	19	63	63	59	27	0
Sierra Leone	20	25	25	31	31	31	30	30	29	19	15	15	7,162	0
Somalia	1	1	1	46	46	46	16	15	14	37	38	38	62,734	24
Sudan	5	5	5	24	24	24	24	21	20	47	51	51	237,600	40
Swaziland	8	11	10	78	64	68	8	6	6	6	19	16	1,720	0
Tanzania	4	6	6	40	40	40	51	49	48	5	6	7	88,604	10
Togo	20	26	26	4	4	4	45	31	25	31	39	45	5,439	0
Uganda	24	28	34	25	25	25	32	30	29	19	16	13	19,955	4
Zaire	3	3	3	4	4	4	80	78	77	13	15	16	226,760	6
Zambia	7	7	7	47	47	47	42	40	39	4	6	6	74,072	24
Zimbabwe	5	7	7	13	13	13	52	52	52	30	29	29	38,667	1
India	55	..	57	5	..	4	20	..	22	20	..	17	297,319	20
China	11	..	11	31	..	31	12	..	14	46	..	44	932,641	20

a/ Refers only to areas larger than 4,000 square kilometers. Wilderness area is defined as land left in its natural state without any transformation by human action. These areas may partly include forests, pasture and other lands as classified by FAO

Source: FAO; and the World Resource Institute and International Institute for Environment and Development (in collaboration with UN Environment Programme). World Resources 1988-89, 1988.

Table 17. Sub-Saharan Africa: per capita arable land

Country	Per capita arable land area (hectares)				
	1965	1980	1987	1990	2000 a/
Sub-Saharan Africa	**0.5**	**0.4**	**0.3**	**0.29**	**0.22**
Angola	0.6	0.5	0.4	0.36	0.28
Benin	0.6	0.5	0.4	0.40	0.30
Botswana	1.9	1.5	1.2	1.06	0.70
Burkina Faso	0.5	0.4	0.4	0.40	0.25
Burundi	0.3	0.3	0.3	0.24	0.18
Cameroon	1.0	0.8	0.6	0.59	0.43
Cape Verde	0.2	0.1	0.1	0.11	0.08
Central African Rep.	1.0	0.9	0.7	0.66	0.48
Chad	0.9	0.7	0.6	0.56	0.51
Comoros	0.4	0.3	0.2	0.18	0.15
Congo	0.6	0.4	0.3	0.07	0.22
Cote d'Ivoire	0.6	0.4	0.3	0.31	0.20
Djibouti	..	..	..	..	..
Equatorial Guinea	0.8	0.7	0.6	0.65	0.51
Ethiopia	0.5	0.4	0.3	0.28	0.20
Gabon	0.4	0.6	0.4	0.39	0.35
Gambia, The	0.3	0.2	0.2	0.21	0.15
Ghana	0.3	0.3	0.2	0.18	0.14
Guinea	0.4	0.3	0.2	0.13	0.20
Guinea-Bissau	0.5	0.4	0.4	0.35	0.28
Kenya	0.2	0.1	0.1	0.10	0.07
Lesotho	0.4	0.2	0.2	0.18	0.15
Liberia	0.3	0.2	0.2	0.14	0.12
Madagascar	0.4	0.3	0.3	0.26	0.20
Malawi	0.5	0.4	0.3	0.28	0.19
Mali	0.4	0.3	0.3	0.23	0.21
Mauritania	0.2	0.1	0.1	0.10	0.00
Mauritius	0.1	0.1	0.1	0.10	0.09
Mozambique	0.3	0.3	0.2	0.20	0.15
Niger	0.6	0.6	0.5	0.47	0.36
Nigeria	0.5	0.4	0.3	0.29	0.19
Rwanda	0.2	0.2	0.2	0.16	0.11
Sao Tome and Principe	0.5	0.4	0.3	0.3	0.23
Senegal	1.1	0.9	0.8	0.71	0.51
Seychelles	0.1	0.1	0.1	0.10	0.08
Sierra Leone	0.6	0.5	0.5	0.43	0.33
Somalia	0.3	0.2	0.2	0.14	0.07
Sudan	0.9	0.7	0.5	0.50	0.36
Swaziland	0.4	0.3	0.2	0.21	0.16
Tanzania	0.3	0.3	0.2	0.19	0.14
Togo	0.7	0.6	0.4	0.41	0.28
Uganda	0.6	0.4	0.4	0.36	0.28
Zaïre	0.3	0.2	0.2	0.22	0.14
Zambia	1.3	0.9	0.7	0.62	0.45
Zimbabwe	0.5	0.4	0.3	0.29	0.21
India	0.3	..	0.2	..	0.16
China	0.6	..	0.4	..	0.32

a/ 1987 arable land areas have been divided by the projected population of the year 2000.

Source: FAO; World Bank, WDR 1991.
1990: World Resources Institute

Table 18. Sub-Saharan Africa: forest area and deforestation

Country	Forest and Woodland 1980 (thousand hectares)	Deforestation, 1980s		Reforestation, 1980s (thousand hectares per year)
		Percent per year	Thousand hectares per year	
Sub-Saharan Africa	678,900	0.6	3,764	229
Angola	53,600	0.2	94	4
Benin	3,867	1.7	67	0
Botswana	32,560	0.1	20	..
Burkina Faso	4,735	1.7	80	3
Burundi	41	2.7	1	3
Cameroon	22,300	0.8	190	2
Cape Verde	..	..	..	0
Central African Rep.	35,890	0.2	55	..
Chad	13,500	0.6	80	0
Comoros	16	3.1	1	0
Congo	..	0.1	22	0
Cote d'Ivoire	9,834	5.2	510	8
Djibouti	106	..	..	..
Equatorial Guinea	1,295	0.2	3	..
Ethiopia	27,150	0.3	88	13
Gabon	20,575	0.1	15	1
Gambia, The	215	2.4	5	0
Ghana	8,693	0.8	72	3
Guinea	10,650	0.8	86	0
Guinea-Bissau	2,105	2.7	57	0
Kenya	2,360	1.7	39	13
Lesotho	..	..	..	0
Liberia	2,040	2.3	46	3
Madagascar	13,200	1.2	156	15
Malawi	4,271	3.5	150	1
Mali	7,250	0.5	36	1
Mauritania	554	2.4	13	0
Mauritius	3	3.3	0	0
Mozambique	15,435	0.8	120 67	5
Niger	2,550	2.6	400 5	3
Nigeria	14,750	2.7	..	32
Rwanda	230	2.3	50	4
Sao Tome and Principe	..	..	..	..
Senegal	11,045	0.5	6	4
Seychelles	..	..	14	..
Sierra Leone	2,055	0.3	504	0
Somalia	9,050	0.1	0	2
Sudan	47,650	1.1	130 12	17
Swaziland	74	..	50	7
Tanzania	42,040	0.3	370 70	11
Togo	1,684	0.7	80	1
Uganda	6,015	0.8		2
Zaïre	177,590	0.2		1
Zambia	29,510	0.2		3
Zimbabwe	19,820	0.4		6

Source: World Resources Institute; Draft data from African Indicators Project; March 1991, Table 13 deforestation and reforestation.

Table 19. Sub-Saharan Africa: fuelwood supply and demand

Country	Fuelwood supply demand balance (million cubic meters) 1980	2000
Sub-Saharan Africa	..	..
Angola	..	..
Benin	17.6	8.9
Botswana	25.6	23.9
Burkina Faso	-2.6	-11.2
Burundi	-3.2	-7.0
Cameroon	72.6	59.6
Cape Verde	..	..
Central African Rep.	111.5	105.6
Chad	-1.2	-9.8
Comoros	..	..
Congo	46.4	43.2
Cote d'Ivoire	43.9	14.4
Djibouti	..	..
Equatorial Guinea	4.6	4.0
Ethiopia	4.4	-30.8
Gabon	42.8	40.9
Gambia, The	-0.6	-1.5
Ghana	29.3	13.8
Guinea	38.6	29.6
Guinea-Bissau	4.8	1.1
Kenya	-4.5	-58.4
Lesotho	..	..
Liberia	11.1	-4.4
Madagascar	5.2	4.4
Malawi	-3.1	-13.1
Mali	0.4	-5.0
Mauritania	3.8	3.8
Mauritius	..	..
Mozambique	16.8	0.3
Niger	-0.9	-5.5
Nigeria	57.5	-89.6
Rwanda	-5.5	-16.0
Sao Tome and Principe	..	..
Senegal	0.3	-4.4
Seychelles	..	..
Sierra Leone	5.0	-1.5
Somalia	11.1	6.5
Sudan	6.1	-39.5
Swaziland	-0.5	-1.3
Tanzania	-5.1	-74.0
Togo	10.3	13.1
Uganda	-18.7	-57.3
Zaïre	388.2	327.9
Zambia	15.2	5.4
Zimbabwe	2.8	-12.2

g/ Fuelwood supply-demand balance defined as increase in stock of fuelwood in the year minus total utilization of fuelwood in that year.

Source :FAO

Table 20. Sub-Saharan Africa: wildlife habitat loss in afrotropical nations, 1986

Country	Original wildlife habitat 1000 (square kilometers)	Amount remaining (square 1000 kilometers	Loss (percent)
Angola	1,246.7	760.9	39
Benin	115.8	46.3	60
Botswana	585.4	257.6	56
Burkina Faso	273.8	54.8	80
Burundi	25.7	3.6	86
Cameroon	469.4	192.4	59
Central African Rep.	623.0	274.1	56
Chad	720.8	173.0	76
Congo	342.0	174.4	49
Cote d'Ivore	318.0	66.8	79
Djibouti	21.8	11.1	49
Equatorial Guinea	26.0	12.8	51
Ethiopia	1,101.8	10.3	70
Gabon	267.0	173.6	35
Gambia, The	11.3	1.2	89
Ghana	230.0	46.0	80
Guinea	245.9	73.8	70
Guinea-Bissau	36.1	8.0	78
Kenya	569.5	296.1	48
Lesotho	30.4	9.8	68
Liberia	111.4	14.4	87
Madagascar	595.2	148.9	75
Malawi	94.1	40.4	57
Mali	754.1	158.3	79
Mauritania	388.6	73.9	81
Mozambique	783.2	36.8	57
Niger	566.6	127.9	77
Nigeria	919.8	230.0	75
Rwanda	25.1	3.2	87
Senegal	196.2	35.3	82
Sierra Leone	71.7	10.8	85
Somalia	637.7	376.2	41
Sudan	1,703.0	511.0	70
Swaziland	17.4	7.7	56
Tanzania	886.2	505.1	43
Togo	56.0	19.0	66
Uganda	193.7	42.7	78
Zaire	2,335.9	1,051.1	55
Zambia	752.6	534.3	29
Zimbabwe	390.2	171.7	56
Total	18,737.4	6,765.3	64
Namibia	823.2	444.5	46
South Africa	1,236.5	531.7	57

Note: Habitat is a place or type of site where a plant or animal naturally or normally lives and grows. The Afrotropical realm is defined as all of the continent south of the Sahara Desert, including the island of Madagascar. Therefore, data for Mauritania, Mali, Niger, Chad, and Sudan cover only parts of these countries. Comoros, Seychelles, Sao Tome and Principe, Mauritius, Rodrigues, Reunion, and the exteme southeastern corner of Egypt are not included.

Source: World Resource Institute and International Institute for Environment and Development (in collaboration with UN Environment Programme), World Resources 1988-89, 1988.

Table 21: Sub-Saharan Africa: droughts

(SIGNIFICANT RAINFALL SHORTAGE AT END OF PERIOD: D)

	1979/80	1984/85	1988/90
Angola	-	-	-
Benin	-	-	-
Botswana	-	D	-
Burkina Faso	-	D	-
Burundi	-	D	-
Cameroon	-	-	-
Cape Verde	-	D	-
CAR	-	D	-
Chad	-	D	-
Congo	-	-	-
Cote d'Ivoire	-	-	-
Eq. Guinea	-	-	-
Ethiopia	D	D	D
Gabon	-	-	-
The Gambia	-	D	-
Ghana	-	D	-
Guinea	-	-	-
Guinea-Bissau	-	-	-
Kenya	-	D	-
Lesotho	-	-	-
Liberia	-	-	-
Madagascar	-	-	-
Malawi	D	-	-
Mali	-	D	-
Mauritania	-	D	-
Mauritius	-	-	-
Mozambique	-	-	-
Namibia	-	-	-
Niger	-	D	D
Nigeria	-	-	-
Rwanda	-	D	-
Sao Tome & Principe	-	-	-
Senegal	D	D	-
Sierra Leone	-	-	-
Somalia	-	-	-
Sudan	-	D	D
Swaziland	-	-	-
Tanzania	-	D	-
Togo	-	-	-
Uganda	-	-	-
Zaire	-	-	-
Zambia	-	D	-
Zimbabwe	-	D	-

Source: UNDP, World Bank, African Development Indicators, 1992.

Table 22. Soil erosion in selected countries of Sub-Saharan Africa, 1970-86

	Location (and extent)	Affected area as percentage of National area	Amount of erosion (metric tons per year)	Amount of erosion (metric tons per hectare per year)	Year of estmate
Burkina Faso	Central plateau	NA	NA	5-35	1970s
Ethiopia	a) Total Cropland (12 million ha)	10	500 million	42	1966
	b) Central highland plateau (47 million ha)	43	1.6 million	0.03	1970s
Kenya	Njemps Flats	NA	NA	138	mid-1980s
	Tugan Plateau	NA	NA	72	mid-1980s
Lesotho	Grazing and croplands (2.7 million ha)	88	18.5 million	7	NA
Madagascar	a) Mostly cropland (45.9 million ha)	79	NA	25-250	1970s
	b) High central plateau	NA	12-40 million	25-250	1980s
Niger	Small watershed (11,700 ha)	0.01	468,000	40	NA
Nigeria	a) Imo State (900,000 ha)	1	13 million	14.4	1974
	b) Jos Plateau	NA	6 million	NA	1975
	c) Anemora	NA	10-15 million	NA	1975
Zimbabwe	Area with moderate to severe erosion (304,000 ha)	0.8	15 million	50	1979

NA indicates not available.

Source: World Resources Institute and International Institute for the Environment and Conservation.

Table 23. Extent of soil degradation in major regions of the world, early 1980s

	Total productive drylands		Productive dryland types					
			Rangelands		Rainfed croplands		Irrigated lands	
	Area (million hectares)	Percent degraded	Area (million hectares)	Percent degraded	Area (million hectares	Percent degraded	Area (million hectares)	Percent degraded
Total	3,287	87	2,586	62	570	60	131	30
Sudano-Sahelian Africa	473	88	380	90	90	80	3	30
Southern Africa	304	80	250	80	52	80	2	30
Mediterranean Africa	101	83	80	85	20	75	1	40
Western Asia	142	82	116	85	18	85	8	40
Southern Asia	359	70	150	85	150	70	59	35
USSR in Asia	298	55	250	60	40	30	8	25
China and Mongolia	315	69	300	70	5	60	10	30
Australia	491	23	450	22	39	30	2	19
Mediterranean Europe	76	39	30	30	40	32	6	25
South America and Mexico	293	71	250	72	31	77	12	33
North America	405	40	300	42	85	39	20	20

Source: United Nations Environment Programme. The term used is "desertification", which has been substituted here with the term degradation which is more accurate.

Table 24 - Results of financial and economic analyses of various land resource management technologies *(Nigeria land resources management study)*

Zone/technology	Problem(s) addressed	Yield increment benefit[a] (percent)	Annual yield decline[b]		Financial analysis results				Economic analysis results				Conservation benefits as % of total benefits[e] (percent)
			Without project (percent)	With project (percent)	Base case[c]		Degraded case[d]		Base case[c]		Degraded case[d]		
					IRR (percent)	B:C ratio	IRR (percent)	B:C ratio	IRR (percent)	B:C ratio	IRR (percent)	B:C ratio	
Very humid zone:													
Vetiver grass contour hedges	Sheet erosion; incipient gullying	5	3	1	20.5	1.20	50.0	2.53	15.7	1.37	40.4	2.91	70
Fanya Juu contour bunds	Sheet erosion; incipient gullying	5	3	1	8.5	0.77	30.6	1.68	23.1	1.91	48.2	4.08	59
Stone-faced terracing	Sheet erosion; incipient gullying	5	3	1	-11.1	0.37	7.5	0.76	11.5	1.16	34.4	2.42	94
Wave Bedding	Gullying	–	–	–	11.4	0.73	12.8	0.83	13.2	1.82	13.6	1.87	90
Improved acioa system	Declining fertility	0	–	–	–	1.45	–	1.12	–	1.81	–	1.40	92
Alley cropping	Declining fertility	20	5	2	17.7	1.06	14.7	1.00	9.5	1.05	4.2	0.94	45
Sub-humid zone:													
Animal traction	Declining fertility	5	2	1	16.6	1.06	24.2	1.39	14.2	1.34	22.0	1.79	17
Fodder banks	Declining fertility	40	2	–	25.3	1.33	23.7	1.27	10.6	1.07	5.8	0.97	11
Grazing reserve improvement	Overgrazing	33	2	–	7.9	0.80	23.5	1.25	-0.2	0.68	8.3	1.04	100
Plateau zone:													
Community woodlots	Woodland degradation	–	–	–	14.5	0.95	–	–	8.0	1.06	8.5	1.11	76
Dry sub-humid zone:													
Tree shelterbelts	Wind erosion	20	2	1	11.5	0.75	18.7	1.31	7.6	1.01	11.6	1.39	75
Vetiver hedge shelterbelts	Wind erosion	10	2	1	29.8	1.32	71.6	2.14	11.0	1.10	38.0	1.92	77
Farm forestry	Wind erosion; declining fertility; woodland degradation	10	2	1	15.0	1.00	16.6	0.12	12.5	1.67	14.2	1.96	5
Private woodlots	Woodland degradation	-	–	–	10.5	0.65	–	–	4.5	0.76	4.9	0.79	76
Indigenous rock bunds	Sheet erosion; incipient gullying	25	2	1	24.2	1.17	66.6	1.84	64.8	2.09	165.2	3.04	57

a. Yield increment benefits were based on the following

Vetiver grass contour hedges Fanya Juu contour bunds Stone-faced terracing	Wiggins (1981) in an analysis of similar slopes and rainfall conditions in El Salvador allowed for a 1% yield increment to account for retention of fertilizer and seeds once project is in place; a somewhat higher figure was judged appropriate for southeastern Nigeria.
Improved acioa system	No yield increment is assumed as the improved system is meant to produce an extra crop one year in four
Alley cropping	IITA studies over the years have demonstrated yield improvements for maize in excess of 40% under alley cropping (Ngambeki and Wilson, 1984; Ngambeki, 1985). For cassava under southeastern Nigerian conditions, Kang et al. (1989) report yields of 15 to 20 t/ha on alley farmed areas compared to 14 t/ha on traditional plots with no fertilizer. Alley farm yields vary according to whether prunings are or are not applied with or without fertilizer, and depending on the tree species planted in the hedgerows. Because of the early stage of reserach, a conservative 20% yield gain was assumed.
Animal traction	There is considerable debate concerning yield gains under animal traction. Pingali et al. (1987) review a large number of studies and conclude the yield impact is minimal, especially when observing an individual farmer converting to animal traction from the hoe without an improvement in the quality of tillage. As a result, only a minimal yield improvement of 5% was assumed here.
Fodder bank	ILCA researchers have demonstrated large yield gains for maize planted in rotation with stylo-based fodder banks. Mohamed Saleem et al. (1985) report a doubling of yields on fodder banks compared to yields on lands fallowed for many years. Tarawali et al. (1987) report an 85% increase for test plots in the sub-humid zone. A conservative figure of 40% was assumed here.
Grazing reserve	Bincan (1988) assumes that a program of grazing reserve improvements could raise carrying capacity from one TLU per 8 ha to one per 6 ha, for an increase of 33%; this assumption is adopted here.
Tree shelterbelt Vetiver hedge shelterbelt Farm forestry	Yield increments are taken from Anderson (1987), who extensively reviews the literature on shelterbelt effects. Since vetiver hedges have not been studied greatly, a conservative figure of 10% was adopted
Indigenous rock bunds	OXFAM's project in Burkina Faso demonstrated yield gains from 9% to 40%, depending on rainfall conditions (Younger and Bonkoungou, 1989). For Nigeria, a figure of 25% was assumed, but rainfall conditions will be important in determining ultimate yield benefits.

b. Annual yield decline figures were derived as follows:

Vetiver grass contour hedges Fanya Juu contour bunds Stone-faced terracing	Using soil loss-yield relationships developed by Lal (1987) for a 15% slope in southern Nigeria, yield loss per year would be 3.5% (assuming a beta value of 0.04 to account for cassava being relatively tolerant of soil loss); on a 5% slope (to imitate project conditions), yield loss per year would be approximately 1%.
Alley cropping	Higging and Antoine (in preparation) report maize and yam yield reductions of about 50% over 15 years and 6 years, respectively, in southern Nigeria on continuously cropped fields. Cassava's yield decline is slower than yam, with 5% selected as an arbitrary figure.
Animal traction	Based on Higging and Antoine (maize yield decline), but since some fallowing is assumed to exist, the yield decline without the improvement is taken as somewhat lower. Manuring and better ridging is assumed to reduce annual yield decline by one half under animal traction, while yield decline is assumed to be fully arrested with fodder banks.
Grazing reserve	An arbitrary decline of 2% per year under existing conditions is assumed.
Tree shelterbelt Vetiver hedge shelterbelt Farm forestry	Annual decline without improvement is taken from Anderson (1987), but an allowance of some continued decline (1% per year) is made here, although not by Anderson.
Indigenous rock bunds	Figures used are arbitrary and are meant to take account of declining fertility due to shortened fallows and to wind erosion, as well as sheet erosion effects

c. Assumes average yields, cropping intensity and yield declines as indicated.
d. Assumes yields at 75% of average, cropping intensity doubled and yield decline at 50% of above indicated value (except wave bedding, where no yield loss is considered, and alley cropping, where intensity is already 100%).
e. Measured as the value of the potential food imports displaced by yield benefits plus fuelwood benefits/total benefits.

Source: Nigeria: Land Resources Management Study (Volume III, Annex 7), FAO/World Bank Cooperative Programme, Rome, 4 April, 1991

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