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THE PROBLEM OF LINEAR PROJECT THINKING IN A NON-LINEAR WORLD:
Experience from the Nexus of Population, Environmental and Agricultural Dynamics in Africa

by

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PREFACE AND ACKNOWLEDGEMENTS

This report builds on a study conducted by the World Bank. That study (Kevin Cleaver and Gotz Schreiber. 1993. The Population, Agriculture and Environment Nexus in Sub-Saharan Africa, revised, hereafter referred to as the "Nexus Study") examined linkages among human population growth, agricultural production and natural resource stocks in Africa. It provided us with a wealth of information and acted as a springboard into an examination of the unintended consequences of development projects that focus on only one dimension of this complex and swirling nexus.

The impetus for the report came from a convergence of two different, but connected, questions. The first was, "Why did population increase in Rwanda not induce agricultural intensification and technology development?" The second was, "If the link between population, agriculture and the environment is fraught with uncertainty, counter-intuitive relationships and non-linear interactions, then how can projects be better designed to intervene effectively in such settings?"

The tentative answers to each question raise more questions, however. The first opens doors into the range and type of interactions documented in the Nexus Study and how we can "know" or predict what we face in the field. The second enters into issues of how AID and other donors structure themselves and reward their employees and contractors for engaging in sustainable development activities in Africa. Both lead to the need to focus directly on context.

This matter of context is inherently counter-bureaucratic. It suggests that standardization and replication, the strong points of bureaucracy, are part of the problem. If context is, indeed, the key to project performance, then there is a need to reward contextual analysis and adaptation. Blanket prescriptions and borrowed solutions are only likely to make things worse. Indeed, the Nexus Study offers many examples to show how this has happened and we have added some other African examples to the Nexus universe.

This report takes an initial step toward a prescription for designing projects from a contextual perspective. First, an overview of the connections among population, agricultural and environmental sectors in Africa is presented. This discussion synthesizes the findings of a wide range of studies of African experience and it clarifies the implications of the disparate conclusions. It forms the backdrop for two exploratory chapters which launch an inquiry into how development projects fit into this nexus and how the nexus experience can inform the project design process.

Three annexes provide complementary background. They present (A) a comparison of the intended and unintended impacts of over 55 development projects in Africa, (B) a discussion of theoretical perspectives related to the intersectoral nexus, and (C) a bibliography identifying sources consulted.

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George Honadle was responsible for establshing the theme, organizing and assembling the paper and writing major sections. Chapter I was written by Scott Grosse with contributions by George Honadle. Chapter II was written by George Honadle and Paul Phumpiu. Chapter III was written by George Honadle. He also took overall responsibility for producing and editing the entire report and annexes. Annex A was produced by Phumpiu, Annex B was written by Phumpiu and Grosse. And the bibliography contains contributions from all three authors.

I.
BACKGROUND: POPULATION, ENVIRONMENT AND AGRICULTURAL CONNECTIONS IN AFRICA

The need to simplify is natural. People do it and organizations do it. When we confront a new problem, we fall back on solutions which we know from the past. Individually, we call it "not reinventing the wheel." Organizationally, we call it "institutional learning." In the jargon of project development it is called "replication."

But when a new understanding of a problem is achieved, replication is often an unsatisfactory response. This report argues that we now confront such a situation. In the past few years much has been learned about the interaction among human population changes, agricultural production practices and environmental quality. And much of that knowledge indicates that we cannot ignore the links among the three sectors, but at the same time, we cannot generalize across time and space as easily as we thought we could. This is certainly the case in Africa south of the Sahara.

This report builds upon the World Bank's "Nexus Report" (Cleaver and Schreiber, 1993) which focusses on the juncture of environment-population-agriculture dynamics in Africa. But we go beyond the nexus report in two ways: first, Chapter I adds some field experience not included in the nexus study and provides a reinterpretation of the data; second, building on the Chapter I findings, Chapters II and III explore both new ways of perceiving how projects fit into this nexus and a potential strategy for modifying project approaches.

Chapter I begins with an overview of the state of environmental degradation in Africa. The overview identifies diversity both among the perspectives held by observers of the African environment and among the experiences recorded. This is followed by an assessment of the contextual nature of the impact of population change on resource bases and food production and some policy implications of the findings. The implications include a warning about blanket prescriptions for altering trends and conditions. The concluding section then concentrates on the difficulty of generalizing solution packages across time, space and sectors.

A. The State of environmental degradation in Africa

Environmental degradation is reported to be a serious problem in much of sub-Saharan Africa. It is also commonly argued that land degradation is contributing to the stagnation in agricultural production and living standards occurring in many African countries. Many observers also contend that rapid population growth is aggravating environmental degradation in the region. Not all observers agree with these assessments, though. The extent of environmental change is complex and difficult to assess with the inadequate databases which are usually available. Further, the net balance of positive and negative changes varies markedly from place to place (Lewis and Berry, 1988) and through time. Finally, even to the extent that negative changes predominate, it is very difficult to rank or discern causation among the numerous potential explanatory variables.

1. theoretical variety

Different observers use different theories guide their inquiries into the factors that determine how population affects natural resource management. First, neoclassical economists usually put the chief emphasis on economic institutional factors, notably security of property rights, robustness and efficiency of markets, and the appropriateness of pricing policies (Repetto, 1989; Pingali, 1990; Jolly and Torrey, 1993; Ruttan, 1993). Neoclassical economists, among others, also acknowledge the importance of physical factors such as topography, soil types, and rainfall in influencing the likelihood of negative outcomes (Pingali and Binswanger, 1988). Second, another group of writers stress the importance of social institutional factors in mediating the response of land use patterns to population growth (Bilsborrow, 1987; Cain and McNicoll, 1988; McNicoll, 1990; Clay et al., 1993). These researchers span the gap between economics and social science and tend to reflect the particular influence of demography/human ecology.

A third perspective is the emerging field of political ecology, developed by geographers and anthropologists (Blaikie and Brookfield, 1987; Bryant, 1992). According to this paradigm, power relationships determine access to resources and thereby influence the extent to which growing populations cause serious environmental degradation to occur. For example, Stonich (1989), DeWalt et al. (1993), and Vandermeer (1991) attribute land scarcity and degradation in Central America to the monopolization of land by large landowners. Similarly, in discussing the case of degradation of pasture land in Kajiado District in Kenya, Campbell and Olson (1991b) stress the loss of land by Maasai pastoralists to European settlers, Kikuyu farmers, and national parks as being largely

responsible. It is interesting that these same points had previously been made by a pair of mainstream neoclassical economists (Repetto and Holmes, 1983), who attributed the most serious cases of environmental degradation to colonial land alienation, monopolization of land by large commercial farmers, inappropriate promotion of export-oriented commercial cultivation, and the destruction of indigenous mechanisms for regulation of access to resources.

It is important not to replace environmental determinism with economic determinism. Neoclassical economic theory predicts the effect of a change in one variable, such as relative prices, on the probability of choices made by economic agents, on the assumption that all other variables remain constant (ceteris paribus). The actual choices made by any individual agent reflect the cumulative impact of idiosyncratic factors which economic theory does not seek to account for. That is, specific factors such as land tenure systems or relative prices may influence, but not determine, the choices made by agents. On the other hand, patterns of responses which might seem to be inconsistent with or unexplained by economic theory may reflect a failure to consider the full range of relevant economic variables.

Blaikie and Brookfield (1987) provide an example from Europe which illustrates the range of responses which may be observed under apparently similar economic and environmental conditions. In the mid-1980s, Alsatian vineyard owners on the French side of the Rhine tore down stone terraces to mechanize their hillside fields, which seriously aggravated soil erosion. At the same time, German vineyard owners on the other side of the valley, facing the same imperative to mechanize in order to reduce labor costs, chose to construct new, wider terraces to accommodate machinery. The different choices made by the French and German vineyard owners, with very different implications for long-term resource management, may possibly reflect cultural differences. They may also be related to differences in planning horizons or discount rates reflecting differences in credit markets or expectations about stability in economic policy-making.

2. empirical uncertainty

Much of the motivation for the urgent discussions of population, agriculture, and the environment in sub-Saharan Africa derives from the numerous reports of allegedly catastrophic environmental degradation. For example, the Mbeya Highlands in southwestern Tanzania are reported to have become severely eroded as a result of short fallowing, overgrazing, relentless cutting of vegetation and burning of pastures. Almost no soil conservation measures have been adopted by the population of the Mbeya Highlands, and instead of investing in protection of soil fertility

the population is migrating outside of their home region. As a result of massive soil erosion in the highlands, severe annual flooding occurs in the surrounding lowlands (Mashalla, 1988).

The extent of environmental degradation in Africa is difficult to assess on the basis of case studies. It can be dangerous to generalize from them to sub-Saharan Africa as a whole (Lewis and Berry, 1988). Since individual case studies may reflect the influence of idiosyncratic factors, they do not necessarily provide general principles regarding the relationship of degradation to population change (Jolly and Torrey, 1993). For example, the failure of Tanzanian highland farmers to invest in soil conservation may tell us more about the failure of agricultural policies in that country than it does about the effects of population growth and land scarcity.

Different studies produce conflicting conclusions about the severity of environmental problems in particular settings in Africa. For example, in the Kano Close-Settled Zone in northern Nigeria, it was claimed by Eckholm et al. (1984) that a woodfuel crisis was about to totally deplete the stock of trees. In contrast, Mortimore (1993a) reported that the actual extent of tree cover on farm land in the area has been increasing since the 1960s. In Machakos District in Kenya, similar claims of an alleged loss of tree cover have also been refuted by evidence that tree cover has markedly increased over the last several decades (English et al., 1994). In the central Kenyan highlands, many areas with relatively steep slopes had been planted in the 1930s with wattle trees, which provided sustainable protection to the land and an economically valuable output (charcoal). In the 1970s, many of these areas were cleared of trees and planted in crops, allegedly because of increasing land scarcity and with potentially ominous implications for soil erosion (Lewis and Berry, 1988). However, Dewees (1993) has shown that at least in Murang'a District wattle trees were replaced chiefly with coffee or tea, which offer similar protection against erosion, and that new areas were also planted with wattle trees. The main constraint holding down wattle planting is said by Dewees to be the official restriction on the transportation of charcoal across district lines.

One of the most controversial issues involving environmental degradation in Africa is the question of "desertification" in the Sahelian countries of West Africa. Environmental problems have become painfully apparent in this region since the major drought of the early 1970s (Shaikh and Snrech, 1993). "Desertification" in terms of southward shifts of boundaries of cropping and pastoral systems, loss of tree cover, drying up of water courses, and declines in crop yields is reported to be widespread in the region (Milleville and Serpentie, 1994). Anyone who has spent time in rural areas in places such as north-central Burkina Faso will have heard stories from elders about how currently dry riverbeds were

formerly filled by permanent, year-round rivers with hippos and other wildlife present (Albarran and Ouedraogo, 1994).

The controversy lies less in whether adverse changes have occurred in the Sudano-Sahelian region than in why they have occurred. One perspective is that the apparent environmental degradation in the region is due largely to externally-imposed factors rather than the actions of cultivators and pastoralists (Watts, 1983). According to this view, "desertification" is blamed on the consequences of the promotion of export crops (cotton and peanuts), including the over-extension of cultivation to marginal areas (Bonte, 1986). Destructive monocropping combined with excluding pastoralists from much of their normal grazing lands eliminated normal herd movement during drought and hastened the decline of the area (Franke and Chasin, 1980).

The major direct explanation for the recession in vegetation is the sharp and prolonged decline in average rainfall, reflected in major southward shifts of rainfall isohyets (Mortimore, 1989). However, it is unclear whether such changes in rainfall are an aberration, a permanent change resulting from human-induced degradation of the natural environment (because of increased albedo from devegetated land), or a normal part of long-term climatic variation within the region. A revisionist view suggests that the latter is most correct. It is now recognized that during the years from the mid-1930s to the late-1960s, places such as northern Burkina Faso had above-normal rainfall levels, and that the subsequent droughts of the 1970s and 1980s to a large extent reflect a part of normal climatic fluctuation (Ford, 1992; forthcoming). To the extent that the changes observed reflect normal climatic variation, it is inappropriate to refer to them as constituting degradation or desertification.

As already mentioned, the dominant view has been that dryland grazing areas in Africa are usually overstocked and becoming rapidly degraded. However, this view reflects certain assumptions which have not been validated. Definitions of "overstocking" have generally been based on standards set for commercial ranches, while flexible or "opportunistic" stocking patterns followed by traditional African pastoralists have been repeatedly shown to result in much higher, and sustainable, total livestock production over a multi-year period (Biot et al., 1992; Behnke and Scoones, 1992; Scoones, 1993). Further, the amount of soil erosion is typically assessed on an impressionistic basis, while rigorous studies have failed to find that communally managed rangelands have soil erosion any more rapid than other areas (Biot et al., 1992). It is misleading to study vegetation patterns on selected plots as indicative of degradation by grazing, since there appears to be a normal cycle in which any given area becomes gradually less productive, is abandoned to grazing because of invasion by herbaceous shrubs, and is eventually reclaimed as fresh and productive pasture (Scoones, 1993). If land degradation is defined

in terms of the capacity of rangeland to productively support livestock, there is very little evidence of any serious problem in most African rangelands (Abel and Blaikie, 1989).

The "new" thinking among range management experts is that overgrazing and degradation is probably a serious risk only in relatively well-watered and climatically stable areas in which herd size gradually builds up over time (Scoones, 1993). In most African dryland environments, catastrophic declines in rainfally periodically decimate herds and usually prevent herd sizes from reaching a point where they would have any substantial impact on vegetation over large areas. Further, in such environments, rainfall crises have much more of an impact on herd sizes than do stocking patterns. Behnke and Scoones (1992) cite a case study from Botswana by Biot (1990) as finding that the rate of soil loss was a small fraction of previously published claims (Cook, 1983) and that stocking levels had virtually no impact on the rate of soil loss. However, the revisionist viewpoint which emphasizes the rationality of pastoralists may overlook important differences in the effectiveness and sustainability of range management practices of indigenous pastoralist groups (Legesse, 1989, see section C.5).

Environmental degradation is not a single process, but has multiple facets. Certain aspects of the environment may be improving while at the same time others are deteriorating. For example, increasing population size and density has been consistently linked to higher rates of deforestation. On the other hand, studies in Africa and Asia find that the density of trees and shrubs on farmland generally increases with increasing population density (e.g., Fotsing, 1992; Roose, 1992; Dewees, 1993; English et al., 1994), although in very dry areas this may not happen (Ford, 1992). Thus, deforestation in the sense of loss of natural forest may coincide temporally with increased tree cover on farm land. On the other hand, exotic species may be less desirable. Direct risk of soil erosion and anti-erosion practices both typically increase with population density, and the balance in terms of net changes in soil erosion is not always easy to determine or predict.

Few studies have directly quantified changes in soil fertility through repeated measurements spaced at long intervals, and these yield results which are difficult to interpret. One was a study in the Kano Close-Settled Zone in northern Nigeria. Mortimore (1993b) reports that soil samples taken in 1977 and 1990 from land under continuous cultivation showed no clear evidence of soil degradation. Average calcium content declined by 14%, although nitrogen content increased slightly. However, the area in question was under permanent irrigation, with heavy applications of both chemical fertilizers and animal manure, conditions which are quite unrepresentative of the vast bulk of African lands under cultivation.

A second study, in Machakos District of Kenya, by Tiffen, Mortimore, and Gichuki (1994), compared soil samples taken at 23 sites in 2 areas in 1977 and 1990. The authors say that these samples do not show unambiguous evidence of loss of soil fertility, but this is a matter of interpretation. A number of nutrients showed serious declines in concentrations, including declines of 25% in carbon and 20% in potassium. Almost all of the sites sampled were uncultivated grazing land, so they do not provide any evidence regarding erosion under cultivation. More relevant information is provided by the authors from a cross-sectional comparison in the Kilungu hill area in 1990 of samples of land that had not been cultivated for at least 60 years (A), previously cultivated land in grazing fallow since 20 years (B), and land which had been continuously cropped for at least 40 years without improved management (no terracing) (C). They found clear evidence of progressive deterioration going from A to B and from B to C. For example, the amount of calcium present declined by 72% from A to B and by 54% from B to C.

Given the difficulties in quantifying soil erosion or soil fertility, it is common to use crop yields as a proxy for soil fertility (Blaikie and Brookfield, 1987). At the local level, a few case studies have documented the link between decreasing crop yields and land degradation. For example, in the Darfur region in the Sudan, it is reported that between 1960 and 1978, millet yields fell by 50% at the same time that cropped area doubled (Ibrahim, 1987; Bilsborrow and DeLargy, 1991). In southeastern Nigeria, cassava yields have been reported to have fallen by over 50% between 1968 and 1988 as the mean length of fallow declined (Goldman, 1993).

Figures on the slow rate of increase in total crop production in Africa have often been used as evidence of alleged environmental deterioration. It is argued 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." (Cleaver and Schreiber, 1993: 17). However, the relatively slow rate of growth in agricultural output in Africa compared to other regions of the world results from a large number of other factors (Eicher, 1984; Lofchie, 1986). These include declining terms of trade for African agricultural exports, a lack of irrigation infrastructure and agricultural research and extension services, inappropriate government economic policies, poor road and marketing infrastructure, and poverty and isolation. It is argued by Boserup (1991) that the lack of rural infrastructure is a major cause of the disequilibrium between population growth and growth of food production in Africa and that increased population density is needed in order to make rural infrastructure more affordable and hence more available.

National statistics on crop yields in Africa are notoriously unreliable. Data on both cropped areas and output are crude estimates, and the ratio of two estimates each of which is measured with error is subject to much wider range of error. Comparing estimates from 1964-66 and 1984-86, Cleaver and Schreiber (1993) report that 12 sub-Saharan African countries had decreases of at least 10% in yields on cereal crops, while 22 countries reported increases of at least 10%. Seven countries reported decreases of at least 10% in yields of root crops. Interestingly, only one country, Cape Verde, reported decreased yields for both cereal and root crops. Cape Verde is a severely drought-stricken island nation which has had a virtual collapse of agricultural production and is hardly representative of Africa. Consequently, these data do not necessarily indicate an overall reduction in crop yields in African countries. And, the primary causes of agricultural production declines may lie outside of the agricultural sector.

A focus on crop yields alone may be misleading as an indicator of soil fertility, since increases in yields and total output can be achieved even if soil fertility is declining. Changes in cropping patterns, including cultivation of higher-yielding crops and crop varieties, as well as increased use of other inputs, such as chemical fertilizers or labor inputs in activities such as weeding, can result in increased yields even if soil fertility is declining. This is particularly relevant to case studies from Kenya, where there has been increased use of high-yielding maize varieties and high-value cash crops (Bernard, 1993; Tiffen et al., 1994; English et al., 1994), and Zimbawe, where high-yielding maize varieties and increased use of fertilizers have also resulted in increased yields (Biot et al., 1992). The increases in crop production reported in these areas should not be taken as necessarily indicating that the new cultivation practices are sustainable in terms of maintaining soil nutrient balance. On the other hand, to the extent that soil fertility has been declining in these areas, as is widely reported to be the case, it has yet to have an apparent impact on crop production (Biot et al., 1992; Turner and Benjamin, 1994).

A recent publication, a book edited by Turner, Hyden, and Kates (1993), offers an important compendium of valuable information on agricultural growth and environmental degradation in selected high-density areas of a handful of sub-Saharan African countries. The book is a comparative study of ten high-density rural areas, from the East African highlands of Kenya (Meru and Kisii), Rwanda (Ruhengeri), Tanzania (West Usambara mountains), and Uganda (Bushenyi) and from Nigeria (Imo and Anambra states, Jos Plateau, and Kano). In all except the Ugandan case, population densities exceeded 200 people per km2. The editors (Hyden et al., 1993) summarize the results as indicating increasing inputs and outputs in each case and increasing crop yields in seven of the ten case studies. Yields are reported to be declining in Imo State, remaining stable in Kano, and varying in Meru. They conclude that

these cases vindicate their belief that population growth has generally been associated with successful agricultural intensification in Africa. If the definition of sustainable development is broadened to include success in maintaining living standards through utilization of resources from outside of the primary sector, this conclusion is undoubtedly correct.

A recent article by Turner and Benjamin (1994) presents a somewhat different picture based on a review of eight of the ten cases from the Turner book with a focus on soil fertility and erosion. The Bushenyi (Uganda) and Kisii (Kenya) studies were excluded from this review because they were not considered to be "fragile" lands. In each case reviewed, either increased soil erosion or declining soil fertility is reported. In two areas, Ruhengeri (Rwanda) and highland Meru (Kenya) soil erosion is reported to be quite serious, although with crop yields remaining stable for the time being. In lowland Meru, settlement by migrants from the upland areas is reported to have resulted in severe erosion and violent land conflicts. The Usambara mountains of Tanzania are characterized as suffering from increasing erosion and a lack of agricultural intensification because of male out-migration. The three Ibo case studies from southeastern Nigeria are all reported to be characterized by declining or stagnant crop yields, with visible soil erosion only in areas with rugged topography. The Kano case study is said to report declining soil fertility and crop yields from the irrigated lowland area and stable yields from the cultivated upland area. Finally, no information is presented by Turner and Benjamin about the Jos Plateau (Nigeria) study.

Turner and Benjamin (1994: 119) conclude that these eight case studies show that intensive cultivation in "reputedly fragile environments" "need not necessarily lead to destructive agricultural practices or major environmental degradation." In other words, the populations studied were able to support expanded populations without causing their ecosystems to collapse. That one should take the absence of catastrophe or collapse as necessarily indicating successful intensification is debatable. Typically, environmental degradation results in a low-level equilibrium trap rather than collapse (Geertz, 1963; Goldman, 1992; Mortimore, 1993a). While less dramatic than ecological collapse, agricultural involution is not an entirely benign phenomenon (Geertz, 1963). Turner and Benjamin present evidence of widespread declines in soil fertility. Whether such development is sustainable or not depends upon one's expectations about whether future generations in these areas will be able to support themselves primarily from nonagricultural sources of income.

A reading of the ten case studies contained in the Turner book supports the interpretation of Turner and Benjamin (1994) in terms of the juxtaposition of widespread soil erosion or declining soil fertility with stability in agricultural production and living

standards. We will begin with the five case studies from Nigeria. The authors of the three case studies from southeastern Nigeria (Goldman, 1993, Martin, 1993; Okafor, 1993) all explicitly refer in their articles to decreasing yields and either increasingly severe erosion or declining soil fertility. The Kano case study from northern Nigeria acknowledges the existence of agricultural stagnation and serious soil erosion (Mortimore, 1993b). This includes major sheet erosion and gullying in the high-density peri-urban zone and desertification (indicated by shifting sand dunes) in much of the low-density zone (Mortimore, 1993a). Kofyar settlers in central Nigeria studied by Netting et al. (1993) are reported to be doing well economically, although no information is presented on either crop yields or erosion.

In East Africa, the case studies present more positive impressions of agricultural improvements. A major exception is the study from the Usambara highlands of Tanzania, where a very negative picture of accelerating erosion and lack of investment in the land is presented (Feierman, 1993). In the Meru District of Kenya, the highland region is reported to be environmentally stable, although severe environmental stress is reported in the lowland region (Bernard, 1993). Neither the Uganda case study (Kasfir, 1993) nor the Rwanda case study (Ford, 1993) make general statements about either crop yields or soil fertility. In the case of Ruhengeri prefecture, Ford notes that it is difficult and misleading to make generalizations across different elevations. Other writers have consistently reported increasingly serious erosion problems in the higher elevation zones within Ruhengeri, and at the national level, crop yields have been stagnant or declining (see Grosse, 1994). Finally, the Kisii case study from Kenya (Okoth-Ogendo and Oucho, 1993) provides evidence of increased agricultural prosperity during the 1970s, although the authors acknowledge that this has been at the price of increased environmental degradation.

The divergence in the site-specific results regarding soil erosion and agricultural production from the ten case studies in the Turner book is a logical reflection of the principle that population growth has different implications for agriculture and the environment in different settings (Mortimore, 1993a). Only the two Kenyan case studies from highland areas provide evidence of increased yields. Thus, at most one and a half (Kisii and Meru highlands) of the ten case studies in the Turner book present evidence of possibly increasing crop yields. It is not clear that even these positive outcomes should be interpreted in terms of the results of population-induced innovation, since they may instead reflect the existence of highly favorable agricultural policies in Kenya. These outcomes could be interpreted as being consistent with the existence of a negative impact on agriculture of population growth ceteris paribus. More plausibly, these outcomes reflect the positive interaction or synergism between

population-induced pressure on resources and policy-led innovations.

We have repeatedly referred to the results of the Machakos District study summarized in two recent publications (English et al., 1994; Tiffen et al., 1994). This very important study emphasizes positive developments within the District over the last half century, especially in the highland part of the District. These authors have demonstrated that visible erosion in 1991 was less than it had been 54 years previously, tree cover was increased, and crop yields were higher. However, 50 years is a very long time span, and there is evidence that the improvements were concentrated in the period up to the 1970s (Bernard and Thom, 1981). Tiffen et al. (1994) acknowledges that while agricultural output per capita more than doubled between the 1930s and 1987, it actually decreased between 1977 and 1987. Other studies have claimed that soil erosion has been increasing in Machakos District in recent years (Bernard et al., 1989; Rocheleau et al., forthcoming, cited in Turner and Benjamin, 1994).

B. The Impact of Population Pressure - Contextual Influences

Many writers have gone beyond the debate over whether population growth does or does not have a deterministic outcome to analyze the factors which help account for why adaptive strategies and outcomes differ across space and time. Marquette (1994) classifies these as "mediating perspectives." For example, Blaikie and Brookfield (1987) note that "pressure of production on resources" (which is more general a concept than population pressure) can lead to either successful Boserupian intensification based on investment in land or to land degradation. Numerous examples of both types of situation exist. Hence, the simplistic idea that population growth can be expected to have uniformly negative or positive effects should be discarded. While population growth does not inevitably result in immediate degradation, Blaikie and Brookfield suggest that it is likely to do so in underdeveloped countries because of unfavorable factors commonly found there.

Consequently, the impact of population growth on the environment is not a constant but varies with physical, economic, and social conditions (English, 1993). The same rate of population growth may have catastrophic effects in one place but not worsen land degradation in another area. One possible type of explanation for why different outcomes might be observed in different places is that population growth has a given, negative impact throughout, but that in some places this is offset by countervailing forces.

Contextual explanations for why population growth may have either positive or negative impacts on agriculture and the environment often focus on institutions, especially the rules and practices governing land use and access to resources (Cain and McNicoll, 1988; Bilsborrow and Okoth-Ogendo, 1992; Clay et al., 1993). McNicoll (1990) observes that agrarian and environmental outcomes under demographic stress depend upon two factors: environmental resilience and social organization, with the latter defined broadly in terms of social, political, and economic mechanisms for incorporating externalities into production decisions. Potentially relevant factors include characteristics of the physical environment, choice of crops, access to markets, the level of industrialization, government policies, cultural norms and practices, gender roles, and migration. We will examine each of these in turn.

1. Physical and biological factors

The first factor which influences the impact of population growth on sustainable agricultural development is the physical characteristics of the environment, chiefly soils and water. Blaikie and Brookfield (1987) define the physical environment in terms of sensitivity to erosion and resilience. A system of low sensitivity and high resilience only suffers degradation under very poor resource management, whereas systems with high sensitivity and low resilience may degrade easily and irreversibly. An example of a system with moderate sensitivity but also low resilience Blaikie and Brookfield cite highland Ethiopia, where cumulative erosion loss has become quite severe, despite relatively slow amounts of soil erosion measured on an annual basis (Hurni, 1983).

Erosion may be worse in a sensitive environment with low population density than in a less sensitive environment which would appear to have greater land scarcity. For example, in Sudan, Barnes (1985 cited in Ho, 1990) emphasizes the importance of the physical context for the effect of declining fallow on yields. In northern Kordofan, which is dry, fallow of 4 to 10 years is not sufficient to prevent declining yields. In the Nuba mountains of southern Kordofan, with better soil and rainfall conditions, fallow of 2 to 4 years is sufficient to maintain soil fertility.

Soil fertility can be adversely affected by both erosion and by changes in nutrient composition and structure. Soil erosion takes various forms, some of which are more obvious than others. Loss of soil fertility other than through erosion tends to be less obvious but is often more important. Loss of nutrients can occur through depletion by crops or through leaching of nutrients by water. Soil can become acidic, which causes roots to become shallow. Organic content of soil is important in part because of

cation exchange, which determines the ability of plants to respond positively to mineral fertilizers (Weischet and Caviedes, 1993). The application of chemical fertilizers to soil with low organic matter content is essentially wasted (Dommen, 1988).

Soil structure may be as important as nutrient and organic content for ensuring optimal productivity. Structure is important for allowing proper water filtration, and interacts with rainfall patterns. A heavy, clay soil can be very fertile if combined with proper drainage and moderately high levels of irrigation or rain water, but have very poor yields if rainfall is too high or too low. Coarse, nutrient-poor soils tend to have low maximal yields, but their water retention capacity can reduce sensitivity to low rainfall (Behnke and Scoones, 1992). Compaction of land through excessive exposure to livestock or to mechanical activity reduces its fertility (Lal, 1979). Exposure of certain types of soil to sun and rain can result in the production of hard crust pan surfaces, which can make the land uncultivable by the usual means, although this phenomenon is common chiefly in the interior of West Africa (National Research Council, 1993).

Besides reducing soil fertility, soil erosion can cause dramatic changes in hydrology which adversely affect agricultural potential throughout a watershed (Lewis and Berry, 1988). Soil erosion can result in siltation of channels, thereby affecting water flow and risk of flooding. Siltation of rivers can drastically reduce the useful life of dams and reservoirs and also damage the coastal environment, including coral reefs and mangrove swamps, as is reported to have occurred in Kenya (Berry et al., 1990). Also, more rapid runoff of water from degraded soils and lack of infiltration of water into the soil results in erratic water courses, flooding, and depletion of ground water and natural springs.

Vegetative cover is extremely important for protecting against soil erosion, especially in tropical environments. The best system is undisturbed forest, and the worst consists of annual crops grown in pure stands, where the land is left exposed during the first part of the rainy season. Annual crops include cereals, cotton, and tobacco. Within cropping systems, erosion has been shown to be much less from perennial bush, shrub, or tree crops, including coffee, tea, bananas, and fruit trees. Indigenous farming systems typically practice intercropping, in which multiple species are grown on the same plot at the same time, often with staggered planting. This provides some vegetative cover almost all of the time.

Rainfall patterns also crucially affect the sensitivity and resilience of ecosystems, as was discussed in an earlier section. Both extremes of very heavy and very sparse rains are problematic, with heavy rains increasing sensitivity to erosion and sparse rains reducing resilience. Within Africa, since both arid and humid

areas are unconducive to permanent rainfed agriculture, successful agricultural intensification is typically limited to areas with intermediate rainfall (English, 1993).

Water scarcity may become the most critical limiting natural resource in much of sub-Saharan Africa, as it already is in North Africa and the Middle East (Lewis and Berry, 1988; Falkenmark, 1991; Cleaver and Schreiber, 1993; Engelman and LeRoy, 1993). Water scarcity is a particularly serious constraint to agricultural intensification in arid or semi-arid areas with short growing seasons in which irrigation is necessary for the expansion of cultivation to take place. Falkenmark (1991) calculates that a minimum of 500 cubic meters per person per year is needed just for irrigation if food self-sufficiency is to be achieved in such a setting. Based on estimates of the availability of renewable freshwater supplies, Falkenmark calculates that countries experience "water scarcity" when they have less than 1,000 cubic meters available per person per year. According to Engelman and LeRoy (1993) 20 countries experienced water scarcity in 1990, almost all of which are either island states (e.g. Singapore) or located in the Middle East and North Africa. In sub-Saharan Africa, Djibouti, Cape Verde, Kenya, Burundi, Rwanda, Malawi, and Somalia all fall in this category.

Falkenmark (1991) points out that the water stress index is not necessarily useful for ranking countries which do not depend on irrigated agriculture. In some countries such as Cape Verde and Djibouti, water scarcity is so absolute that most food must be imported. Similarly, while Burundi, Rwanda, and Malawi have low calculated ratios of water availability (650 to 950 cubic meters per person) they are not dependent upon irrigation because of long growing seasons. In contrast, Lesotho, Zimbabwe, and South Africa, as well as parts of Tanzania and Nigeria, have higher water availability ratios (1,300 to 2,300 cubic meters per person) but are considered to be at much greater risk of water scarcity constraining agricultural production and economic development.

The main constraint to irrigation in sub-Saharan Africa is less the absolute availability of water than its difficulty of access. Because of generally flat topography, shallow rivers, lack of permanent water courses, scarcity of large expanses of irrigable soils, and lack of groundwater or aquifers, large-scale irrigation in sub-Saharan African countries has generally failed to serve as an affordable option for sustainable agricultural intensification (Barghouti and Lallemant, 1988; Falkenmark, 1991; Weischet and Caviedes, 1993). Most African rivers have extreme annual variations in flow because most watersheds have rainfall concentrated within 3 months and lack snowcaps to store water, and hence these rivers are difficult to utilize for irrigation (Lewis and Berry, 1988).

The comparison of ten case studies from African high-density areas by Hyden et al. (1993) revealed one consistent lesson. In each case where agricultural intensification had been relatively successful, soils were reported to be above average in quality and rainfall was either adequate in amount and distribution or there was an aquifer available for irrigation (Kano case study). The most problematic cases, including especially the three studies in southeastern Nigeria, were all reported to have had relatively marginal soils.

Regardless of type of ecosystem, choice of crops may make an important difference as to whether a cultivation system is sustainable. As was discussed in a previous section, perennial crops usually result in much lower rates of erosion that annual crops. For example, in Wollo region of highland Ethiopia, those few areas which cultivated coffee, qat, or bananas as cash crops were found to be less subject to land degradation than areas cultivating only annual crops (Dejene, 1990). A national sample of 47 highland districts found that areas cultivating perennial or root crops with hoe cultivation had much lower erosion than the more northerly districts which used oxen-drawn plows to cultivate annual cereals (English, 1993). Accordingly, areas such as highland Machakos and Meru in which farmers cultivate coffee as the main cash crop are much less prone to soil erosion than are areas in which farmers cultivate other cash crops such as tobacco, cotton, and peanuts, which offer poor ground cover (Blaikie and Brookfield, 1987).

2. Economic factors

Economic factors which are likely to affect the success and sustainability of agricultural intensification include relative prices, transportation and commercial infrastructures, the size and proximity of urban markets, access to external markets, and opportunities for nonfarm labor (English, 1993). We will begin by discussing relative prices, which neoclassical economists consider to be a major determinant of household resource allocation and investment decisions (Reardon and Islam, 1989; Ruttan, 1993). It is conventionally argued that unfavorable producer prices in agriculture increase the risk of environmental degradation by lowering expected returns to investment in land and thereby discouraging soil conservation investments by farmers (Repetto, 1989; Jolly and Torrey, 1993). For example, an economic analysis in Ethiopia calculated that the market price of dung sold as fuel substantially exceeded its market value when used as fertilizer, but this is alleged to have been a consequence of grain prices being kept artificially low by government controls (Newcombe, 1989).

Either unfavorable or favorable producer prices can result in more land degradation (Blaikie and Brookfield, 1987). In situations where returns to land investment are low because of physical characteristics, mining the soil through increased production may be a rational response by households to increased producer prices. Unlike environmentalists, economists may look on resource mining with some degree of equanimity as possibly optimal from a social perspective in certain situations (Ruttan, 1993). Soil mining in response to market incentives is likely to be aggravated in situations where farmers lack long-term land rights and where subsidized inputs and credit are made available to maximize production. In such situations, individual and social interests may diverge, and the excessive exploitation reflects market failure.

The importance of shifts in relative agricultural producer prices for the rate of environmental degradation depends on the nature of the crops in question (Repetto, 1989). As discussed above, under usual cultivation practices, annual crops carry much higher risks of soil erosion than do perennial crops or the raising of livestock on grazing land. Hence, increases in the prices of the latter relative to the former may be expected to induce changes in land use patterns which will reduce the rate of erosion. For example, increased rice production and incomes in lowland Java during the Green Revolution of the 1970s resulted in reduced demand for maize and cassava (which were inferior staples in terms of consumer demand) and increased the demand for foods with higher income elasticities of demand, such as vegetables, fruits, and animal products. These shifts had opposite implications for soil erosion in upland Java (Roche, 1988). In mid-elevation areas, erosion decreased as a result of a shifting of land from cultivation of cassava and maize to tree crops and pasture, while in higher elevation zones erosion greatly increased as a result of putting steep slopes into cultivation of vegetables.

Access to markets may be a key intermediate mechanism between population and land use change (Pingali et al., 1987). This is true first of access to output markets, since the ability to produce high-value crops for sale in order to purchase food is a crucial adaptation for high-density areas (Hyden et al., 1993). Similarly, access to purchased science- and industry-based inputs such as improved seeds and fertilizers is necessary in order to reach a high level of agricultural intensification (Boserup, 1965; Pingali and Binswanger, 1988). The apparent success of the Kofyar in achieving an intensive and sustainable cultivation system in their new settlements in the Benue plain of central Nigeria is said to have been conditioned on their ability to purchase fertilizer and to sell output to traders who came to their communities on motorized transport (Netting et al., 1993).

Living close to a city may provide important economic advantages which facilitate agricultural intensification. Rural

areas located within a reasonable distance of the city can supply fresh fruits and vegetables (Hyden et al., 1993). In Machakos District, Kenya, market gardening was adopted only by villages with easy transport to Nairobi (Tiffen et al., 1994). Similarly, in Burkina Faso, only farmers living in areas close to urban centers have been able to complement their incomes during the dry season by using small irrigation systems to grow garden crops during the dry season for sale to urban consumers (Albarran and Ouedraogo, 1994; Milleville and Serpentie, 1994). It is noted by Hyden et al. (1993) that well-functioning market systems and transportation infrastructure are rare in sub-Saharan Africa, which greatly limits the potential for these positive linkages to facilitate agricultural intensification under population pressure.

Proximity to urban markets is not necessarily a positive factor for environmental protection and sustainable development. In areas where access to trees is not restricted by either individual tenure or customary regulation, urban market demand is likely to result in widespread destruction of forest resources (Cleaver and Schreiber, 1993). For example, in one region of Sierra Leone, the main factor compromising the viability of fallow land is reported to be urban fuelwood and building pole demand rather than local population pressure (Leach, 1991). Conversely, in the belt of villages surrounding Kano, Nigeria, trees are individualized, and the burden of supplying urban fuelwood demand has been shifted to areas further away from the city (Mortimore, 1993a).

An economy in which nonagricultural jobs are abundant is also necessary if rural populations are to escape from the trap of low incomes. Every case in which dense populations have succeeded in improving their living conditions in a sustainable way has involved increasing reliance on nonagricultural incomes (Hyden et al., 1993). For example, in Kisii, Kenya, over two thirds of all farm income is reported to be nonfarm (Okoth-Ogendo and Oucho, 1993). An even greater dependence of rural households on urban jobs for subsistence is reported from Anambra State in Nigeria (Okafor, 1993) and from peri-urban villages near Kano (Mortimore, 1993a). Without ready access to urban jobs, each of these communities would have been faced with a grave subsistence crisis, regardless of their success in agricultural intensification.

Availability of nonagricultural employment is not a sufficient condition for sustainable development to occur. If physical conditions are unpromising, reliance on nonagricultural incomes may constitute a substitute rather than a complement to investment in soil fertility (McNicoll, 1990). That is, the development of nonfarm sources of income may make agricultural intensification, which involves very labor-intensive and often unpleasant tasks, both unnecessary and unattractive (Mortimore 1989).

3. Public policies and political economy

Political and economic stability may be a prerequisite of sustainable agricultural development and environmental protection (Shaikh and Snrech, 1993; National Research Council, 1993). Economic stability may be an important precondition for successful agricultural intensification. Market-oriented agriculture which relies on regular supplies of purchased inputs and outlets for its produce may collapse if markets become disrupted or if through abrupt devaluation imported inputs become unaffordable. More generally, uncertainty regarding input prices and availability and output prices and marketability inhibits investments and shortens planning horizons (Reardon and Islam, 1989; Mink, 1993).

Political and economic instability in many African countries poses a grave threat to all development programs, but especially to soil conservation investments which rely on long-term planning horizons for their justification. The attempt to shift from centralized state power to democratization in Africa has resulted in a high incidence of frustration, alienation, and political and social chaos, with negative implications for investment and economic development (Shaikh and Snrech, 1993). To the extent that population-induced resource scarcity aggravates political conflict and instability, a downward spiral of population growth and environmental degradation may ensue (Myers, 1989c).

Public policies may provide a crucial mediating role between population growth and successful agricultural intensification or natural resource management. The traditional approach involves specific natural resource management or agriculture projects, such as afforestation or promotion of high-yielding varieties, but this approach is inadequate (Warford, 1989). Policies influencing market access, producer prices, capital markets, and nonagricultural employment generation may ultimately have more influence over resource use and environmental protection than can direct natural resource management policies (Reardon and Islam, 1989; English, 1993; Pinstrup-Andersen, 1993; National Research Council, 1993).

Unfortunately, the influence of economic policies on the environment may be negative, causing an aggravation of resource management problems. For example, policies which subsidize the commercial production of timber may overwhelm efforts devoted to the direct protection of forests (Repetto and Gillis, 1988; National Research Council, 1993). Conversely, a policy which severely restricts the transportation and sale of charcoal artificially depresses the economic value of planting and maintaining trees for the purpose of charcoal production and thereby encourages the substitution of crops which may provide less protection to steeply sloped land (Dewees, 1993).

The relative returns to different activities may be influenced by a range of policies, and these may have unintended effects on environmental degradation. Since the colonial era, governments of Sahelian countries working in close cooperation with European companies have strongly promoted the cultivation of two industrial export crops, cotton and peanuts (Franke and Chasin, 1980; Bonte, 1986). Expansion of production has occurred by providing subsidized inputs and credits for the cultivation of export crops and by depressing food crop prices through the importation of low-price grains. Despite the fact that cotton and peanuts have been implicated in the land degradation troubling the region, the focus of international agricultural development assistance to the region has continued to be placed on the promotion of these export crops (Raikes, 1988). At the same time, food aid provided to these countries has continued to depress producer prices for food crops.

Along with most other observers, Lele and Stone (1989) conclude that spontaneous agricultural intensification has generally not been very successful in Africa in terms of achieving output increases in parallel with growing populations. Policy interventions may be necessary in order to induce small farmers to use modern planting materials and methods and to enable small farmers to grow higher value crops. Measures such as distribution of fertilizer, increased credit to smallholders, access to export markets, and improvements in the physical and social infrastructure in rural areas may facilitate the transition to more intensive agriculture. Unpublished studies from Kenya and Zimbabwe are cited by Kates et al. (1993) as showing that intensification proceeds faster in areas which are better provided with infrastructure supporting production for the market.

On the other hand, public interventions may aggravate problems of soil erosion and environmental degradation, which are then blamed on local populations (Falloux and Talbot, 1993). For example, improved range management programs in Africa over the last few decades have resulted in greatly increased herd sizes through provision of borehole wells and other services. Such herds have often exceeded the carrying capacity of the land, especially during dry years. This is said to have resulted in severe overgrazing, reduced carrying capacity, and much greater vulnerability of human and animal populations to drought (Talbot, 1986).

Agricultural development policies which have pushed the extension of cultivation of annual crops for export are also a major part of the problem of environmental degradation in lowland parts of Africa because of the excessive soil erosion associated with these crops (Repetto, 1989). In particular, West African governments which have heavily promoted smallholder production of peanuts and cotton have unintentionally caused serious harm to the environment (Rochette, 1988), with the farmers usually being blamed. The international agencies and corporations which continue to induce African governments to expand cotton and peanut

cultivation should also shoulder much of the blame for the resulting environmental degradation.

Large-scale agricultural development projects have also often caused considerable environmental harm. This includes both externally-funded public projects and commercial farming by wealthy individuals given long-term leases by governments at low, subsidized rates. One major reason for the serious degradation which almost invariably accompanies such projects is the use of mechanical equipment for clearing land (Bilsborrow and DeLargy, 1991). While all clearing of land for cultivation in the tropics poses an increased risk of erosion, this is far more likely if mechanical means are used (Roose, 1984). The numerous projects which have used mechanical clearing have almost all failed within 2 to 10 years (Lal, 1979). Tropical forest soils tend to have their nutrients and organic matter concentrated in a relatively thin top layer (Weischet and Caviedes, 1993). If this layer is destroyed by compaction or scraping in the process of mechanical clearing, the land may have little fertility left to grow crops (Repetto, 1989).

Agricultural extension services aimed at smallholders have sometimes done more harm than good for the environment. For example, in the Northern Province of Zambia, a very successful program in the 1980s encouraged farmers to continuously crop maize in pure stands with the use of chemical fertilizers. The result on the majority of the poor, acidic soils of the region was rapid depletion of soil nutrients, increased acidity of soils, deterioration of soil structure, and abandonment of most land within 5 years (Blackwell et al., 1991).

Even Zimbabwe's famed agricultural extension services have been criticized for being part of the environmental problem rather than being part of the solution (Bradley and Dewees, 1993). It is argued that the most cost-effective approach to environmental protection on communal lands is to encourage the retention and natural regeneration of trees in fields, but this is the opposite of what is promoted. Instead, farmers are advised to clear all woody vegetation from their fields, to plant pure stands, and to use chemical fertilizers. The extension services promote the planting of heavily-subsidized eucalyptus seedlings, even though the economic returns to farmers for planting these seedlings are calculated to be negative and even though farmers are much more interested in acquiring fruit and shade trees. It has been argued by researchers working in Rwanda and Cameroon that eucalyptus trees provide little protection to soil, and may even reduce soil fertility (Jones and Egli, 1984; Moeyersons, 1989; Fotsing, 1992; König, 1993).

Regional political economy may also matter. It is suggested by Blaikie and Brookfield (1987) that in declining regional economies one many expect a lack of initiative and investment of

labor and capital in managing (protecting) land. In such a setting, most actors will be focused on seeking their economic and social advancement outside of the region. Analogously, a regional or national political system in which the leadership is mostly power-oriented or concerned with maintaining order and privileges is unlikely to initiate or support creative programs mobilizing populations for environmental protection (English, 1993).

Further, a society which is polarized between extremes of rich and poor, as in much of Latin America, may have greater difficulty protecting the land than a more egalitarian society, at a given population density (Myers, 1989b; Ruttan, 1993). The rich tend to be absentee owners of land and do not depend on the land for their livelihood, while the poor may lack the resources or will to invest in the land. Thus, in Central America, it has been reported that the very poor tend to cut down all trees on their land, although farmers at all scales of operation follow destructive practices (Bilsborrow and Okoth-Ogendo, 1992; Stonich, 1989). In contrast, in African societies, it is common to find the density of trees on farm land on smaller farms to be as high or higher than on larger farms (English et al., 1994).

We do not subscribe to the notion that the poor have an inherently greater tendency to mine resources through an allegedly shorter time horizon and higher subjective discount rate. As Mink (1993) has observed, there is no empirical research from rural areas of developing countries that has substantiated the hypothesis that poverty or wealth is an important influence on time preference. Rather, the existence of short time horizons may reflect the results of policy, institutional, and social failure, and this tendency may occur among all income strata within a population. The Latin American poor may engage in resource mining because of their lack of secure land tenure and social alienation, but the non-poor in the same societies engage in resource mining as well. And in both Asia and Africa the poor have often been the source of environmental protection movements and efforts (Broad, 1994; Harrison, 1987)

4. Tenure systems

The structure of landholdings in a society may be expected to affect the risk of environmental degradation depending upon the ratio of population to resources. Traditional African shifting cultivation and long fallow cultivation and transhumant pastoralism have been proven to be environmentally sustainable under low population densities. Under shifting cultivation and long fallow, land was generally left to rest for 15-20 years and soil nutrients were replenished under tree cover. Under traditional transhumant pastoralism, herds of animals did not remain in one place long

enough to disturb vegetation or compact soils seriously. However, much of Africa now has population densities exceeding the thresholds above which such systems put lands at risk without improved management (Dommen, 1988; Cleaver and Schreiber, 1993).

To simplify a very complex pattern of arrangements, traditional African land management practices were based on communal ownership of land. Land was typically periodically allocated to household groups on the basis of need and labor power. Access to common property resources such as pasture land and forest resources were regulated by complex means. Common property resources have often been blamed for causing overuse and degradation of natural resources. Cleaver and Schreiber (1993) note that it is necessary to distinguish open access systems from common property resources managed under traditional regulation, since only the former can be expected to result in the "tragedy of the commons" (Hardin, 1968).

One generalized result of increased population pressure in Africa has been a gradual shift in customary tenure arrangements toward more permanent or quasi-permanent allocation of plots of land to households (Migot-Adholla et al., 1991; Cleaver and Schreiber, 1993). This phenomenon is consistent with the predictions of Boserup (1965; 1987), who posits that a shift from communal to private tenure is a necessary intervening mechanism for successful agricultural intensification to take place.

The security with which an individual or household holds use rights to the land they cultivate appears to substantially affect their incentive to invest in the long-term productivity of the land (Noronha, 1985; Pingali, 1990). A comparative World Bank-funded study in 10 regions in Ghana, Kenya, and Rwanda carried out during 1987-88 gave support to the hypothesis that security of tenure influences farmer investment in land. Farmers with either ownership or long-term use rights were found to be substantially more likely to use fertilizer, mulching, and to plant tree crops (Migot-Adholla et al., 1991). The same study found virtually no evidence that transfer rights, that is, being able to sell or bequeath land, made any additional difference to the adoption of inputs or land investments (Place and Hazell, 1993).

Not all African societies with relatively dense populations have moved in the direction of land rights being clearly vested in individual families. Cleaver and Schreiber (1993: 33) cite Darfur in western Sudan and the Ibo areas of southeastern Nigeria as examples of African societies which have failed to adopt permanent assignment of specific plots of land to households despite increasing population pressure. Interestingly, as mentioned above, both areas have reported among the greatest declines in crop yields on the continent. Highland Ethiopia represents another example of an area with serious land degradation, high population density, and a lack of individualized land tenure (Whiteman, 1988). A system of

insecure land tenancy under a quasi-feudal system was followed after 1975 by the socialization of land ownership in which land was periodically reassigned by peasant associations to adult males and in which all non-homestead land was open access to grazing during the dry season (Dejene, 1990). Similarly, the fact that trees belonged to no one meant that no one took care of them, and most afforestation projects ended in failure.

The West Usambara mountains in northern Tanzania represent another example in which increased population density has been accompanied by serious environmental degradation (Fleuret and Fleuret, 1980). Feierman (1993) attributes the lack of measures taken to avert degradation to the failure to adopt individualized land rights, which could have provided an incentive to invest in soil conservation measures. The Shambaa people of the area have traditionally guaranteed rent-free access to unimproved land within the village to women, and there are large numbers of female-headed households. Ownership rights in improved land is restricted to men. Shambaa women have successfully resisted efforts to introduce soil conservation practices onto village lands, since this would have eliminated their traditional use rights.

Population growth may also induce changes in the structure of landholdings which have negative implications for soil conservation. Increasing population density under conditions of freehold tenure is often reported to result in increased prevalences of landlessness, tenancy, and absentee ownership (Clay et al., 1993). Such changes typically occur as a result of fragmentation of land holdings by inheritance and distress land sales. The reason why this pattern of change is serious is that tenants who lack long-term use rights have no incentive to improve the fertility of the land they cultivate. Absentee owners may also rarely bother themselves with labor-intensive improvements, since they are typically not dependent upon the land for their long-term economic future. The empirical evidence from Africa indicates that it is long-term use rights rather than legal ownership which matters for the adoption of sustainable cultivation methods such as agroforestry (Cook and Grut, 1989, cited by Clay et al., 1993; Place and Hazell, 1993). Consequently, any increase in the prevalence of short-term tenancy contracts may be expected to weaken efforts at soil protection.

5. Cultural and human ecology

The impact of human populations on their environments depends in large part upon the socially structured 'choices' made by population groups (McNicoll, 1990). The field of human ecology has long posited that human organization intervenes between populations and their environments (Clay et al., 1993). For example, in the

Himalayan region of northern Pakistan, there are two types of societies: hierarchical societies which were ruled until the early 1970s by principalities, and acephalous groups in which communal action was almost totally lacking (Kreutzmann, 1988). The former groups, most notably the Hunza, developed intricate irrigation systems which allowed for sustainable intensive agriculture. The Hunza have retained their labor-intensive subsistence cultivation system, despite negative economic returns, because of their commitment to maintaining their way of life.

Human ecologists or ethnologists have often observed that neighboring ethnic groups display rather different approaches toward resource management. For example, in northern Kenya, the Gabra pastoralists are reported to be much better at range management than are the neighboring (and rival) Rendille pastoralists (Legesse, 1989). Consequently, degradation of rangeland is reported to be occuring among the Rendille but not the Gabra. In other cases, an indigenous group which is closely tied to a local environment and which has ritualized mechanisms for protecting the environment may be found in close proximity to another group which has migrated into the region from elsewhere and which displays scant concern for the environment, preferring to mine the land and move on when it becomes degraded.

In the peanut basin of Senegal, for example, the Sereer people have long practiced agroforestry as well as agropastoralism in order to maintain soil fertility. They protect indigenous acacia trees whose roots fix nitrogen and make this and other nutrients available to crops, as well as protecting the soil from wind and water erosion (Dommen, 1988). In contrast, the more numerous Wolof people have generally cleared trees from their fields, resulting in more rapid soil depletion. Thus, within virtually identical demographic and ecological settings, the Wolof cultivate larger areas of land with lower yields, while the Sereer choose to apply much greater inputs of labor and fertilizer to achieve higher yields from smaller areas of land (Stomal-Weigel, 1988). While the choice of adaptive strategies is mediated in part by cultural norms and practices, it should not be assumed that these are immutable or innate. Outside of their home area, the Sereer are said to engage in equally destructive clearing practices (Rochette, 1988).

Another expanding ethnic group who have been alleged to cause widespread environmental destruction are the Mossi of Burkina Faso, who have seriously degraded their homeland on the Central plateau. In northern Burkina Faso, the indigenous Fulani pastoralists are reported to take great pains to identify and protect vulnerable vegetation, while Mossi peasants who have acquired cattle allow their livestock to graze indiscriminately (Anne Bergeret, personal communication). Similarly, the indigenous Kurumba and Dogon cultivators have sought to protect stands of trees by ritual means, while nearby Mossi communities have aggressively cut back their own groves (Ford, 1992). The Mossi are also reported to be causing

widespread destruction in southwestern Burkina Faso, where the indigenous Bobo and Dagari cultivators have vainly sought to keep the Mossi out (Rochette, 1988).

In the highlands of Tanzania, the Chagga people living on the slopes of Mount Kiliminjaro have long been famed for their intensive and sustainable cultivation practices (Harrison, 1987; Maro, 1988). These practices are in sharp contrast to those followed by other groups living in ecologically similar areas in Tanzania (e.g. Feierman, 1993). Furthermore, the Chagga people traditionally resisted migrating outside of their home district, preferring to derive their livelihoods from local production. It is not clear why such differences emerged, but it is clear that they have not tended to diminish over time. It is not common for even clearly optimal conservation practices to spontaneously diffuse across ethnic boundaries (Harrison, 1987).

The Kamba people of Machakos District in Kenya also appear to have some distinctive characteristics which may have favored successful intensification. Two of these, as discussed further below, are relatively equal sex roles in agriculture and a strong attachment to residing in their home district (English et al., 1994; Tiffen et al., 1994). Another is a relatively pragmatic approach to vocational education, along with an openness to borrowing innovations. In most societies, including in Africa, parents prefer to have their children receive academically-oriented schooling to prepare them for non-manual jobs if at all possible. In Machakos District, on the other hand, where virtually the entire population is Kamba, the population has shown a strong preference for Village Polytechnics rather than academic secondary schools, unlike other areas of Kenya (English et al., 1994).

In addition to indigenous cultural practices, formal social organization also appears to be a crucial intervening mechanism in the population-sustainable intensification nexus (McNicoll, 1990; English et al., 1994). Kenya is well-known for having a much denser network of voluntary collective self-help organizations than other African countries (Hyden, 1990). Harrison (1987) has singled out Kenya's dense network of local popular organizations together with its effective agricultural extension service and a deliberate strategy of identifying and promoting indigenous conservation strategies as the reasons why Kenya appears to be out in front in the widespread adoption of soil conservation strategies, including terracing and agroforestry.

The Kamba people of Machakos district have been singled out as having been particularly energetic and effective in the application of soil conservation practices by voluntary communal organizations (Harrison, 1987: 121-122; Tiffen et al., 1994). On one badly eroded hillside, between 1981 and 1985 terracing is said to have halted further erosion and to have doubled maize crop yields. Most of the work is done on a collective basis by women's groups.

Individual women could never achieve nearly as much working alone. As noted above, the existence of voluntary communal organizations in Machakos District is not an inherent part of the social system but was permitted to emerge by an unusually open political environment in Kenya.

Political and economic factors may also adversely impact upon culturally-delimited adaptation strategies, with important environmental ramifications. Cohesive communities often practice long-term investments in resource management despite grinding poverty (Mink, 1993). The breakdown of traditional resource management systems is often the real problem, generally as a result of political conquest and social and economic disruption, including migration. For example, the Sankara government in Burkina Faso during the mid-1980s abolished traditional tribal authorities, thereby eliminating the ability of indigenous chiefs to restrict access to fragile resources (Ford, 1992). The unwillingness of authoritarian governments to tolerate genuinely autonomous popular organizations is one of the most serious obstacles to environmental protection in many countries.

6. Migration

Migration may be either a stabilizing or destabilizing factor for environmental protection and sustainable development. Out-migration from a rural environment can potentially serve as a safety valve allowing for the moment of reckoning to be postponed. This can be positive in the sense of reducing pressure on the land in the short run. It may also be negative in the sense of reducing investments which maintain soil fertility in the long run. That is, the possibility of migrating elsewhere may greatly reduce the incentive for local people to protect their own local environment and to seek sustainable agricultural development (Bilsborrow, 1987; Mortimore, 1989; McNicoll, 1990; Roose, 1992). It is a mistake to view the residents of low-potential agricultural areas primarily as farmers, since they generally maintain a diversified set of income-earning strategies, which may compete with the labor needed for on-farm investments (Reardon and Islam, 1989).

An example of the mixed benefits of out-migration comes from Imo State in Nigeria. It was found by Goldman (1992; 1993) that comparing five Ibo villages, mean length of fallow had fallen the most in the one village which had originally had the lowest population density. It turned out that that village had experienced almost no out-migration while the other villages all had high out-migration rates. Length of fallow was an excellent predictor of yields, so the village that did not rely on migration had by far the worst deterioration of crop yields. Conversely, less migration was found to be associated with greater investments

in agroforestry (cultivation of a plant for producing yam stakes), since this provided an alternate source of cash incomes.

The impact of rural out-migration on sustainable local development may depend crucially on the utilization of migrant savings. Migrant remittances can be used to help finance soil conservation measures such as agroforestry (Haggblade et al., 1989). In addition, the fact that woodlots are less labor-intensive than cropping makes them more attractive to households with members absent as migrants (Dewees, 1993). The use of migrant earnings for on-farm investments is dependent upon factors which influence the expected rate of return in such investments. Thus, it was found in a study in Zimbabwe that migrant remittances were used to finance land improvements only on male-headed farms located in environmentally well-situated localities (Mazambani, 1990 cited in Hyden et al., 1993).

In general, most studies conclude that out-migration has few positive economic consequences for agricultural development in sending communities in sub-Saharan African rural areas (Rochette, 1988; Mabogunje, 1990). As already indicated, this generally boils down to location and physical characteristics. In general, agriculture may be expected to benefit from out-migration in relatively well-watered areas which are close to urban centers and to be neglected in ecologically marginal or remote areas. In Kenya, areas located in close proximity to Nairobi have often had their agricultural development benefited by the use of migrant earnings for purchasing agricultural inputs (Tiffen et al., 1994). On the other hand, in other parts of Kenya, migrants have generally made the calculation that returns to such investments are too low to be justified. Instead, migrant earnings are invested primarily in the education of the young, to prepare them to migrate elsewhere and to earn higher incomes in urban labor markets (Francis and Hoddinott, 1993).

The impact of migration on agricultural development may shift over time in conjunction with the relative economic returns to local agricultural production and urban employment, which drive migration flows. When the balance is skewed toward outside incomes, migration flows tend to be high and there may be little incentive to invest in local production. When the balance reverses, the incentive to invest in local production capacity occurs even independently of reverse migration, and the two may reinforce each other. Thus, in western Cameroon, the traditionally labor-intensive agroforestry system of the Bamileke people declined during the colonial period because of discrimination against agriculture and induced labor migration. After independence, many young Bamileke preferred to remain at home, in part because fair producer prices for food crops made agriculture economically attractive, and the system of agroforestry began to flourish again (Barbier, 1988).

It has long been noted that out-migration may result in population decline and the collapse of traditional labor-intensive soil conservation or irrigation systems in densely-settled but isolated mountainous areas (Blaikie and Brookfield, 1987). For example, in Yemen, large numbers of the stone terraces found throughout the highlands were abandoned and allowed to collapse during the 1980s when many men left the country to work in the oil states (Vogel, 1988). Similarly, on the Jos Plateau of Nigeria, traditional Kofyar hill villages have become seriously depopulated as a result of migration to the plains. Deintensification is resulting in the collapse of stone terraces and increased erosion in the Kofyar home area (Netting et al., 1993).

Conversely, if a population from a low-potential area is committed to maintaining an agricultural life style in its home area for communitarian rather than economic reasons, migration earnings may facilitate this goal. In the Mandara mountains of northern Cameroon, very high densities of population were traditionally found on isolated rock outcrops. Only constantly maintained terraces and manual application of manure from animals kept penned up allowed the maintenance of soil fertility. It was suggested by Riddell and Campbell (1986) that because of out-migration, the labor supply was being reduced and terracing and manuring were in danger of being abandoned. However, in most cases migration is only temporary, and while some terracing is falling into disrepair, the overall system is being maintained in through migrant remittances (Iyebi-Mandjek, 1993). Similarly, in the mid-Senegal valley, migrants have invested heavily in providing inputs such as small-scale irrigation systems to their home communities, even though the economic returns do not justify such expenditures (Chastenet, 1991; Lavigne Delville, 1991).

Migration flows may both promote and threaten the sustainability of local populations and their adaptations, depending upon the temporal dimension. In a number of cases populations relying on migration have clearly outstripped the carrying capacity of their local environment which would support the standard of living to which they have become accustomed. Such populations have mortgaged their future to continued access to migration destinations. However, migration flows are subject to rapid change if economic or political conditions in receiving areas become profoundly altered. For example, recent political and economic changes have led the French government to close off earnings opportunities on which the population of the middle Senegal valley had become dependent. Thus, perturbations in one part of a system may quickly have major effects on geographically separated components of the same system.

Reversals of migration flows may have unanticipated consequences. Traditionally, much of the younger population of Burkina Faso has migrated to the southern part of Côte d'Ivoire to earn cash incomes. However, since 1980, opportunities to migrate

have been sharply reduced, and there has been substantial reverse migration. Most development experts were caught unawares by this sudden shift. The 1985 census of Burkina Faso revealed several hundred thousand more people than expected, in large part because planners had extrapolated migration flows from the early 1970s. Similarly, in Abidjan, the 1988 census revealed a much smaller population than expected (LePape, 1993). In Burkina Faso, it is reported that returning migrants have paid more attention to soil conservation and other efforts to wrest a living from the land, given that alternatives now appear to be closed off (Batterbury, 1994). On the other hand, returned migrants have also been engaged in stripping remaining forest resources for immediate cash incomes (Ford, 1992).

In-migration to rural areas by settlers clearing new land is fairly consistently reported to aggravate environmental degradation in the short to medium term (Leonard, 1989). Migrants are said to typically employ practices which are poorly adapted to their new environments and which often cause serious degradation (Cain and McNicoll, 1988; Bernard et al., 1989). This may occur in large part because of a lack of perceived ownership rights and responsibilities in their new area of residence (Rochette, 1988). It may also reflect the fact that it takes time before new residents come to understand the specific features and limitations of the new environment.

Ironically, migrants coming from densely-settled areas with traditional intensive cultivation practices incorporating soil conservation techniques usually abandon such practices when settling in low-density areas (Rochette, 1988). An example is the Kara people who live on the densely-settled Ikara island in Lake Victoria. When they migrate to rural areas on the mainland, the Kara immediately abandon the labor-intensive and unpleasant practices such as fertilizing fields with manure from stabled animals, green manure, and household wastes (Cleaver and Schreiber, 1993). The explanation is one of rational response to a change in relative factor proportions. Extensive cultivation practices are economically rational when land is no longer scarce (Netting et al., 1993).

A longer-term perspective on settlement migration often gives a different perspective. In areas of new settlement, squatters typically follow unsustainable cultivation practices, but permanent settlers who follow are more inclined to adopt sustainable practices, as noted in an unpublished case study from the Philippines cited by Pingali (1990). Further, even if it is the same settlers who remain, they tend to eventually adopt more long-term sustainable practices as land scarcity and erosion become apparent. Among the Kofyar of Nigeria who moved from a high-density hill district to a low-density plains area, shifting cultivation was initially used, but within 20 years they gradually instituted more intensive practices, including manuring from

corralled goats and pigs (Netting et al., 1993).

In Machakos District, in the past it typically took 20-30 years after settlement of a new area before farmers began adopting soil conservation measures. This was generally done only following the appearance of gully erosion and declining yields. In particularly sensitive areas, land was often abandoned because of degradation before people realized what was happening. However, land settled for the first time in the 1970s was much more quickly provided with soil conservation investments, as farmers had begun to learn from experience elsewhere (Tiffen et al., 1994).

It can be argued that the effect of rapid in-migration is analogous to extremely rapid natural increase. The full adaptation of cultivation techniques to environmental and demographic constraints within a particular setting generally takes many decades to evolve. Rapid population growth, whether through natural increase or migration, means that serious degradation may occur before new adaptations have a chance to evolve.

As was discussed above, cultural differences may modify the impact that settler migration has on environmental deterioration in newly settled lands. In Southeast Asia, Peltzer (1968) has contrasted the behavior of Javanese migrants in Sumatra, Indonesia. and Cebuano migrants in Mindanao, the Philippines. The Javanese migrants are reported to practice intensive, sustainable rice cultivation as in their homeland, causing little stress on the environment. In contrast, the Cebuano migrants are said to practice the same land-extensive, destructive cultivation techniques as they used in their now-treeless homeland (cited in McNicoll, 1990).

7. Gender

No discussion of agricultural intensification or environmental degradation in Africa is complete without a major focus on the role of women. It is believed that African women provide the majority of all labor in African agriculture. A widely cited figure is that 70% of all agricultural labor in sub-Saharan Africa is performed by women (Boserup, 1970; Blumberg, 1982). The data base of methodologically sound time-use studies is too fragmentary for much confidence to be placed in specific numeric estimates. Some time-use studies conducted in nuclear family farm households suggest that African husbands may spend as much or more time in combined agricultural production and animal husbandry activities as do their wives (McSweeney, 1979; Guyer, 1984). An analysis of African ethnic groups included in the 1967 Ethnographic Atlas found that women were reported to provide the majority of agricultural labor in half of the societies, in 30% the two sexes are said to

contribute roughly equally, and in the remaining fifth male labor predominates (Bryson, 1981).

The traditional African type of division of labor in agriculture involves complementarity between men and women and is generally regarded as being reasonably efficient (Dey, 1984). In most societies, wives are mainly responsible for cultivating food for household consumption while men focus on cultivating cash crops (Boserup, 1990). Complementarity also occurs at the level of cultivation tasks. Typically, men are expected to clear fields for their wives as well as themselves, while women are responsible for weeding their husbands' fields as well as their own. One major problem with this general system is that in most African societies, land is allocated by men, and women derive rights of access to land only in terms of their relationship to men. Further, even if the amount of time spent on agricultural and livestock activity is comparable, men perform those tasks which are considered less unpleasant (Ibrahim, 1982).

Despite these positive elements, under conditions of stress, sex role specificity and the differential access of men and women to resources can comprise significant potential constraints to the successful adaptation to increased land scarcity. The complementarity in sex roles breaks down when men are no longer present, whether because of marital conflict, death, or migration. In some African societies, 40% or more of rural households are female-headed, and the labor and capital constraints faced by these households, as well as uncertain land tenure, pose serious obstacles to agricultural intensification (Chipande, 1987).

Even in intact joint male-female households, differences in the perceived interests of men and women may hinder the development of optimal responses to changing economic incentives. Economists have conventionally ignored this problem by assuming that households have unified objective functions and budget constraints. Increasingly, it is recognized that men and women may have differing objectives (Fapohunda, 1988). Men are typically interested in increasing the cash income under their control, and may reallocate land and their wives' labor away from food crops toward cash crops in order to achieve this aim (Owusu-Bempah, 1988). Also, money may be used by men to buy fertilizer and other fertility-enhancing improvements on the plots they control but not on the food crops controlled by their wives. The men may feel no incentive to help maintain soil fertility on food-producing plots if it is their wives' responsibility to provide food.

Conversely, because of inequitable access to resources, African women often have very little incentive to protect or improve soil fertility. If men are free to reallocate plots of land, women have no reason to improve or protect soil fertility on their plots, since the men can then be expected to take them over for their own crops (Falloux and Rochegud, 1988). For example, in

central Burkina Faso, women were discouraged from building rock lines, an effective but backbreaking technique for increasing soil fertility because their husbands would reclaim the improved parcels for their own use during the following crop season (Wardman and Salas, 1991). Even if women household heads with secure land use rights are interested in protecting the soil, labor constraints may prevent them from undertaking the necessary work, and lack of money may prevent them from using purchased inputs (Chipande, 1987).

An analogous argument can be made with respect to fuelwood. In many parts of Africa, trees are planted and controlled by men, while women have the responsibility of providing fuelwood for the household. In Murang'a District of Kenya women have no right to plant trees, because planting trees implies permanent ownership of land (Chavangi, 1992). In Zimbabwe, women are said to be permitted by men to plant trees, but they have no rights to them if they leave their husband's household upon death or divorce (Fortmann and Bruce, 1993). Kenyan men are said to plant trees for the purpose of obtaining building materials or as a cash crop (e.g. for charcoal or building poles) without usually giving any thought to them as a source of fuelwood for their own household (Chavangi, 1992).

Consequently, it has been observed by Chavangi (1992) that there has been increased on-farm tree coverage in Murang'a District while at the same time fuelwood scarcity has become a preoccupation among women. In Machakos District, where a similar system is in place, English et al. (1994) deny that fuelwood scarcity is a problem, but it is not clear that the researchers asked women whether this was the case. In any event, the lesson is that fuelwood scarcity may not result from an absolute lack of trees or alleged loss of tree cover but rather from unequal access to trees.

Those African rural societies which have done the best job of coping with increased population pressure through agricultural intensification have often been characterized by predominantly nuclear family systems and sharing of tasks by men and women in agriculture. In these societies, there may be more of a sense of shared interest and a willingness to sacrifice for the common long-term good of the household. One well-documented case is the Kamba people of Machakos District in Kenya (Tiffen et al., 1994). Another is the Kofyar people of central Nigeria, where husbands and wives are said to almost equally share agricultural field work (Netting et al., 1993). Ironically, two of the most degraded regions in Africa are highland Ethiopia and highland Madagascar, two regions where monogamy has traditionally been relatively strong (Dey, 1984).

It is often hard to separate the effects of gender issues from other factors. One of the most celebrated instances of how sex-role specificity is alleged to have resulted in environmental

degradation comes from the Northern Province of Zambia (Cleaver and Schreiber, 1993). The traditional "chitemene" shifting cultivation system involved lopping branches from a large area of trees, piling them on a smaller cleared section, and burning them to fertilize the soil and kill weeds. Men were responsible for cutting trees and branches, while women handled the cultivation. During the 1960s, large numbers of men left the province as long-term labor migrants. According to researchers, because women could not climb trees to lop them or cut branches, they resorted to cutting down entire trees, which is more destructive (Tembo and Phiri, 1988). Blackwell et al. (1991) point out that despite reduced migration since the 1970s and no shortage of male labor, the custom of cutting down whole trees persists. Moreover, regardless of specific method used, the chitemene system is beginning to break down because population densities of 5-10 per km2 exceed the maximum density of 2-4 per km2 which is probably sustainable under this system. Consistent with the experience of other systems observed by Boserup (1965), Ruthenberg (1980), and Pingali et al. (1987), chitemene is increasingly being replaced by alternatives, including the "fundikile" grassmound system, which is more labor intensive but has up to 10 times higher yields and needs much shorter fallows.

C. Implications for policy

The population-agriculture-environment nexus is far too important to be left to the spontaneous working of history. It is still sometimes argued, two decades after the International Population Conference in Bucharest in 1974, that "development is the best contraceptive." Most people, though, now agree that African countries cannot afford to wait until they have reached a higher standard of living before starting to actively lower their population growth rates. Population policies targeted at improving women's education and health and their access to family planning services are necessary in order to achieve population stabilization in the foreseeable future. Similarly, while a few die-hard Boserupians believe that spontaneous agricultural intensification by African farmers will be sufficient to outstrip rates of population growth, most experts are of the opinion that policy-led intensification is a necessity (Pingali and Binswanger, 1988; Lele and Stone, 1989).

1. Population

Contrary to what some might think, a Malthusian perspective is not necessary for African population trends to be seen as worrisome. We have freely acknowledged the evidence of successful agricultural intensification and diversification of income sources by rural populations in parts of the continent. Economic policies appear to be far more important determinants of these processes than are population variables. On the other hand, in countries with weak economies and inadequate infrastructures, population increase appears to be aggravating already bad situations. Further, even in those relatively fortunate countries with stronger economies and increases in production, rapid population growth appears set to bring populations up against binding physical constraints, especially in terms of water supply (Falkenmark, 1993; Engelman and LeRoy, 1993) and renewable energy (Barnes, 1990).

Reducing the rate of population growth through promotion of family planning is an obvious response to the implications of increasing resource scarcity. This must be seen as a long-term intervention to forestall a future crisis rather than as something which will have any noticeable impact in the short term. It may take decades for reduction in birth rates to have an important impact on population pressure. Population growth over the next 30 years is largely determined by the current young age structure (Shaikh and Snrech, 1993). Because of the demographic momentum inherent in a young population age structure, it is too late to wait until an environmental crisis is upon one before reflecting on the unsustainability of rapid population growth (Jolly and Torrey, 1993).

We agree with Falloux and Talbot (1993) that every National Environmental Action Plan (NEAP) should have a strong population component. This population component needs to be broader than family planning. As a report issued by the United Nations Population Fund (UNFPA, 1994) in preparation for the International Conference on Population and Development to be held in Cairo in September, 1994 makes clear, improving women's status through education, health care, and empowerment is equally important for bringing about reduction in fertility. Introducing family planning services without providing adequate education and quality health care services is unethical as well as ineffective.

As mentioned above, there is a widespread belief that poverty is an important cause of high fertility in Africa and that sustained economic growth is needed for fertility decline to occur (National Research Council, 1993). For example, Cleaver and Schreiber (1993) contend that agricultural stagnation is a major factor impeding the onset of fertility decline in sub-Saharan Africa. However, the opposite may be more nearly true, that prosperity stimulates Africans to have more children. Agricultural progress and relative economic prosperity in the 1960s and early

1970s stimulated increases in fertility in countries such as Kenya and Rwanda (Abernethy, 1993).

The pronounced fertility declines observed in Kenya and Rwanda since the late 1980s have occurred in the context of, and possibly been stimulated by, agricultural stagnation and falling living standards. One of the most important factors inducing reduction in family size in a number of Eastern and Southern African societies may be the perception of increased resource scarcity (Boserup, 1985; Hyden, 1990; Mink, 1993). This is especially likely to be the case in societies with relatively high standards of educational attainment and health care. Thus, there is no reason to wait for economic development to occur before beginning efforts to persuade couples to space or limit their childbearing.

2. Gender

A consensus has emerged that gender concerns should constitute one of the major priority areas for interventions aimed at reducing negative interactions among population growth, agricultural stagnation, and environmental degradation (Cleaver and Schreiber, 1993; Jiggins, 1994). These include interventions in the areas of education, health, and reproduction as discussed above. In the fields of agricultural development and natural resources management, it is necessary for projects to explicitly recognize that men and women's interests may diverge and that programs designed and implemented largely by men may fail to meet the needs of women. This is not only an issue of equity but one which is central to sustainable development, since women are directly affected by environmental degradation in ways that men are not (especially with regard to fuel and water scarcity), and in turn their actions have as much or more of an impact on the environment as do those of men (Ibrahim, 1982).

Agroforestry and energy comprise key sectors for sustainable development. Increasing the supply of fuelwood and enabling households to more efficiently utilize the limited supply of fuel are both crucial if further degradation of the environment is to be avoided. As already mentioned, most agroforestry programs have been responsive only to male farmers' desire for growing trees for sale and have ignored women's need for fuel for domestic use. Similarly, energy conservation programs which promote the purchase of improved cook stoves overlook the divergence in interests of men and women. Men, who control the purse strings, may have no strong interest in reducing the amount of fuel that needs to be collected, since that is usually the responsibility of women and children.

Extension services are an area where African women farmers have been very poorly served (Boserup, 1990). The vast majority of

agricultural extension agents are male, a legacy of the colonial past in which farmers were assumed to be male. Studies have demonstrated that women farmers, especially those in households where no man is present, are far less likely to receive visits from extension workers, to participate in training, or to receive other services such as agricultural credit (Staudt, 1982). One obvious solution to this problem is to hire female extension workers. However, this is a very limited solution, since the orientation of agricultural research and extension services needs to be changed as well if women farmers' needs are to be addressed.

Women farmers in Africa are neglected in part because the crops in which they specialize are neglected. Since the colonial era, the bulk of research and extension has focused on male-controlled cash crops (including rice and maize in some countries) and has paid little attention to food crops grown primarily for subsistence, especially root crops and other non-cereals (Lewis, 1984). The conventional agricultural research and extension model emphasizes growing pure stands (monocultures) of single varieties of crops of commercial value, in contrast to traditional African cropping patterns in which a variety of crops and varieties are grown in association with each other. Since intercropping generally provides more protection to the soil, agricultural extension has often been part of the problem rather than part of the solution of sustainable development.

Agricultural projects also need to make special allowances for the resource constraints faced by female-headed farm households. Agricultural projects need to be redesigned to make them less capital- and labor-intensive in order to make them more accessible and attractive to women heads of farm households (Chipande. 1987). Also, existing systems of credit fail to reach women, who are typically perceived as poor credit risks. Group lending schemes for rural women, pioneered by Grameen Bank in Bangladesh, have been shown to be effective in extending credit to large numbers of women for the first time, and have had excellent results in terms of repayment rates and improved economic conditions for the participants.

Finally, one of the most difficult challenges facing agriculture and natural resources management projects is dealing with tenure rights for women, including rights to trees planted (Fortmann and Bruce, 1993). This is especially crucial for agroforestry schemes, since women may refuse to participate if their labor is required to maintain trees, the benefit of which accrues chiefly to their husbands (Leach, 1991). Many programs have had the unintended consequence of reducing African women's security of access to farm land. These include registration of land holdings, since women are very rarely able to have land registered in their own names (Boserup, 1990). Agricultural commercialization schemes, to the extent that they have been successful in expanding cultivation of the targeted crops, have

also typically resulted in land being removed from women's control and placed under men's control (Daddieh, 1989). Large irrigation and settlement schemes have routinely deprived women of the land needed to grow secondary crops by allocating land to male household heads for primary crops (Dey, 1984), although women farmers may find ways to circumvent this (McMillan, 1987).

A policy implication of gender differences for forestry projects is that negotiation between men and women over which kinds of trees to plant may be as important as additional tree-planting programs (Rocheleau, 1988; Chavangi, 1992). Most tree-planting programs have focused on exotic tree species and dealt with male farmers, who have been attracted to their usefulness for building poles. In contrast, indigenous tree species may be superior to the exotic species promoted by official agencies as sources of soil fertilization, foods, medicines, and fuelwood (Bradley and Dewees, 1993). Women farmers are generally far more knowledgeable about these benefits of indigenous forest plants, since they pertain to their areas of domestic responsibility (Owusu-Bempah, 1988). Disregard for women's indigenous knowledge by development programs may be a major factor hindering creative approaches to environmental protection.

3. Tenure

The widespread view that a shift from customary to individualized land tenure is needed to induce on-farm investment implies support for formal registration of land. However, there are multiple arguments for this to be done only on a gradual basis and with respect for customary arrangements (Cleaver and Schreiber, 1993). Place and Hazell (1993) contend that tenure reform or registration should not be a priority in Africa, because the issue is not so much one of formal land tenure but the extent of use rights over specific land parcels. Even where land registration is made available to farmers, as in Kenya, few seem to take the trouble to register titles, while in the other countries studies (Ghana and Rwanda), customary tenure appeared to be perfectly adequate to resolve use and transfer rights. Their research showed that the most important determinant of land investment is secure use rights, not ownership (Migot-Adholla et al., 1991).

Registration of land titles can adversely affect land use patterns and soil conservation. If smallholders have the ability to sell their land freely, some may quickly lose their lands under the pressure of wealthy urban residents wanting to engage in real estate speculation (Livingstone, 1990). Further, national land registration as implemented in Kenya and Botswana is reported to have been manipulated by elites to obtain large tracts of land, ignoring customary land rights and displacing substantial numbers

of people (Cleaver and Schreiber, 1993). As already argued, the combination of landlessness and tenancy is likely to be destructive of soils. Only farmers who depend on access to their own land have a strong incentive to maintain its productivity, while numerous cases exist of capitalist farmers exhausting the land to maximize short-term profits, which they reinvest elsewhere (Williams, 1991; Bilsborrow and DeLargy, 1991).

Tenure reform legislation may also have perverse effects on land use. Tenancy reform typically specifies conditions under which long-time tenants may be removed from the land, usually with some form of compensation specified. Often, the unintended consequence of tenancy reform is to reduce security of tenancy, since landholders may perceive an incentive to avoid having permanent tenants and can often manipulate local authorities so as to avoid compensation to displaced tenants. Fusch (1991) discusses an example of this phenomenon from Uganda, which officially nationalized land ownership in 1975, with ownership replaced by leaseholds. In principle, customary tenants cannot be evicted from leaseholds without compensation being paid and alternate land provided by the government. However, no empty land is available, and compensation is not paid. Thus, security of access to land has been virtually eliminated, reducing the incentive of farmers to invest in land.

Another policy implication of the importance of land tenure issues is that natural resources management policies which fail to pay explicit attention to tenure may not succeed (Falloux and Rochegud, 1988). This is particularly true of agricultural colonization, since failure to quickly endow settlers with ownership rights can result in a failure to adopt soil conservation practices (Rochette, 1988). Ownership rights to trees may also play a crucial role in determining the success of tree-planting and reforestation efforts. Numerous studies have reported that in the absence of ownership rights to trees and the ability to benefit from their products farmers have little incentive to either plant trees or ensure the survival of seedlings (Dejene, 1990). However, formal ownership rights may not correspond closely with de facto access, and it is necessary in each situation to carefully determine prevailing customs before attempting to launch an agroforestry or tree-planting project.

In review, we return to the principle that the nexus of the population-agriculture-environment sectors is always site-specific. Some positive changes in the direction of sustainable development have been reported in the literature, and these should provide a measure of hope and encouragement. However, they can rarely serve as a direct guide for project 'replication.' Besides the obvious point that physical conditions differ between locations, sociological variations may differ. For example, subtle differences in the productive roles of men and women or in the

rights of women to land and trees may spell the difference between success or failure of a given project.

National economic policies may be more important influences on project outcomes than anything which comes under the specific control of natural resources project managers. This is true both of policies which directly influence resource use patterns and those policies which influence the rate of economic growth outside of the resource sectors. Linkages to non-agricultural sectors are among the most important determinants of success or failure of projects within the agriculture and livestock sectors. Rural communities need to maintain diversified sources of income and employment, and any development projects which address rural residents only as farmers or herders are likely to be unsuccessful. Similarly, agricultural and livestock development projects can be truly successful only if a growing economy is providing both markets for surpluses and affordable supplies of industry-based inputs.

It is probably no coincidence that the best examples in Africa of successful agricultural intensification under population pressure seem to come from Kenya (Tiffen et al., 1994; English et al., 1994; Bernard, 1993; Okoth-Ogendo and Oucho, 1993). In particular, the physical, geographic, economic, political, social, and cultural factors of Machakos District seem to have been well-suited for facilitating positive outcomes. The relative success of Machakos District cannot be divorced from its extremely favorable location and unique social character. Much of the District is within commuting distance of Nairobi. Consequently, the area has become in large measure dependent on the Nairobi metropolitan economy, both for nonagricultural jobs and for outlets for its horticultural produce. The reputedly pragmatic Kamba population of the District are said to distinguish themselves by their attachment to their homeland. The Gusii people of Kisii District (Ogoth-Ogendo and Oucho, 1993) and the Meru people of Meru District (Bernard, 1993) are also reputed to share some of the same characteristics as well as to benefit from favorable locational characteristics.

In the case studies from Machakos and Meru Districts, agricultural stagnation and increasing soil erosion were characteristic during the 1930s and 1940s, followed by rapid growth in the 1950s and later. Successful intensification took place only when the government started to integrate smallholders into the market economy by providing infrastructure and supportive policies for growing cash crops and when popular organizations emerged as their active partners.

Other studies have also noted the relative success of Kenya compared to its neighbors in terms of achieving labor-absorbing rural development. Livingstone (1990) observes that while small farms have been a "sponge" for absorbing rural labor in Kenya, they

have not had this effect in Malawi, where intensification on small farms has been much less. In Malawi, the government has favored the large-scale commercial sector at the expense of smallholders, in sharp contrast to Kenya. In Ethiopia, successful labor absorption in smallholder agriculture has been even less than in Malawi.

The importance of national-level political factors and public institutions and policies appears clear from these comparisons. Similarly, English (1993) compares Machakos District in Kenya with highland Ethiopia. In the latter case, pressure of human and animal populations on the land is clearly and strongly associated with higher rates of soil erosion, while in Machakos this does not appear to be the case. The explanation offered by English is that political and social conditions in Ethiopia have consistently discouraged local farmer innovation while population increase in Machakos occurred under a context which fostered adaptive social and economic changes. Sadly, Kenya is the exception, not the rule in sub-Saharan Africa, with regard to political stability, a developmentalist bureaucracy, a relatively large and flourishing nonagricultural economy, and an open arena for (and high density of) voluntary popular organizations.

This discussion sugests that there are some important policy-related issues contained in the nexus experience. They include:

(1) the importance of agroforestry and agropastoralism as key ingredients in sustainable development for rural African populations;

(2) the unadvisability of using "Blueprint" development projects and the concomitant importance of using participatory processes which capitalize on indigenous technical knowledge and which incorporate local understanding of resource constraints and access to resources;

(3) the need to understand women's perceptions of resource control and to solicit their active, voluntary, and self-interested participation in resource management; and

(4) the need to fit each project to the nature of its immediate context.

Indeed, the tremendous variation among local circumstances noted above points toward a key nexus lesson -- blanket solutions and blanket project designs will often miss the mark. Because of the uncertainty and complexity of agriculture-population-environment interactions, generic prescriptions often will sacrifice sustainable impact.

D. Sustainability and Uncertainty - Three Dimensions

Sustainability is the ability to meet the needs of the present-day human population while at the same time maintaining or enhancing the quality of the environmental resource base needed to support future generations (WCED, 1987; Reardon and Islam, 1989). The concept is imprecise, because the boundaries of the system in question, the types of human needs, and environmental quality are all difficult to pin down. If local environments were closed systems, in which human needs could only be met by the output of the circumscribed system, evaluating sustainability would be much simpler. But, few systems are closed, and their sustainability rests largely on their members' ability to draw upon external resources. This implies that sustainability is not a fixed characteristic of a given system, but is determined by the flux of relations across sectors, space, and time. Hence, there is an enormous degree of uncertainty involved in assessing sustainability.

Sustainability is assessed either by measuring living conditions of the human population or by inventorying the characteristics of the physical environment. These two types of assesment are conceptually distinct and are not necessarily related to each other within open systems. Serious environmental degradation may be compatible with stable or rising living standards if a local population is 'connected' to a broader system. For example, the population of the middle Senegal River valley has experienced rising living standards at the same time that perennial drought has dramatically eroded the resource base and population numbers have steadily multiplied. This has been achieved through reliance on earnings from temporary migrants working in the cities or in France to purchase food and other goods and services (Chastenet, 1991; Lavigne Delville, 1991). This strategy imposes uncertainty because it is politically dependent on continued access to France, and hence its sustainability is uncertain.

The ten case studies in the recent book edited by Turner, Hyden, and Kates (1993) which are discussed in part B illustrate the importance of considering intersectoral linkages rather than narrowly focusing on agriculture. Despite ambiguous or negative changes in soil fertility in most of the case studies, living standards are reported to have been improving. Thus, in a very real sense successful intensification could be said to have been occurring. This is particularly true of the Nigerian case studies, including the areas in southeastern Nigeria which are notoriously degraded. The primary response to increased population pressure in these communities has been to seek earnings opportunities in the urban, nonagricultural economy, which in the 1970s and 1980s was a quite viable and successful strategy. Indeed, the primary determinant of changes in living standards in rural communities appears to be the health of the national economy, such that Nigerian and Kenyan communities seem to have done relatively well,

while the Tanzanian, Rwandan, and Ugandan case studies reflect economic stagnation at the national as well as the local levels.

We need to look beyond any one sector in one locality at one point in time in order to understand the causes of environmental problems and threats to sustainability in rural Africa. The three sections below organize African experience to show the difficulties associated with generalizations across time and space as well as the need to look across sectors.

1. Across sectors

The associations between population and environment in Africa are usually viewed primarily within the context of the agricultural and livestock sectors. It is important that attention not be restricted to variables within these sectors. The resilience or viability of an agricultural or pastoral subsystem may depend upon access to resources located outside of that particular subsystem. This is particularly obvious with respect to pastoralism, since pastoralists require access to land from a wide range of microenvironments in order to successfully cope with climatic variations, and they depend upon transactions with agriculturalists to obtain the bulk of their food. Indeed, it makes less and less sense to focus on agriculture and livestock as separate sectors, since pastoralists are increasingly practicing cultivation and farmers are herding livestock. This interpenetration of agriculture and pastoralism means that agropastoralism is not just a nice concept but a reality which program managers cannot afford to overlook.

It is generally believed that dryland grazing areas in Africa are under serious stress from numbers of herding animals (Cleaver and Schreiber, 1993), although range management experts are now beginning to question this widespread belief (Behnke and Scoones, 1992; Scoones, 1993; see part B). Even to the extent that it is a real and serious threat, overgrazing may result more from loss of dry season pasture land to cultivators and the cutting off of seasonal migration routes than from the growth in numbers of pastoralists (Campbell, 1981; Talbot, 1986; Campbell and Olson, 1991b; Ngoufo, 1992). Also, growth in pastoralist numbers may reflect a lack of alternative economic opportunities for the youth of pastoralists. Transhumant pastoralism can sustain only limited numbers of people. The real issue determining whether overgrazing occurs may be the extent to which pastoralists are able to diversify their economic activities outside of pastoralism (Campbell and Olson, 1991b). Thus, it may be the lack of access to outside resources which needs to be explained in apparent cases of excessive pressure of local populations on resources (Campbell and Olson, 1991a). Demographic entrapment in terms of the limiting potential of a local ecosystem to support a given population is an

issue chiefly if a population is cut off from the opportunity to bring in outside resources by selling its goods or services or by migrating elsewhere (King, 1993).

Deforestation is closely linked to the agricultural and livestock sectors. While commercial logging often provides the entry point for squatters to follow, the large majority of deforestation in tropical countries is attributed to the expansion of cultivation and livestock grazing or ranching (Barnes, 1990; Myers, 1991; Cleaver and Schreiber, 1993). Consequently, addressing the problems of landlessness and land hunger may be as important for stemming deforestation as are any direct measures intended to protect forests. This point is illustrated, perhaps too neatly, by the contrast between Costa Rica and Nicaragua. Vandermeer (1991) cites estimates that the rate of loss of tropical rain forest was almost three times as high in Costa Rica as in Nicaragua, despite Costa Rica having numerous foreign-funded projects aimed at protecting tropical rain forests. The explanation proffered by Vandermeer is that Nicaragua alleviated peasant land hunger through a redistributive land reform while Costa Rica has sought to alleviate land hunger by encouraging peasants to find new land to cultivate.

The intersectoral conversion of land from pasture to cultivation is commonly reported to cause environmental degradation, but this does not have to be the case. In the highland part of Machakos District in Kenya, two recent publications (Tiffen et al., 1994; English et al., 1994) provide photographic evidence of increased tree cover and reduced gullying between the late 1930s and the late 1980s, despite a five-fold increase in population size. During this period, much land was converted from pasture to land cultivated in terraces. Studies demonstrated that soil erosion was much worse on overgrazed pasture land than it was on terraced crop land. Further, because of the elimination of bush fires for maintaining grassland, between 1960 and 1990 the proportion of pasture area covered by trees increased from 1-2% to 11-15% (English et al., 1994). On the other hand, in dryer, lowland areas of Machakos District, the spread of cultivation into dryland grazing areas is widely reported to have resulted in serious land degradation (Bernard et al., 1989; Rocheleau et al., forthcoming) over time.

2. Through time

Insights about environmental degradation are very elusive when the time dimension is not made explicit. Single point, or "snapshot", impressions of environmental degradation are inherently suspect. Natural environments vary widely in terms of their biological potential. To refer to a low-productivity environment as "degraded" implies that in the past it had a higher level of

biological potential and that within the historical past it had become measurably less productive. Further, degradation is usually understood to be the consequence of human-directed actions rather than a natural phenomenon and to imply a degree of irreversibility. The presence of visible evidence of soil erosion, such as gullies, may be difficult to interpret in terms of ongoing land degradation, since the causes may be natural, the gullies may have been inactive for many years, and gullies can also be reclaimed.

Much of the uncertainty about population-environment relations stems from the temporal dimension. Environmental degradation can be either acute and obvious or chronic and insidious (Blaikie and Brookfield, 1987). In general, people are able to recognize dramatic changes or direct causes, but they have trouble grasping the reality of more gradual changes or indirect and long-linked chains of causes (Ornstein and Ehrlich,1989). Changes which occur slowly can breed an attitude of complacency. If people have adapted successfully so far, then why should they not continue to adapt successfully in the future? Skeptics ask "What catastrophe?" or "What disequilibria?" (e.g. Williams, 1991).

Extrapolation of past trends into the future can be risky. This is particularly true for cases of what would appear to be successful adaptation. Apparent stability in crop yields may mask serious underlying degradation. Soil erosion may have relatively small and reversible effects on crop yields until a certain point is reached, after which loss of soil fertility and hence fall in output may be rapid (Dommen, 1988). Thus, obvious degradation may be only a relatively late sign that demographic entrapment has already occurred (King, 1993).

We will consider three examples. Côte d'Ivoire for decades had the highest rate of population growth in Africa, over 4% per year, because of high fertility and especially immigration from neighboring countries. The country also had one of the highest economic growth rates on the continent, based on the extraction of natural resources through tree crops and logging. By the mid-1980s, the supply of underexploited resources began to dry up, economic growth came crashing down, and Côte d'Ivoire could no longer continue to employ large numbers of new migrants from Burkina Faso and Mali. Projections made for Côte d'Ivoire and surrounding countries on the basis of the assumption that the very high economic and demographic growth in Côte d'Ivoire could continue indefinitely have proved illusory.

The second example comes from Rwanda. From the early 1960s to the early 1980s, Rwanda was one of the few agricultural success stories in sub-Saharan Africa, with agricultural production outpacing population growth. However, this was based on the expansion of cropped area, and by the early 1980s this source of growth was no longer available. Since 1983, agricultural production has stagnated in absolute terms. Those observers who

based their assessments on the pre-1984 performance of Rwanda have had their expectations dashed. Further, reports of serious environmental degradation in Rwanda have multiplied within the last decade.

Third, Tiffen et al. (1994) and English et al. (1994) have highlighted the success of the Kamba farmers of Machakos District, Kenya, in dramatically increasing agricultural production without apparently causing increased environmental degradation. However, English et al. (1994) acknowledge that the present agricultural production system in Machakos District is not sustainable in terms of being able to further support further growth in population. They project that a growing population in the district will be readily accommodated, based on the assumption that proximity to Nairobi will allow them to rely on non-agricultural sources of income. This presumes that the Kenyan national economy will continue to be robust and that supplies of affordable staple foods will be available from other regions of the country. Based on the preceding examples, these are not necessarily safe assumptions.

Inadequate responses to population and environmental changes may result from lags or other limitations to our ability to respond to change. A population growing at slightly less than 0.5% per year will double in roughly a century and a half, while a population growing at 3.5% per year will double in less than two decades. The autonomous intensification model of Boserup (1965) was developed to explain agricultural growth patterns of economies growing at the former type of rate. The higher rates of population growth observed in contemporary developing countries are likely to overwhelm the gradual, endogenous types of responses described by Boserup (Pingali and Binswanger, 1988; Lele and Stone, 1989; Ruttan, 1993).

The pace of change in developing countries is so rapid and diffuse that social scientists, development planners, and local populations are often unaware of these changes or their foreseeable implications. This is critical, because "on-going changes imply a structurally different economy and society" (Shaikh and Snrech, 1993). Within a few decades, countries can go from being predominantly rural to being majority urban. Within an even shorter period of time, an autarkic, subsistence-oriented society can become transformed into an outward-oriented society consuming imported foods and living off the money remittances of its migrant members. Projects which implicitly assume one type of society may find that the rapidly evolving nature of the society makes their proposed intervention fundamentally irrelevant.

A proactive, forward-looking approach to social, economic, and demographic change is called for. However, this requires flexibility. Whereas one may be able to predict that a crisis will occur at some future date, it is extremely difficult to reliably predict the timing of turning points or the outcome of the

subsistence crisis. Population-environment dynamics are not automatic but depend upon the choices and strategies of human actors. Historically, growing populations often experience subsistence crises when a given adaptation strategy reaches the limits of its potential. A prolonged period of stagnation may result until some social, economic, or technological change allows new resources to be exploited and growth in output to resume. It is not possible to predict the timing, character, or even the emergence of the needed adaptations. Systemic collapse of local subsistence systems has sometimes occurred in the past when successful adaptations did not occur (Sutton, 1984), and this may occur again in the future. However, a low-level equilibrium trap (or agricultural involution) is far more common than collapse (Goldman, 1992; Mortimore, 1993a).

It is generally agreed that no development strategy in Africa will ultimately prove to be sustainable unless rapid population growth is brought under control (National Research Council, 1993). In the face of rapid population growth, improved natural resource management may at best serve as a way of "buying time" for population growth to be controlled and for nonagricultural economic activities to be developed (Shaikh and Snrech, 1993). Otherwise, ecological crisis may be postponed rather than averted. Rural populations cannot indefinitely grow and still support themselves on the basis of local resources. No subsistence system can be considered sustainable without either population regulation or induced shifts to other technologies and market exchanges. But these shifts may exhibit great variety over space.

3. Over space

The risk of environmental degradation is highly uneven across ecosystems. Some lands are more "fragile" (high sensitivity to degradation and low resilience) than others under usual cultivation and grazing practices (Turner and Benjamin, 1994). Making negative generalizations about environmental degradation in Africa without taking these differences into account can be seriously misleading (Lewis and Berry, 1988). In this section, we discuss some of the physical differences between major ecosystems in Africa which have profound implications for the risk of environmental degradation in different settings. This does not mean that sustainable agricultural intensification is not technically feasible within each ecosystem, only that this may be more difficult to achieve and less likely to occur in some settings than others. To summarize from the discussion in section C.1, the major factors affecting the rate of soil erosion and loss of soil fertility are soil type, organic content of the soil, slope, amount and intensity of rainfall, temperature, vegetative cover, and land management practices.

Lowland African soils, which comprise most of the African continent, are at particularly high risk of loss of soil fertility under permanent cultivation. The traditional explanation focuses on the allegedly inherently poor quality of these soils. These soils are said to be mostly acidic or sandy, with low proportions of clay and organic material, low nutrient densities, and often containing either aluminum oxides, which are toxic, or iron oxides, which form hardpan crusts, especially in West Africa (National Research Council, 1982; Harrison, 1987). A revisionist view questions either the validity or importance of these generalizations about soils in the humid tropical lowlands of Africa and America (Moran, 1982; Kates et al., 1993; National Research Council, 1993).

A newer view stresses climatic factors as making permanent, year-round cultivation in a sustainable manner difficult to achieve in tropical lowland environments (Weischet and Caviedes, 1993; National Research Council, 1993). High temperatures and highly intense rainfall leach unprotected soil of nutrients, mineralize existing organic matter, and inhibit biological activity in the soil. Perennial shrub and tree crops which provide continuous vegetative cover and impose relatively low nutrient demands are sustainable as permanent cropping systems in the semi-humid and humid lowlands (Ruthenberg, 1980). Unfortunately, limited market demand for crops such as oil palm prevents their widespread expansion (Weischet and Caviedes, 1993).

Despite the serious difficulties posed by high temperatures and rainfall, it has been demonstrated that sustainable methods of permanent or quasi-permanent cultivation incorporating staple crops are technically feasible in at least limited areas in humid tropical lowland environments (Greenland, 1981; Lewis and Berry, 1988; Sanchez, 1992; National Research Council, 1993). This is particularly true for forms of agroforestry, such as alley-cropping, which integrate staple crops with nitrogen-fixing bushes or trees (Ehui et al., 1992). However, technical feasibility does not necessarily mean that such practices are likely to be widely adopted. Issues of resource constraints and gender differences in responsiblities and tenure need to be addressed (section C.7). For example, Nigerian Ibo women farmers have refused to practice alley-cropping techniques because of lack of secure tenure and a reluctance to take care of "men's trees" (Leach, 1991).

Two major types of African environment are usually considered especially vulnerable to degradation because of high populations relative to estimated carrying capacities. These are the semi-arid lowlands, especially in West Africa, and the East African highlands (Lele and Stone, 1989; Cleaver and Schreiber, 1993; Turner and Benjamin, 1994). It is often stated that the elevation, steep slopes, and relatively high rainfall found in the East African highlands, conventionally defined as lands located more than 1500

meters above sea level, and which comprise much of Ethiopia, Kenya, Tanzania, Rwanda, and Burundi, make them environmentally fragile (Lewis and Berry, 1988). Actually, Ethiopia differs sharply on both physical and cultural factors from the other highlands of East Africa and hence should not be included in the same category (Berry et al., 1990). On the other hand, it is also often recognized that more lowlying areas within the same countries appear to be at even higher risk of erosion and degradation (Bernard et al., 1989).

Contrary to some pessimistic assessments, the East African highlands (excluding Ethiopia) share a number of physical characteristics which make them relatively favored for sustainable agricultural intensification. First, soil types are among the most fertile in Africa, especially those found on volcanic or basaltic substrates (Harrison, 1987). Second, rainfall conditions tend to be relatively moderate (typically between 900 and 1400 mm per year), with less rain than in more humid lowland environments but more than in dry lowlands. Both extremes of rainfall increase the risk of serious soil erosion. Further, the rainfall in these highland areas tends to be less concentrated temporally and less aggressive (Bidou, 1989).

African mid-elevation highland environments (especially between 1200 and 2000 m in altitude) also generally have superior agricultural potential because of their moderate temperatures (Lewis and Berry, 1988; Weischet and Caviedes, 1993). Below 1000 to 1200 meters above sea level, minimum monthly temperatures in tropical Africa are generally above 18 degrees, which is a criterion for tropical climates (Weischet and Caviedes, 1993). Above 1200 m, the mineralization of soils and the breakdown of organic content by biological activity are greatly slowed down, thereby protecting soil fertility. This also allows mulching, the application of crop wastes or other plant matter as ground cover, to be used at these elevations as a method of soil conservation (Lewis and Berry, 1988). The cooler temperatures associated with greater elevation also reduce the risk of wilting experienced by plants at high temperatures owing to high evapotranspiration rates. Finally, lands in this range of altitudes are usually suited for a number of perennial crops, including coffee, tea, and/or bananas. These provide excellent vegetative cover and minimize the risk of soil erosion (which is true for coffee only if mulching or intercropping is practiced) (Jones and Egli, 1984).

In comparison to the East African highlands, the Sudano-Sahelian lowlands of West Africa appear to be more susceptible (sensitive) to erosion. The Sudano-Sahel zone suffers from high-frequency torrential rain storms, poor vegetative cover, nutrient deficiency of soils aggravated by high soil temperatures, unstable soil structure, and low water infiltration of soil surface (Wardman and Salas, 1991). Because of variations in soil type and rainfall aggressivity, it is reported that erosion is greater from a slope of only 1-3% in Burkina Faso or northern Nigeria than from

a much steeper slope of 20-30% in Rwanda (Roose, 1988). Further, economically useful bushy crops which protect the soil from rain and sun thrive cannot be grown in these areas.

Not all African highland environments enjoy advantageous characteristics (Lewis and Berry, 1988). Highland Madagascar suffers from torrential rainstorms, and it appears to have both very high sensitivity to erosion and low resilience when ecosystems are disturbed (Rossi, 1979). The highly eroded highlands of northern Ethiopia are a well-known example of severe land degradation (Dejene, 1990). Whiteman (1988) discusses a number of relevant physical features. Their high elevation (above 2000 m altitude) is associated with the cultivation of a grain, teff, as the staple crop, which exposes the soil to the full force of the rains each year. Further, the rainfall distribution is extremely uneven, with sharp peaks. The heavy clay soils have a low infiltration rate and easily become waterlogged. To drain them, farmers plow up and down slopes, which aggravates soil erosion.

As already noted, the relatively successful experience of agricultural intensification in the highland parts of Machakos District has been held out as a model for the rest of Africa (English et al., 1994; Tiffen et al., 1994). It is argued in support of this thesis that the physical conditions in semi-arid Machakos District were not particularly conducive to agricultural intensification (English, 1993). On the other hand, the higher-elevation parts of Machakos District, where the successful intensification has occurred, share the favorable characteristics of other East African highland regions, including moderate amounts of rainfall. Most importantly, the climatic and soil conditions there are suitable for growing coffee, and this perennial crop has been, until recently, both lucrative and good for the environment. Further, Machakos has enjoyed a number of unique locational and social advantages, as well as being located in one of the most stable and advanced economies in Africa.

The major policy implication of these differences across regions and elevation zones is that it can be misleading to take successful agricultural, forestry, or range management experiences from one area and attempt to directly apply their lessons to other areas within Africa. This is true with respect to differences between the East African highlands and the Sudano-Sahel lowlands. It is even true within highland environments, comparing the Great Lakes highlands with Ethiopia or Madagascar. The differences in terms of soils, rainfall, and cropping systems are too great. On the other hand, lessons about the importance of participatory project design and adaptive project management methods may be quite transferrable (Honadle and VanSant, 1985; Uphoff, 1992; Scoones, 1993).

Thus, our review and reinterpretation of the environment-poulation-agriculture nexus in Africa suggests that we need new

lenses for seeing the relationships between projects and their surroundings. Lack of conformity to planetary panaceas does not explain the reasons why projects fail to achieve sustainable results. Rather, the reasons are more likely to be found in contextual diversity and the difficulty of transporting stock solutions across time, space and sectors. We need to focus on new models of project impact and new hypotheses about the source of threats to project success.

II.
FOCUS: HYPOTHESES AND THREATS TO PROJECT SUCCESS

The previous chapter documented the fact that interactions among the population, natural resources and agricultural sectors are dynamic and they exhibit great variety in Africa. The task for this chapter is to present a framework for conceptualizing what can happen when development assistance is applied in such settings. We need a typology to describe the different ways that development projects "fit" into nexus dynamics.

Our discussion of fit will begin with a focus on the natural resources sector. Here is a case where policies (and the projects related to particular policies) outside the sector can be major determinants of what occurs within the sector.

A. Sectoral Myopia

Natural resource policies do not aim at natural resources -- they are aimed at human behavior. Nature does not respond to human policy.

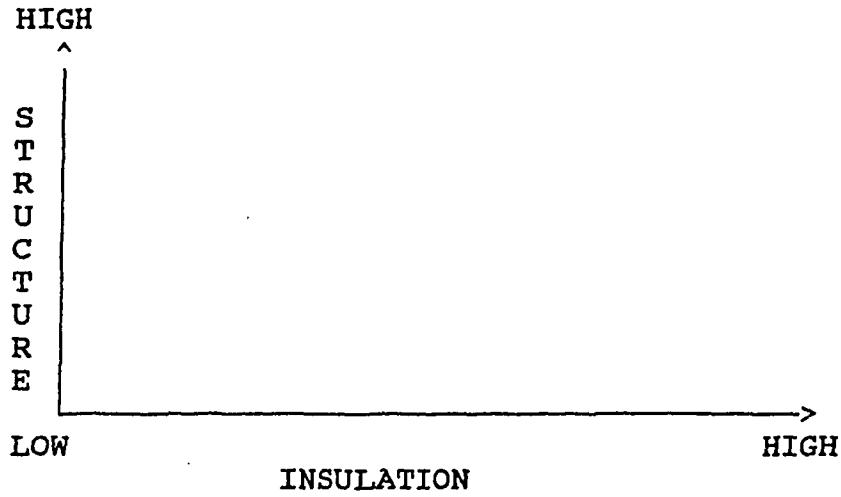
And yet typical policy categories are based on the resource base involved -- water, forests, wildlife, etc. What is needed is a set of policy types that goes beyond this limitation. But to develop a typology it is useful to first see the underlying dimensions that characterize it.

Structure and insulation are the two dimensions which can be used to characterize the degree of autonomy available to those who use a resource. Structure refers to the level of control held by the resource managers. The more structure a policy has, the narrower the scope for user decisions. Policies within the natural resources sector can fall along a continuum from high to low autonomy.

Insulation refers to the collateral effects that a policy can have over other sectors. For example, if a tax policy shapes the activity of natural resource managers toward the resource, then it exhibits low insulation. (eg. rapid depreciation of farm equipment promotes capital-intensive cultivation leading to wetland loss) Conversely, if an export policy has no influence on the decisions and actions of the resource manager, then it shows a high level of insulation. In other words, if a policy does not have effects that spill over into other sectors, it is highly insulated. But if it does affect the activity in other sectors, its insulation level is low.

These two dimensions of structure and insulation are displayed in Figure 1. This depiction will be useful for seeing the relationships among the clusters of policy options presented below.

FIGURE 1



In figure 1, the further up on the vertical axis, the lower the individual options available for participation and influence in the actual policy design rules. In the other extreme, closer to the lower end of the vertical axis, there is almost complete autonomy and great possibility for individual influence in the policy specifics.

Toward the right on the horizontal axis there is more insulation or less possibility for indirect effects. Toward the left, however, policies intended for one sector or purpose can spill over into other sectors and affect them.

General macro or micro policies are likely to have collateral effects since they do not aim to be sector specific. In this situation, however, low insulation does not necessarily imply a particular degree of structure. They may range from specific price subsidies of certain inputs (high structure), to limiting themselves to encourage and facilitate the formation of mutual assistance production community groups (low structure).

Natural resource policies with a high or low structure all may be affected by the collateral effects of general policies or other non sectoral policies. This is because widening the scope of influence of individuals in the design of sectoral policy rules does not neccesarily mean that these rules are not going to have

indirect effects in other sectors nor that they are less subject to side effects of other policies. The two dimensions of structure and insulation are, therefore, independent.

The framework above is based on a two-dimensional classification developed in cultural theory in order to understand the relationship between social environment and individual relationships (Douglas, 1990). The typology below comes from four policy clusters which are being used in a study of environmental policy implementation (Honadle,1994). Although parts of this set have been used by others (see Eskeland and Jimenez, 1992), Hans Gregersen of the University of Minnesota was the first to propose four categories (comand and control, direct incentives, indirect incentives and stakeholder self management) as a viable alternative to traditional economic policy categories such as fiscal policy, trade policy, etc., and as a substitute for sectoral policy divisions such as population policy, macro-economic policy, transportation policy, agricultural policy, and so forth (see Gregersen et al, 1991).

The value of this typology is fourfold: first, it is comprehensive enough to include nearly any conceivable policy; second, it allows a direct focus on environmental consequences whether they are intended or not; third, it provides an integrated and applied focus rather than a set of categories based on disciplinary or institutional slices of reality; four, it allows the formulation of hypotheses about the sustainability of some policies.

The figure 2 below maps the classification of policy clusters according to the two dimensions described above: structure (vertical axis) and insulation (horizontal axis). Three of the clusters lie along the structure dimension while the fourth, indirect incentives, lies along the insulation dimension. Weak indirect incentives are highly insulated and have few intersectoral consequences. But strong indirect incentives have lower insulation and can cause unanticipated impact across sectors.

In figure 2 it is also hypothesized that the sustainability of policies will vary with the relationship between their autonomy levels and the nature and insulation of indirect incentives. If indirect incentives support the sectoral policy, then they are not an issue. But if they have deleterious effects, then the more insulated they are, the better.

But if they do create problems across sectors, then the level of structure of policies within the sector may be important. Highly structured policies will exhibit much greater implementation costs in settings with strong indirect incentives pulling away from the sectoral policy objectives.

FIGURE 2

```
          HIGH
           ^
           |
        COMMAND
          AND
        CONTROL
S          |
T          |
R       DIRECT
U       INCENTIVES
C          |
T          |
U       STAKEHOLDER
R         SELF
E       MANAGEMENT
           |
           |
           |          STRONG                    WEAK
           |          INDIRECT                  INDIRECT
           |          INCENTIVES                INCENTIVES
         LOW-------------------------------------------------->HIGH

                       INSULATION
```

The typology of policy clusters introduced above needs elaboration. This is done below.

1. command and control

The first policy cluster is COMMAND AND CONTROL. This is familiar to everyone. It is the sequence of policy or legislation followed by regulation. It is a common approach to protection of wildlands, species and resources. National environmental protection acts, enforcement of maximum pollution levels, setting aside of natural areas for parks or research, limiting timber cutting or requiring certain silviculture practices, restricting access to precious minerals, banning commerce in ivory or endangered species, or even forcing compliance with hunting and fishing laws all provide examples of this approach. It is perhaps the oldest natural resource policy practice, dating back thousands of years to the protection of royal game.

The image it evokes is one of denying people the right to do something and it explains why natural resource management agencies and regulatory bodies are seldom popular. China's population control program is an example of this approach to limiting human population growth and mitigating its effects on the environment.

2. Self-management

The second option is the polar opposite of command and control. It is STAKEHOLDER SELF-MANAGEMENT. This is giving total control of a natural resource to a local population and trusting that they will manage it on a sustainable basis. The assumption is that they have a long-run stake in maintaining the resource and the most effective way to ensure sustainable use is to let them do it.

Self-managed situations result from enabling policies that devolve authority, recognize and legitimize pre-existing traditional authority structures and resource management systems, and foster local empowerment. Decentralized administrative strategies, privatization initiatives, Aborigine reserves, community resource management programs, local eco-development programs and many social forestry efforts provide variations on this theme. In the wildlife management sphere, the CAMPFIRE program in Zimbabwe is one of the most famous examples. (here local communities determine what level of hunting is appropriate and they receive income and employment from wildlife-viewing tourism). In the area of population planning this is the most common approach -- people are supplied with information and contraceptives, but they are responsible for what ensues.

3. Direct Incentives

The third policy cluster is DIRECT INCENTIVES. Discussion of pollution credits, water markets, stumpage fees, green labelling, and other examples of market-based environmentalism fit into this category. This focusses on the structure of benefits and costs surrounding a particular resource, product or process. Direct incentives enable behavior, or they require it as a qualification for rewards.

Subsidized costs for logging equipment, agriculture or aquaculture inputs, marketing assistance or the establishment of favorable prices for certain products are other examples of direct incentives that are commonly found in third world settings. In fact, attempts to establish direct incentives have been integral to agricultural development projects for decades and both bilateral and multilateral donors routinely incorporate price incentives into project investment packages.

Although subsidies have bounced in and out of favor, producer responsiveness to farmgate prices has been raised to nearly mythical proportions and direct incentives are likely to occupy a key role in donor strategies for some time to come. This is especially true given the present enthusiasm for using markets to solve environmental ills.

4. Indirect Incentives

The fourth cluster is INDIRECT INCENTIVES. This is a particularly pervasive set of influences on resource use because it usually results from the pursuit of other, seemingly unrelated, objectives and thus it is ignored by most environmental observers. Indeed, this policy cluster needs more detailed treatment here because it is less understood and less likely to be examined when policy options are discussed.

Policies promoting labor-intensive technologies often have benign environmental impacts due to limitations on the use of large, environmentally destructive equipment. Tax codes intending to promote reinvestment in private enterprise, structural adjustment programs opening up previously closed economies, or tariffs biased against specific technologies can be examples of this policy cluster. Although they may encourage either protective or exploitative behavior, indirect incentives often work against sustainable resource use. But because of their indirectness, the impact is seldom understood.

Tax codes in some third world nations may also encourage inefficient or environmentally-destructive behavior. Across-the-board export levies, for example, can make non-timber forest products less competitive for producer attention and speed deforestation.

The proliferation of macroeconomic adjustment efforts in Africa has created many opportunities for the inadvertent imposition of indirect incentives for environmental destruction. Zambia in the mid-nineteen eighties provides an example.

The introduction of a new system for setting the foreign exchange rate of the Zambian Kwacha resulted in a setback for investment in agricultural and natural resource initiatives. The focus was on replacing an administered foreign exchange system with a market-based one. The solution to poor economic performance was cast as reforming economic policy and introducing a market regime. No one anticipated any impact on the environment.

The way the new system worked was as follows: Actors interested in purchasing foreign currency held by the central government presented bids to a bank on a certain date each month;

The bids indicated how much currency was desired and how many Kwacha would be paid; The bids were examined, the high bidders received their allocation and the next highest received their amounts until the total consumed all the foreign exchange that the government held at that time; The high bid established the official exchange rate for that month. Some modifications occurred during the life of the auction process, but the changes made no difference in the impact on agricultural and natural rescurce investment.

An examination of the successful and unsuccessful bids revealed a disturbing pattern. The winning bids invariably were for activities with fast turnarounds that were often simple middleman operations importing consumer goods and equipment. Lower risk, rapid cost recovery activities allowed higher bids. But higher risk, longer turnaround activities (such as forestry, fisheries and agricultural investments) forced lower bids. This was exacerbated by subsidized food for urban population which then made agricultural investments even less profitable. Thus the currency auction process contained an inherent bias against natural resource investment and it provided an indirect incentive for further sectoral imbalances in a country characterized by major environmental deterioration and chronic food shortages.

This case shows how indirect incentives can be both important and difficult to identify. Indeed, interactions among multiple indirect reward systems can weave a web of barriers to sustainable resource use. And yet they may lie far outside the common boundary of the natural resources sector. Indeed, indirect incentives focus on other sectors by definition.

The side effects of seemingly unrelated policies of one sector to others, supports the possibility of advocating coherence of policies across sectors as an important element of sustainability. Projects from different sectors will have coherent objectives to the extent that cumulative side effects are taken into account by the entire project array.

If various sectors adopt policies with strong indirect incentives (i.e. low insulation), they will export side effects to other sectors. Whether these spillover effects, positive or negative, are taken into account or not by other sectors depends on whether or not there is intersectoral coherence of objectives.

Given the discussions of Chapter I and above, it is clear that a natural resources sector analysis may miss the critical determinants of behavior in the sector because they lie outside it. Figures 1 and 2 have helped to visualize the potential cross-sectoral impact of policies, but we also need a framework for visualizing both the side effects of a project across sectors, and the effects of events within those other sectors on the project.

B. The Centrality of Project Side Effects

In a classic 1967 volume (Development Projects Observed), Albert O. Hirschman titled one chapter "The Centrality of Side Effects." In his study of World Bank projects he found that often the most profound impact resulting from the projects was unintended. For example, the construction of a processing plant that was a financial failure nevertheless promoted a new pattern of inter-community cooperation that later became the stimulus for successful development in a particular region of the country.

Over 25 years later, his observations are particularly pertinent to the population-environment-agriculture nexus. A project with intended impact in one sector may actually produce greater impact in one or both of the other sectors.

1. intersectoral impact

When viewed through the lens of a project's intended impact, unanticipated impact can be positive, negative or neutral. The example above of the processing plant provides an illustration of a positive side effect.

Negative impacts are legion. For example, a project may have an intended objective, in the agricultural sector, of promoting agricultural intensification and raising family income. But chemical runoff could harm fish stocks in the natural resources sector or reduced women's access to field plots could lead to their disempowerment and weaken attempts to lower fertility rates.

Side effects can affect the achievement of an intended impact of a project and/or create externalities to other sectors. Illustrative cases come from Burkina Faso and Mali. In Burkina Faso, project developers and male farmers shared the same values and economic incentives to successfully implement a line stone technology which intended to prevent land degradation. The adopted technique consisted on ranging lines of stones along the contour on land suffering from, or threatened by, erosion. As a matter of fact, around 6,000 ha of this country's land had been treated with the line stone technology. However, in the Mossi Plateau of Burkina Faso, women were discouraged from continuing the building of rock lines.

In Burkina Faso, women do not own land, they "borrow" it from their husbands. After women labored hard to treat their fields with stone line technology, many of them found that men were reclaiming these improved plots for themselves. This resulted in a negative side effect. It forced women to move again to another untreated piece of land and it discouraged them from continuing to use the stone line technology.

In Mali a cookstove program that intended to implement a low-cost technology that was fuel saving (and thus reduced pressure on the forest resource) did not succeed. The problem was the misperception of the value of fuel saving stoves to women. They valued more saving the time which is required for food preparation and cooking, rather than saving the time used for collecting fuel. Also, stoves may be used not only for cooking, but also for heating. Given that Mali women preferred a fast cooking stove to a fuel saving stove, this cookstove program had a weak response there.

In other places, such as Kenya, Senegal and Niger, fuel saving stoves had been successfully introduced. In these countries, the main reason for the success of the cookstove program seems to be their monetary economic incentives. Overall, the use of the new stoves implied a very favorable cost-benefit ratio. Even though cooking stoves costed more, they lasted longer and were more fuel efficient. As an illustration, in Kenya, the percentage difference of fuel efficiency when the new stoves were compared with the old ceramic stoves (jikos) was around 11%.

Projects that have encouraged the use of agricultural fertilizers can also serve as examples of development projects that have triggered unintended outcomes. Fertilizers are used to improve agricultural yields. Nonetheless, an unintended effect of the use of fertilizers could be the reduction on the supply of safe potable water. In turn, this negative effect over the supply of water can contribute to increase infant mortality rates and/or to expose the population to debilitating diseases that would affect their labor productivity. After this possible effect of the use of fertilizers and the supply of safe potable water, the use of fertilizers and increments in infant mortality, do not longer have a seemingly disconnected relationship.

In some areas of Zimbabwe, for instance, water sources have become polluted or contaminated by agricultural fertilizers. In these cases, the use of agricultural fertilizers to improve crop yields has had unintended effects over the supply of safe water. The shortage of safe drinkable water has, in turn, put additional constraints on women's allocation of time. Women who formerly used to get water from wells that were close to the fields have now to travel to more distant sources to fetch water. As a result, the use of fertilizers in Zimbabwe has had unintended negative effects because, women are spending more time fetching water and have less time for productive activities in the field, child care, attending school or technical training, etc.

Figure 3 provides some illustrations of intersectoral impact among the three nexus sectors. Some of these side-effects are generally considered to be negative and some are considered positive. All are both real and common. Indeed, the importance of unintended impact is widespread in Africa. This is documented in

FIGURE 3:
INTERSECTORAL PROJECT IMPACT ILLUSTRATIONS

	TO: AGRICULTURE	TO : NATURAL RESOURCES	TO : POPULATION
FROM: AGRICULTURE		1. herbicides, insecticides and fertilizer pollute surface and groundwater killing flora and fauna; 2. cropland increase leads to soil erosion and deforestation.	1. production project leads to weakened position of women and higher fertility; 2. polluted ground and surface water affects human health and reproduction.
FROM: NATURAL RESOURCES	1. watershed management / reforestation improves crop yields; 2. protected area increases predation on livestock in nearby locations.		1. forest improvement reduces perception of population pressure and fertility rises; 2. income increase from ecotourism leads to less pressure for large families.
FROM: POPULATION	1. fertility decline improves food security; 2. population increase leads to intensified agricultural practices.	1. fertility decline lowers pressure on natural resources; 2. fragile area destroyed by resettlement.	

Note: The exporting sectors are on the vertical axis and the receiving sectors are on the horizontal axis.

Appendix A, where a 10-page table displays cross-sectoral and unanticipated effects of over 55 development initiatives in Africa. This table is based on information contained in the World Bank's nexus report.

The above discussion suggests that monitoring cross-sectoral impact is important. This has been recognized since the 1970's in the case of selected health impacts of agricultural activity such as irrigation-induced schistosomiasis. But the recognition of a population-agriculture-environment nexus propels the need for intersectoral impact monitoring to center stage. And it broadens the concern and interjects the realm of social context into the monitoring arena.

2. Nexus - Project Relationships

Projects may achieve desired objectives within the target sector without having noticeable effects in the other two sectors of the nexus. But, given the tight entanglement of the three sectors, this is unlikely. The boundaries between the nexus sectors are quite permeable.

Projects may also change the target sector and simultaneously change one or both of the other sectors. Alternatively, changes in those sectors may influence the performance of the project. In some cases, the interactions may be incremental changes that bend the direction or rate of change, but in other cases, thresholds may be reached and the direction or pace of change will alter dramatically in a very short time. Or, incremental changes may accumulate until a threshold is reached and the impact promotes a crisis in one or more sectors.

Moreover, all unintended impacts are not undesirable. Agricultural success may reduce fertility and lessen pressure on natural resource stocks, for instance. But the difficulties associated with undesirable side-effects are more commonly noted. For example, investments in specific locales can create growth poles, which, in turn, increase environmental stress in those locations. Indeed, a pressing issue for natural resource efforts focussing on "buffer zones" is how to secure local livelihoods without having just such an effect. There is thus a need to identify different types of interactions between projects and their surroundings.

What we need, to guide our thinking, is a simple typology of project-nexus relationships. We need to depict basic interaction patterns and give them labels.

In what follows, we proceed to develop this typology. As it was explored in the previous chapter, a typology of project-nexus interactions will include the dimensions of time, space, and cross sectoral influences.

For the cross sectoral dimension we postulate two basic directions of project-nexus interaction and two basic types of impact. The two directions of influence are:

1. from a project to its context; and

2. from the context to the project.

Here, the word context is used as a global term that refers to material conditions and social arrangements of a project's surroundings, such as those depicted in the first chapter (for an implementation-based contextual map, see Honadle, 1994).

In the first directional mode, the project can affect the context or surroundings of the same sector and/or any of the other two sectors. In the second direction, changes in the surroundings or contextual conditions can affect the assumptions on which a project is based. This effect can also cross sectors. As a consequence, changes in the surroundings may threaten the successful implementation of a project in either obvious or subtle ways.

The two types of impact are:

1. providing feedback; and

2. crossing thresholds.

Feedback can reinforce or counteract an existing trend or condition, generally in an incremental way. A threshold, however, suggests that ongoing dynamics are altered in a major way and that the rate or nature of previous interactions undergoes a transformation. Each of these impact types may be anticipated or unanticipated. Likewise they may occur either in the target sector or in untargetted sectors, or in both simultaneously.

Combining these two types and directions of interaction gives us the basis for a typology of project-context dynamics. When a project affects its surroundings it can reinforce, counteract or modify ongoing dynamics. But when the surroundings affect the project, the project is cast in the role of bystander. Each of these types is elaborated below.

A project is a <u>reinforcer</u> if it accentuates current context bias or trends in its own sector and/or any other of the two sectors. For example, if a project to halt soil erosion actually hastened it, it would be a reinforcer.

Projects are counteractors if they have the opposite effect of project reinforcers; that is, projects smooth context bias or slow or reverse ongoing trends. And remember, the reach of a project is across sectors. So, if a natural resource management project, through the strengthening of women's groups, helped to turn around rising fertility rates, it would be a counteractor.

Projects are modifiers if they introduce new conditions or trends in any sector. For example, if a gardening project led to the establishment of a new, female dominated, marketing network for vegetables, it would be a modifier.

When the interaction is from the context to a project, projects are bystanders. That is, they are the receivers of the effects of conditions in their surroundings. It may be that conditions change during project implementation, or it may be that the projects were based upon inaccurate assumptions about initial or evolving local conditions. For example, if an NGO-dependent social forestry project collapsed due to the non-performance of local organizations, it would be a bystander.

Figure 4 captures this discussion in a visual form:

FIGURE 4
A CROSS SECTORAL TYPOLOGY OF PROJECT-NEXUS INTERACTIONS

TYPES OF INTERACTIONS	DIRECTION OF INFLUENCE		TYPE OF INFLUENCE	
	PROJECT AFFECTS SURROUNDINGS	SURROUNDING AFFECTS PROJECT	FEEDBACKS	THRESHOLDS
REINFORCER	X		X (a)	
COUNTERACTOR	X		X (b)	
MODIFIER	X			X (c)
BYSTANDER		X		X (a,b,c)

(a): Existing trend accelerated or maintained
(b): Existing trend dampened or reversed
(c): New trend or condition introduced

One dimension missing from the above presentation is time. If a project produced side-effects early on, it could then become the recipient of those effects later in its lifecycle. Thus, it would play different roles in different phases.

Indeed, the present depiction of projects as promoters of intended impact in the target sector only, makes it difficult to identify cross-sectoral impact until the project does become a bystander. But this will be examined in more detail in Chapter III.

Other transitions are also possible. For example a reinforcing feedback could reach a boundary point where it crossed a threshold. Relieving constraints in the availability of water for cultivation could create a totally new crop husbandry regime, introduce social change, and even transform aspects of a culture.

Most of the time, we cannot assume that the magnitude of influence and the ordering of side effects do not matter. This is especially true when these effects form part of the assumptions of a different project.

This typology helps to visualize and dissect the interactions between a project and its surroundings across sectors, through time, and also through space. Indeed, similar project initiatives have encountered reinforcement, counteraction and modification dynamics in different places.

For example, hybrid maize cropping projects in several African countries illustrate the importance of the space dimension. In Zimbabwe, hybrid maize was introduced directly to women and the result was a substantial increase in production. The opposite outcome happened in Tanzania. In this latter case, a woman only saw an increase in her workload while working on her husband's land. Men controlled access to the subsidized seeds, fertilizers and pesticides. 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, and needed fertilizers which affected its taste.

The typology and discussion above use the project/context dichotomy to help us label, and therefore gain some understanding of, a complex set of interactions. We are moving closer to the non-linear world depicted in the nexus studies. But the project/context separation is also artificial -- what we are witnessing is more like projects and contexts acting in concert. They may be supportive and cumulative, or they may be destructive and negative, in their net effects. But, in either case, considering projects and contexts as co-actors might help us to move toward improved practices for the application of development assistance.

3. projects as co-actors with context

The intersectoral nexus of population, natural resources, and agriculture is complex. Indeed, the linkages among these sectors are intricate and the dynamics of their interactions can take numerous configurations, as Chapter I documented.

Interactions are difficult to identify because there is a mutual interdependence between changes in one sector and changes in the other two sectors. And the nexus of interactions among sectors becomes fuzzier as soon as one sector interacts with another. When interactions are not linear and unidirectional it is far more difficult to sort out cause and effect.

But we already have knowledge of some discrete sectoral events which have been observed to affect other sectors. From our previous observations and the similar repetition of equivalent sectoral events, we can discover and explore patterns of their occurrence. Then, we can sometimes relate previously disconnected observations.

However, the dynamic conditions of the context in which new observations are occurring make us realize that similar sectoral events may take place in completely different contexts and, therefore, are not comparable. Or, on the contrary, we can learn about nexus interactions from observing apparently disconnected sectoral events but which are taking place in similar contexts.

That is, success or failure does not result from project attributes, such as many reports conclude (see Brinkerhoff et al, 1993), but rather they result from the "fit" between attributes and context. The challenge is to develop a technical assistance mode that supports contextual inquiry and an implementation style that is driven by the testing of hypotheses about both project-induced and parallel changes in the nexus of the agriculture, population and environmental sectors.

4. path-dependent scenarios

The concept of path dependency is useful for placing project outcomes in context. Path dependency means that history matters. It emphasizes that observed outcomes should be examined from a process perspective (Rosenberg, 1994). Analytical "snapshots", as noted in Chapter I, often mislead observers and produce misinterpretations of events. When observations are lifted out of the historical and social matrix that gives them meaning, they are no more than artifacts of the technology used to interpret them.

Development project outcomes, then, cannot be predicted by simply looking at prior conditions and projecting linear consequences flowing from resource injections and intended results. Rather, outcomes are a product of a combination of the sequence of events resulting from implementation decisions, the timing of their occurrence, and their scope of influence on the project's surroundings.

Moreover, the above factors are not deterministic. This is because not only do they interact with and act upon an evolving context, but also (and what is perhaps more fundamental), their evolution is idiosyncratic; the context by itself matters.

In the process of project implementation, there is an uncountable number of interactions among individuals that can affect subsequent social outcomes. In many instances, social context implies causation in terms of interactive and inseparable reactions rather than precedent or simultaneous causes which have mechanical effects. Hence, social phenomena cannot be understood only in terms of conditions that are necessary and/or sufficient under a given social context.

Thus, applying the path dependency perspective to development projects reveals that the process of interactions matters and the context matters. The starting point for serious thinking about development projects is the recognition of a range of outcome possibilities far beyond the achievement of intended objectives. The outcome that results from the implementation of a development project is specific to a particular context and to its own evolution. Thus, the indiscriminate replication of successful projects to other contexts is likely to have weak positive outcomes, and perhaps strong negative outcomes.

Traditional project design methodologies construct a single, linear scenario that shows how an injection of resources will alter a situation and contribute to a national economy. Sectoral myopia reinforces the weaknesses of such methods as it propels attention away from the probability of non-linear, cross-sectoral, outcomes and interactive impact flowing both from project to context and from context to project. The discussion above, combined with the nexus experience, suggests a need for the construction of alternative path scenarios as an integral part of the project evolution process. Indeed, when confronting the intersections of the population, environment and agriculture sectors, we see a need to rethink the linear project concept.

III.
CONCLUSION: RETHINKING THE LINEAR PROJECT CONCEPT

The previous two chapters of this report have marshalled evidence and perspectives supporting a shift in viewpoint. That shift is away from seeing a development project simply as an intervention that does or does not achieve certain intended results toward depicting it a mechanism that may induce totally unintended results as it interacts with its surroundings. And these unintended impacts may overshadow the formal objectives.

This final chapter closes this discussion by rethinking the project concept. And it outlines an alternative approach to project design and monitoring.

A. Alternative Models

To refocus the project concept, two dichotomies might prove instructive. The first postulates the abandonment of replication as a project development paradigm. The second proposes that hypothesis testing should override the imposition of solutions as the dominant implementation style.

1. replication versus contextual fit

As the previous chapters have made clear, local rules and systems for determining who gets what access to natural resources comprise a key factor in all three sectors of the nexus approach. That is, contextual considerations begin with the resource regime.

Although general categories of resource regimes have been identified, such categories are of little help to policy implementers. The variations on a theme seem infinite, and it is those variations that spell the difference between success and failure. Take the case of property rights. Much discussion of this issue promotes generalizations and obscures the variations. Sometimes this takes the form of a blanket call for "clear" or "secure" property rights. Other times it takes the form of inferring that rules found in one location apply elsewhere, without examining if, ideed, that is the case. For example, the point has been made that trees in India are state property. Thus, when a private landholder plants a tree he can create a resource owned by the state rather than himself (Chambers et al,1987). Tree planting, then, can take control of the land away from the rural dweller. This generates opportunities for corruption as forestry officials look the other way or it provides disincentives for

planting trees to ease the fuelwood shortage. But this specific practice has evolved into an assumption that the same thing happens universally.

A recent conversation with a donor official about African land tenure was riddled with questionable generalizations based on this Asian experience. Because a similar situation exists in Ethiopia, the model was assumed to be the normal one for Africa. But among the Nyakusa/Ngonde people of Northern Malawi and Western Tanzania, for example, this is not the rule governing tree ownership. Indeed, to know what the situation is, one must also know whether the trees in question are banana, cashew or other species, whether they occupy homestead or field sites, and whether the location involved is lakeshore, upland or in volcanic craters (see: Gulliver,1958; Wilson & Wilson,1945 ; Honadle,1980). In some situations, the trees remain the property of the one who planted them even years after the planter has moved away and the use of the land has been assigned to someone else by the Village Headman. In other cases, the trees go with the land. In no cases do privately planted trees automatically become state property. But to this official, the Nyakusa/Ngonde practice was simply an aberration. The attention given to the finding in India had propelled it into a norm. But it is not. The case of India is just that -- a case and not a planetary practice. What matters for environmental policy implementation is the resource decision system operating in the micro region where implementation occurs.

Wildlife "ownership" also varies from place to place. In much of Europe and Australia and New Zealand wildlife belongs to the owner of the land on which it is found. If a deer moves from ranch to ranch it transfers owners (unless it is royal game). In the United States, however, wild game belongs to the state - not the proprietor of the land. In the state of Minnesota this also extends to surface water -- the landowner owns the ground under the water, but the state regulates activity in and on the water itself. Again, the particular rules surrounding a particular resource are key.

But generalizations are popular because they support a desired characteristic in donor projects -- replicability. The push for replicability encourages the acceptance of generalizations because it fits into the drive for standardization and it enhances the illusion of organizational learning. An example comes from the Natural Resources Management (NRM) project in Botswana. This project was designed to replicate aspects of the Campfire experience in neighboring Zimbabwe. Unfortunately, the resource decision system was different in Botswana and the effects were not the same as those in Zimbabwe(Odell et al,1993). Even close neighbors exhibit diverse micro-environments. A sure recipe for failure is to replicate project characteristics without understanding the interplay between those characteristics and context.

In fact, resource decision systems continue to evolve. Just as the stability and "balance of nature" is a myth (Botkin,1990), so too the view of a constant traditional society is a myth -- all are changing. The decision systems encountered during the colonial period in Africa were evolving due to population pressure, migration and climatic cycles. They continued to change as colonial regimes attempted to freeze the traditional systems and superimpose imported legal systems and market linkages.

And change continues. Human mobility in the 1990s is far greater than it was 100 years ago. Today in West Africa migration and transient populations often result in large percentages of local populations not adhering to local rules -- they consider themselves temporary residents without a long term stake in responsible use. In other places (e.g. Malawi) refugee numbers have swelled to large proportions of the total national population and this introduces still other resource management approaches. The aftermath of civil war in places like Cambodia or Rwanda or Mozambique can be an inability to agree on what rules are legitimate. The result of all of these situations is systems in flux and chaos.

When resource decision systems are in flux they often contain pressure points where policies can be targetted to guide the direction of change. Demographic pressure, for example, can cause great changes in land tenure systems. When change is in progress, policy interventions can channel that change. But it is necessary to understand the direction of change and the reasons for it. Otherwise, policy remedies may exacerbate system failings.

The key is to understand the matrix of social relationships that guide decisions about the use of natural resources and resource products. This is a paramount element of context. And projects must be developed to explicitly state how the fit between project activity and the existing system will lead to impact, including impact in all three sectors. Indeed, the guiding assumptions will be:

- all projects intervening in any nexus sector will affect the other two sectors;
- there will be negative side effects that must be postulated beforehand; and
- if components are imported from projects elsewhere, knowledge of the reasons why those components worked elsewhere must be made explicit and the local context must be tested to judge the potential fit.

And evaluations will look specifically at the context-project fit as the independent variable in causal relations. Scopes of work, Project Evaluation Summaries and the products of funded research

will look quite different from most of those produced today. Both the findings and conclusions will contain new insights.

Project evaluations should focus explicitly on the match between project attributes and contextual factors that existed both at the time of project initiation and during the implementation phase. The fit, not just the attributes, should define the independent variable set. This agendum should guide the inquiries of the evaluation division of AID's Center for Development Information and Evaluation (CDIE). And, more directly operational, the instructions for completing AID's Project Evaluation Summaries should make this clear.

More general AID-funded research should also be fit-focussed. For example, the research agenda for the "Institutions and Policy Implementation" research team of the EPAT project is looking at the design of environmental protection institutions. But rather than just examining organizational structure and process, it is looking directly at the fit between the organizations and their contexts. (see Erickson, et al,1994) This should be the norm, not the exception, and scopes of work should reflect this shift in emphasis.

Donor country strategies need natural resource sector studies. Such studies do occur. But they should be much broader than current practice. Indeed, this report suggests that a sector analysis should spread out from the resource itself to encompass the full range of human behavior affecting it and to examine all four policy clusters to extract the role of policy in promoting such behavior. Especially indirect incentives, which by their nature will be external to a traditional sector focus, must be examined. The resource offers a beginning point, not a closed boundary, for a sector study. Any human behavior that affects a natural resource lies within the realm of the sector.

Casting a wider net is more apt to identify combinations of constraints and opportunities that add up to a singular situation. Project design, then, will flow from an analysis that isolates those unique conditions that favor success. Indeed, identifying unusual combinations of circumstances has already been associated with some aspects of success in Africa. For example, an evaluation of the Land Conservation and Range Management Project in Lesotho concluded:

> <u>Circumstances favorable to a project's success may also argue against its replicability</u>. The location of the RMA was a deliberate choice based on a unique combination of favorable political, ecological and functional factors. Because this combination of factors is unlikely to exist elsewhere in Lesotho, LCRD may be only partially replicable in other parts of the country. (Warren et al,1985:16)

Thus this assessment doubted the replicability of a project's profile within a small country, let alone between countries, regions or continents. Nearly a decade later it is time to heed the warning.

But even if AID moves away from an emphasis on replication toward an emphasis on contextual fit as an espoused operating style, there must be an operational system to reinforce the move. A system based on hypothesis testing might fill that role.

2. hypothesis testing versus imposition of solutions

It is easier to attribute leadership qualities to someone who seems to have the answers than it is to bestow them on one who has only more questions. The first we follow; the second we only consult. And projects are committments to action. They too must take the lead; they too must bring solutions, right? Perhaps, but how it is done can vary considerably. A focus on learning, adjusting, regrouping and trying again is far different from a focus on the imposition of a predetermined blueprint.

One of the dogmas of sustainable development thinking is that agricultural stagnation leads to rising fertility, whereas economic success leads to falling fertility. But there was evidence presented in Chapter I that this has not always been the case in Africa -- in some places (eg. Kenya and Rwanda) it has sometimes operated in exactly the opposite fashion. Sequences may vary and sometimes a period of higher fertility may be necessary to transit to a period of lower fertility. But the imposition of blanket policy prescriptions ignores such variation through time and space.

Policies are built upon hypotheses that if this is done, then that will ensue. Policy implementation strategies are then built on those hypotheses. Project designs are the embodiment of such sets of hypotheses. Indeed, the Logical Framework portion of each Project Paper outlines a sequence of hypothetical relationships.

But what if the hypotheses are wrong? The discussion of side effects, nexus-project interactions and path dependency in the last chapter suggested how difficult it is to be sure we are right. This is especially true when we see the intersectoral interaction of the agriculture--environment--population nexus.

The discussion of policy clusters also indicated that policy constraints outside the focal sector (indirect incentives) can invalidate the assumptions we use to develop project substance. The data base for project development must be intersectoral. Otherwise, the probability that a project will become a bystander goes up.

But, if hypothesis testing is to become a central focus rather than an occasional evaluation activity, what would be done differently? One difference is captured by the idea of reversibility. This is a concept used widely in the private sector in the area of new product development. The idea is not to go so far down the road toward a course of action that sunk costs become the driving force in determining what is done. As each committment is made, the question is asked "If this does not work out, can we pull out our resources and use them for another approach?" Phased activities, shifting mixes of short-term expertise rather than a single resource committment to a long-term staff, and rewards for learning about pitfalls and developing contingency plans rather than implementing the original designs are integral to this approach.

Moreover, failure to succeed with the original design is not punished. This is key. An emphasis on hypothesis-testing is also a capacity-building emphasis. Learning by people, groups and organizations is central to it. Making mistakes is not bad -- just repeating mistakes is bad. The rewards come from recognizing approaching thresholds, identifying parallel developments that threaten to counteract intended impact, and uncovering the emergence of (and developing plans to react to) side effects.

This would drastically alter the nature of project implementation review sessions. Typical sessions focus on achievement of intended outputs. But a nexus perspective would make cross-sectoral impact and changing context central issues.

Since AID is a wholesaler of goods and services to developing countries, AID's interaction with its contractors would change. Financial rewards would accrue to those who identified key contextual factors responsible for success or failure. This would alter both design methods and management practices.

But to discover intersectoral linkages and to test nexus hypotheses, a non-linear approach is needed. Unfortunately, AID's analytical frameworks impose linear blinders. The challenge is to move toward alternative nexus scenarios.

B. Linear and Non-linear Design Frameworks

AID and its contractors have been working for decades to develop and improve analytical methods for project design and management. Presently AID has two frameworks that it is using that are pertinent to the nexus issues.

The first is a generic design model called the "Logical Framework for Project Design", or the "LOGFRAME". This dates back to the late 1960s (it was incorporated into the agency's evaluation handbook in 1972) and is integral to the agency's programming process.

The second is a recent addition to AID's analytical tool kit. It dates to the early 1990s and focusses specifically on the natural resource arena. It is called the "NRM Framework".

Although both of these tools have positive attributes, both concentrate attention on intended impact and slight the possibility of side effects. They display both the strengths and weaknesses of linear logic. Each is discussed below.

1. The Logical Framework as Linear Thinking

The LOGFRAME depicts a chain of hypothetical linkages between AID funding for an activity and the eventual impact of the activity. There are three hypotheses connecting the four links of the chain -- (1) the provision of INPUTS will produce a set of OUTPUTS, (2) those OUTPUTS will help people to change their practices and acheive a PURPOSE, and (3) that PURPOSE will lead to an improved situation or GOAL of the project.

The jargon of the Logical Framework for Project Design is arrayed along with more specific interpretations of the terms in Figure 5. These terms make the different impact levels mutually exclusive and thus they refine and clarify the logic. Moreover, behavioral impact becomes a central emphasis as the PURPOSE of the project.

As Figure 5 shows, the hypothesized relationship between funding and goal is thus a linear set of dependent impacts. The focus is on what is intended, rather than what necessarily ensues. Impact is discovered by measuring the relationship between the level of intended impact and the level of that impact that actually was achieved. Side effects are peripheral to the logic and focus.

When performance lags behind expectations, the ASSUMPTIONS column of the LOGFRAME may be consulted to help explain what went wrong. Context may be blamed for poor performance, but the negative side effects induced by the project can completely escape notice. Evaluation activities are focussed on the gap between intended and achieved results along this linear chain. Thus the LOGFRAME encourages linear thinking.

FIGURE 5:
THE LOGICAL FRAMEWORK SEQUENCE

traditional terms

INPUT---leads to---OUTPUT---leads to---PURPOSE---leads to---GOAL

refined terms

RESOURCES	---	produce	---	GOODS & SERVICES	---	promote	---	LOCAL ACTION (behavior change)	---	promotes	---	WELFARE OR CAPACITY CHANGE

This has been criticized from a sustainability perspective since sustainable development requires the generation of successor and complementary goods and services that go beyond the original (and intended) project impact. In fact, the analogy of a starter motor versus main engine was used to show how the intended project impact related to sustained development processes (Honadle and VanSant,1985). The linear project was merely the starter motor, yet it was accorded so much attention that people began to believe it was the main engine.

But the sustainability perspective depicted the main engine dynamics as resulting from goal achievement. The nexus experience indicates that side effects can be PURPOSE-level, sectoral crossings that create negative conditions. The human behavioral responses to new goods and services in one nexus sector can lead to deteriorating conditions in the other nexus sectors. The linear, intentional focus imposed by the LOGFRAME diverts attention from non-linear impacts that may have more important consequences than the intended ones.

2. The NRM Framework as Linear Thinking

A recent addition to AID's toolkit is the NRM Framework. This was developed to link people-level impact to activities in the natural resources sector. It depicts a sequence of five levels of changes leading to impact on the biophysical foundation of development. The framework is displayed in Figure 6.

This framework is very similar to the LOGFRAME, but it specifically uses language and boxes to centralize two dimensions that are neglected by the original LOGFRAME jargon. First, it brings behavior change into focus in level III along with conditions (policies/social structure/incentives) that influence behavior in level II. That is, it makes people's participation central to agency programming. Second, it concentrates attention on the natural resource realm surrounding social action by making levels A, II and IV central to the perspective. That is, it directly incorporates biophysical considerations into development initiatives.

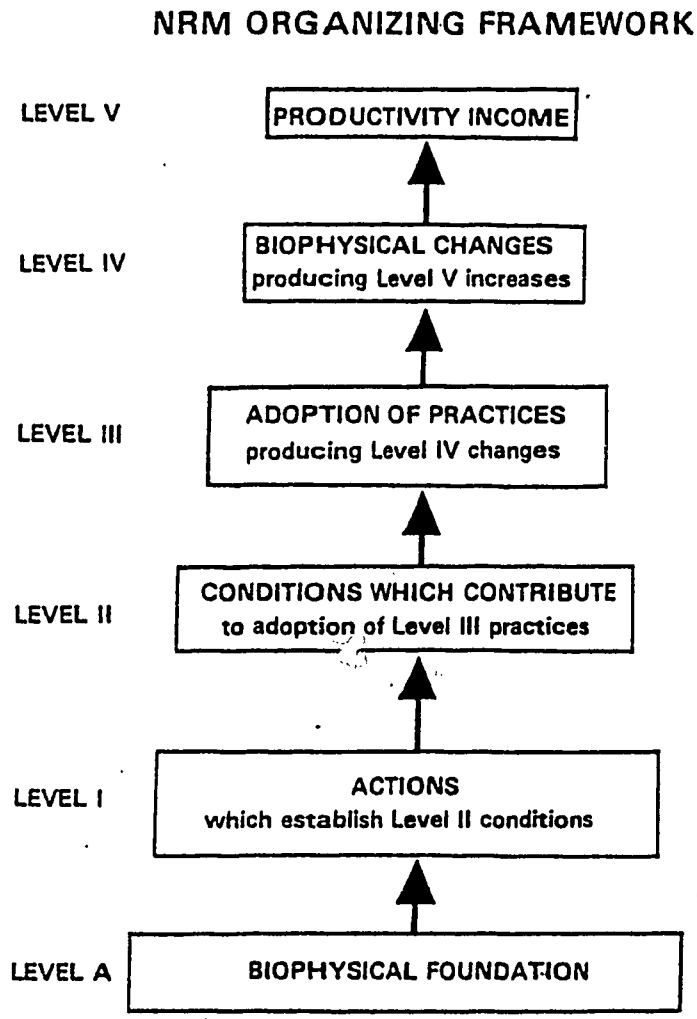
Thus the NRM Framework does incorporate some elements that are left to that peripheral category of "assumptions" in the Logical Framework. But it still exhibits the LOGFRAME weakness of a linear point of view. Examination of the application of the NRM Framework indicates that intended, single-sector impact sequences are the dominant concern (see Weber,1991). The NRM model is another example of a linear project approach.

The sequence chains integral to these two frameworks display another characteristic -- the certainty of the linkages diminishes as one progresses from the beginning to the end points. This tends to push management attention to the initial links because that is where the most control can be exerted. This exacerbates the tendency to avoid issues of side effects, indirect impact and project-context interactions.

Both of the approaches noted above have utility -- they provide simple models of project logic. They also explicitly identify the hypotheses that form the foundation for project investments. But the nexus experience suggests that their strengths need to be redirected toward a more accurate approximation of a non-linear world. Programming tools need to be adapted to the tasks of testing cross-sectoral linkages and capturing the characteristics of different contexts.

This might be done by completing parallel frameworks (LOGFRAME or NRM Frame) as part of the project design process. If the discipline of these tools were applied to alternative scenarios and non-linear chains of events, then programming might identify some of the risks identified by the nexus experience.

FIGURE 6:
THE NRM FRAMEWORK SEQUENCE



3. Alternative Scenarios and Non-linear Hypotheses

There is an inherent tension between knowledge and action. Too much knowledge often cripples action, whereas only a little knowledge makes it easier to forge ahead. Because of this, knowledge of nexus interactions implies paralysis to some observers. Since we cannot know everything, and since negative impact of some type is probable, the reaction is inaction.

And this is reinforced by some ascendant perspectives. For example, the "precautionary principle" that was endorsed at the Rio summit in 1992 suggests that it is better to err on the side of too little intervention rather than too much. Since our knowledge of natural systems is incomplete, and since many actions travel through long impact chains before we see the results, we are more likely to benefit from preservation than from transformation of natural resources.

This perspective has deep roots in the environmental community. It springs from Aldo Leopold's admonition to "save all the parts" when tinkering with natural systems (Leopold,1949). And, indeed, it has merit.

But the linear models noted above (Logframe and NRMframe) represent another tradition. This tradition was articulated by Hirschman (1967) as the principle of the "hiding hand". From this perspective, in the field of international development we always face complexity and uncertainty beyond our ken. But we still act. It is our mandate and our destiny to act and so we simplify the hurdles we face: we underestimate risk; we make "assumptions"; we "replicate"; we learn as we go.

This is certainly true of AID because AID is not primarily a research institution -- it is an action agency. Thus, the use of purposive, linear models. But the nexus experience points toward core weaknesses in linear thinking. The question, then, is one of blending an action orientation with the precautionary principle in light of the nexus findings. A possible method for doing this is the construction of alternative scenarios.

This could be accomplished using the frameworks noted above. Using the LOGFRAME, for example, three scenarios could be constructed for an agriculture sector project. One would be the intended effects, just as is now done. But the other two would show different turns of events.

Each of the others would identify impact in either the population or the natural resource sectors. The Input and Output levels would be identical to the agricultural design, but the purpose and goal depictions would show potential side-effects in each of the other sectors. And by displaying objectively

verifiable indicators at each level, the alternate scenarios would contain the basis of a monitoring system to capture negative, cross-sectoral impact. An evaluation team could then come in and test which scenario(s) seemed to be happening. And management could be on the lookout for side-effects that threaten sustainable success. In the event that positive side-effects are discovered, redesign activites or parallel investments might be able to maximize those effects.

One result of this practice would be to focus attention on the Purpose or local action level of the LOGFRAME. This would automatically incorporate women in development (WID) and people-level-impact (PLI) issues as elements of the population sector into projects in all three nexus sectors.

The NRM Framework might also be used to suggest alternative outcomes from a natural resources project. Again, the intended scenario would be displayed as it was with the LOGFRAME. The alternate scenarios would trace changes in the agricultural and population sectors by introducing unintended impact sets at levels II, III and IV. And the level II analysis would incorporate data on all four of the policy clusters presented in Chapter II of this report.

If there is knowledge of physical thresholds or feedback loops associated with certain levels of behavioral change or system conditions, that data could be used to forewarn managers and evaluators of impending changes. Indeed, CDIE's data base could be developed to provide assistance to the scenario builders -- project evaluations, sector analyses and funded research could be organized to emphasize key hypotheses about nexus interactions through time.

Methods also exist to identify and build upon contextual opportunities (see Ford et al,1993). A combination of nexus data and participatory rural appraisal approaches could improve the chances that projects will build upon context instead of importing project designs that will not fit.

This suggested approach to alternative scenarios is in some ways incremental -- it builds upon existing tools and concepts. But it is also potentially radical in its implications. We are entering the 21st century with a very different understanding of our relationship to the biophysical systems of this planet than the one that dominated the immediate post-World War II years. It is time to adjust what we do to fit what we have learned.

C. Synthesis -- Crossings that Matter

This report has ranged far and wide through experience with the population, agriculture and environment sectors in sub-Saharan Africa. The results of that trip are:

1. A questioning of attempts to replicate solutions through time and space;

2. A recognition of the importance of project side-effects in the nexus of these three sectors;

3. A preliminary typology of hypothetical project-context interactions;

4. A suggestion that the time is ripe for the introduction of an alternative paradigm into the way donor-assisted development projects are conceived and nurtured; and

5. The promotion of alternative scenarios as the foundation for developing the new paradigm.

And we have also suggested some key elements of the alternative. Indeed, we suggest that crossing through time, space and sectors creates problems for us because of the way we do our work and receive our rewards. But there are strategies for overcoming these problems.

The relationships among these crossings, problems and strategies is summarized in Figure 7. This figure identifies causes associated with the problems encountered when project designs cross time or space and when project impact crosses sectors. Likewise, it shows strategies that have been, or could be, employed to mitigate the problems.

Hypothesis testing holds promise for lessening the difficulties created by all three crossings. And alternative scenario building is a potentially useful foundation for a hypothesis-testing modus operandi in AID.

AID is facing an important historical juncture. The agency's evolution has taken it from the Point Four focus on physical infrastructure, through the "new directions" mandate to focus on social equity, and beyond the 1980s emphasis on economic liberalization to a point where simple goals seem quaint. With the collapse of cold war motivation, the emergence of a planetary human population approaching six billion, and the appearance of an information revolution, mission redefinition is inevitable. AID can either seize the moment and chart a new course or sit back and respond to the initiatives of others.

FIGURE 7:

CROSSINGS THAT PRODUCE PROBLEMS

CONCERNS	DIMENSIONS: TIME	SPACE	SECTORS
PROBLEM CAUSES	* linear projections * thresholds * unforseen disruptions * replication	* replication * assuming universality * ignoring prerequisites	* side-effects * non-linear impact * incompatible objectives
STRATEGIES	* reversibility * pilot tests * hypothesis testing	* reversibility * participation * contextual design * hypothesis testing	* monitoring * reversibility * comprehensive strategy (IRD ?) * hypothesis testing

The agriculture-population-environment nexus is at the heart of AID programming. And new knowledge in this area gives AID a chance to seize the moment. But it must be done in a way that casts off old operating styles and problem definitions. It must be based on institutional learning that recognizes shifting contexts and evolving dynamics. Hypothesis-testing offers promise for this effort.

What remains to be done is twofold. First is the adoption of a mission incorporating contextual and learning strategies. Second is the explication of the organizational, motivational and procedural implications of the changes suggested by this study. The result would be not just rethinking, but REDESIGNING, the linear project model to fit the state of knowledge of the agriculture-population-environment nexus.

APPENDIX A

SIDE EFFECTS AND CROSS-SECTORAL IMPACT: A COMPARISON OF OVER 55 DEVELOPMENT INITIATVES IN AFRICA

(Chart constructed from information in the World Bank's nexus Report)

Project	Country & Target Sector	Intended Effect (type of impact)	* Unintended Effect (type of impact)	type of influence of unintend-ded effect
Cash-crop (tobacco)	Malawi Food Security	Improve levels of Income (counteractor)	* Lowered production for own food consumption (modifier) * Lowered nutritional levels of children (modifier) * Women lost income independence (modifier)	threshold threshold threshold
Dam Construction	Guinea-Bissau Food Security	Irrigation of lands (bystander)	* Increase salinity of Bolanhas--swampy paddies (modifier) * Decreased productivity of women's labor (counteractor)	threshold feedback
Titles on land based on family ability to cultivate	Several Subsaharan Countries Food Security Stock and quality of resources	Incentives to invest on land (bystander)	* Desincentives to control human fertility (reinforcer)	feedback

Commercial-ization of woodfuels in urban areas	Burkina Faso Rwanda Ethiopia others Stock and quality of resources	Lower costs for suppliers of woodfuels in urban centers (counteractor)	* Increase the time allocated for the collection of fuelwoods in rural areas (modifier) * Substitution of woodfuels for less efficient fuels in rural areas (reinforcer) * Due to the exports of woodfuels to urban centers, there was an scarcity of woodfuels in rural areas. As a consequence, the amount of cooked meals in rural areas decreased and they were cooked less well (modifier)	threshold feedback threshold
Cash-crop	Cote d'Ivoire Food security	Increasing income opportunities for men in rural areas (modifier)	* Lower availability of male labor supply needed in female crop cultivation (counteractor) * Women cultivate in lands that need fallowing (reinforcer)	feedback feedback
Adoption of technology that was successful in a different country	Mauritania Stock and quality of resources	Prevent soil degradation (counteractor)	* Stone line technology was not adopted. The social context was not taken into account. (bystander)	threshold

Planting trees Getting support from women participation and institutions	The Gambia Stock and quality of resources	Hinder deforestation and soil degradation (counteractor)		
Cookstove programs that succeeded in other social contexts	Mali Stock and quality of resources	Save fuel (counteractor)	* Weak response. Stoves were not used. (bystander)	threshold
Lower the demand for woodfuels in urban areas	Botswana Malawi Nigeria Tanzania Stock and quality of resources	Substitute urban demand for woodfuel by kerosene, gas and/or electricity (modifier)	* Unequal urban access to alternative sources of energy. (modifier) * Urban poor still demanded woodfuel (reinforcer) * Woodfuels were cheaply supply from "open access" lands. This causes damage to the environment (reinforcer)	threshold feedback feedback
Cash-crop Mechanization Access to credit & services	Zambia Food security	new cash earning opportunities for land owners (modifier)	* increased the gender gap regarding access to markets and other resources. It only favored male headed households and not female headed households (reinforcer)	feedback

(cocoa)	Ghana Food security	Introduce new income possibilities (modifier)	* Without male help, women switched to the cultivation of other food crops. (modifier)	threshold
Cookstove programs Involving local participation	Kenya Senegal Niger Burkina Faso Stock and quality of resources	Save fuel (modifier)		
Planting trees Involving local participation	Kenya Stock and quality of resources	Overcome negative effects of changes in the hydrology caused by water abstraction for irrigation schemes (counteractor)		
Introduction of agricultural fertilizers	Zimbabwe Food security	Increase agricultural yields (reinforcer)	* Pollution or contamination of water sources that limited the supply of safe water in areas near the field. (bystander)	threshold

Cash-crops It assumed that food production was a family farm operation	Nigeria Cameroon Food security	Raise the productivity for all food and cash crops (counteractor)	* Uneven increments on the amount of labor input that was put by women (17%) in comparison to men (6%) (reinforcer) * Women had to contribute with their labor in male farms. (reinforcer) * Women were expected to carry out traditional tasks in men's fiels in addition to their cultivation for family subsistence. Project exacerbated the problem of gender division of labor and limited more women's opportunities outside the farm (modifier)	feedback feedback threshold
Increase private cost of having children	Several Sub-saharan countries Total Fertility rate (TFR)	Lower the demand for children (counteractor)	* In Kenya TFR was not reduced. Parents instead decided to ration access to education among their children. Also, educating boys may be favored to educating girls (modifier) * Women with low education and income will tend to have higher fertility rates. (reinforcer)	threshold feedback

Construction of roads	Cameroon Food security	Improve communities access to markets (bystander)	* Men spend less time helping their wives to grow food crops for the household subsistence (modifier)	feedback
Water supply	Kenya Stock and quality of resources	Participation of women in water supply projects, in the village decision-making, provide training in health, water use, pump maintenance, etc. (bystander)		
Land management and water conservation	Senegal Niger Burkina Faso Mali Stock and quality of resources	Involvement of local people in order to generate positive reactions to manage their own resources (bystander)	* Local communities were willing to change their beliefs when they think that their efforts will pay off (modifier)	feedback
Small scale water management systems	Mauritania Nigeria Chad Niger Stock and quality of resources	Involve and incentive locals to participate in the development of low-cost technologies (bystander)		

Introduce hybrid maize They were directly introduced to women farmers	Zimbabwe Food security	Increase the production of a variety of hybrid maize (modifier)		
Introduce hybrid maize Men were in charged of the subsidized seeds, fertilizers and pesticides.	Tanzania Food security	Increase the production of a variety of hybrid maize (modifier)	* It did not succeed (reinforcer)	threshold
Introduce hybrid maize	Ghana Food security	Increase the production of a variety of hybrid maize (reinforcer)	* Women were reluctant to switch to new hybrid maize variety due to its unplesant taste, were harder to prepare, were less resistant to insects and droughts, etc. (bystander)	threshold
Majjia valley windbreak project. Local people were incentived to participate	Niger Stock and quality of resources	Soil conservation and improve conditions for agricultural production (counteractor)		

Introduction of hand-operated cornmills	Cameroon Food security	Introduce a Female - targeted technology. It will be owned and operated by women (bystander)	* It involved women in other learning activities apart from the ones related to farming techniques, such as how to look after their children, to cook and make soap, to read and to write, and to do simple arithmetic (modifier)	threshold
Introduction of soybeans They were not introduced as cash crops. When women asked for small plots to grow them, men did not object.	Togo Mali Ghana Food security	Substitute the disappearance of dawa dawa trees due to deforestation. Women used to collect wood and seeds from these trees (modifier)	* Used in several dishes and as a high-protein porridge for children (modifier)	threshold
Introduction of stone line technology	Burkina Faso Stock and quality of resources	Prevent soil erosion (counteractor)	* Women were discouraged to treat their fields with this technology. After plots were improved, men were reclaiming them for their own production and forced women to move to untreated pieces of land (modifier)	threshold

Cash-crops	Nigeria Food security Stock and quality of resources	Promote market oriented agricultural policies (bystander)	* Farmers abandoned intensive farming techniques. Instead, they adopted an extensive forest-fallow farming system which was focused on cash cropping and market-oriented animal production (modifier)	threshold
Cash-crops (maize, cotton, sunflower, tobacco groundnuts, etc.)	Zambia Cote d'Ivoire Food security	Incentive the production of these products (modifier)	* Men use the better land for themselves and became less willing to allot good land to women for food cropping (counteractor) * In Cote d'Ivoire, women had to leave their own fields due to the expansion of coconut and oil palm plantations. They settled in lands cleared by loggers. Soils were not adequate for cultivation, and their farming caused environmental damage (counteractor)	Feedback Feedback

Training men as para-vets Agricultural extension workers were also involved in improving animal husbandry	Kenya Stock and quality of resources	Improve husbandry methods and sell veterinary services in order to raise the percentage of vaccinated animals (modifier)	* Extension workers taught local people water harvesting techniques which have been adopted in small farms. (modifier) * Moving from trait-taking to trait-making. Private sector and local communities have incentives to overtake and further develop their own skills and the organization of their production activities (bystander)	threshold threshold
Adoption of terraces in slopping land The government supported it by launching a national conservation program and by creating a permanent presidential commission on soil conservation and afforestation.	Kenya Stock and quality of resources	Soil conservation, increasing agricultural productivity, and tree crop diversification (counteractor)		

Adoption of agricultural machinery	Senegal and other countries Food security	Introduction of new technologies such as animal draft power (bystander)	* Increased the gap in the productivity and income inequalities between genders. In Senegal, women are the last ones in the household to use the available machinery. Machinery is first used by men in order to expand their own cash crop acreage and production (bystander)	threshold
Introduce new environmental technologies.	Ethiopia Kenya Madagascar Nigeria Rwanda Tanzania Stock and quality of resources	Prevent soil erosion and water waste (counteractor)	* Lack of success in introducing these technologies. They were developed without taking into account low-cost indigenous technology. (bystander)	threshold

APPENDIX B

PERSPECTIVES ON THE NEXUS RELATIONSHIPS: MALTHUS, BOSERUP AND CRITICS

APPENDIX B:
Perspectives on the Nexus Relationships: Malthus, Boserup, and Critics

The purpose of this appendix is to outline major theoretical perspectives that are commonly used to interpret relationships among changes in agriculture, environment and population. Graphical displays will be used to offer a unifying framework and a complement to the predominant theories.

The three sectors can be seen as consisting of three main building blocks: total fertility-mortality rate (population balance), stock and quality of resources (environmental security), and food security (agricultural sustainability). Health is not regarded as a different sector. Instead, health security is considered to be the result of the interaction among population balance, environmental security and food or nutritional security.

The analysis of the linkages among population, agriculture, and environment is established through the side effects that one sector has on any of the other two sectors. Sectoral side effects are activated when changes in one sector cause changes in another sector.

Our initial situation is one of equilibrium. That is, there are no side effects from one sector to any of the other two sectors which result in a major threat to the satisfaction of minimum subsistence levels of food production.

Hence, an equilibrium among the three sectors is a situation in which there is always food security. A disequilibrium problem will happen when changes in the fertility-mortality rate and/or in the stock and quality of resources cause problems in the adequate provision of food to the community.

Some of the potential sources for disequilibrium are presented in table 1 below. Each of the three main building blocks can have sectoral changes which may cause a disequilibrium problem. It should be noted that the building block of stock and quality of resources (environmental security) does not only refer to natural resources but it also includes human resources. This is important because socio-economic activities often require an allocation of both natural resources and people's time and effort.

TABLE 1

Basic building block (sectoral concerns)	Total fertility-mortality rate (Population balance)	Stock and quality of resources (environmental security)	Food Security (agricultural sustain-ability)
Potential sources for a disequilibrium problem	- Exponential population growth rates	- Deforestation - Soil erosion - Recycle of water - Constraints in people's time/opportu-nity costs	- Stagnation in the growth rate of agricul-tural and livestock production

Some illustrative examples of the basic relationships among the building blocks follow:

(a) Deforestation and soil erosion or loss in the soil fertility can cause lower agricultural output per hectareage (environmental security problems create food security problems).

(b) Stagnation in agricultural production can cause migrations to forest lands, which are not suitable for intensive agricultural production. Since trees would be turn down, there would be less prevention in the loss of soil nutrients. Cultivating in these lands would affect the cycle of reforestation and create ecological imbalances (food security problems create environmental security problems)

(c) The lack of access to male labor may increase the demand for children. In turn, there can be a population explosion that can cause unmet food demands and migrations to lands that are not suitable for cultivation (population imbalance creates environmental security problems, which in turn aggravates the problem of population imbalance)

(d) With lower yields per hectareage, the quality of food production can also decrease. Then, food quality can affect the levels of nutrition and, in general, health problems which, in turn, can affect the productivity of labor (food security problems and environmental security problems creates health security problems, which are reflected in further food and environmental security problems).

A stationary equilibrium is in most cases an ideal case because the building blocks are likely to be changing and adjusting to each other in order to avoid a situation of disequilibrium. Even in the case where there is already disequilibrium, the sectoral conditions under which it persists or it is turned into an equilibrium situation implies sectoral changes and adjustments.

Therefore, for the exploration of the population, agriculture and environment nexus dynamics our focus is on disequilibrium situations, the reasons for the persistance of a food insecurity condition, and how changes in the building blocks could threaten an equilibrium situation and turn it into a disequilibrium situation.

Based on the nexus report of the World Bank (Cleaver and Schreiber, 1993), it is considered that the basic relationships among population-agriculture-environment are embedded in an institutional context. Following Davis and North (1971), we regard this institutional context at two levels: a macro level and a micro level. The macro level is called "institutional environment" and the micro level is called "institutional arrangements". The institutional environment is the set of fundamental political, social and legal ground rules that supports production, exchange and distribution. The institutional arrangements are the organizational norms and rules that govern transactions between economic agents.

The institutional context and the distinction between the institutional environment and institutional arrangements is important for understanding the population-agriculture-environment nexus relationships and the different perspectives on this issue. As we will see, some authors have not explicitly considered sectoral linkages as embedded into an institutional context. Others, on the contrary, have placed more emphasis on the institutional environment and/or the institutional arrangements over particular sectoral variables.

Only recently the development literature has explicitly connected the linkages among population balance, environmental security, food security, and the institutional context. In most cases, different perspectives tend to emphasize distinct aspects of these linkages. The following exposition starts with an emphasis on the relationship between population balance and food security, and it later incorporates environmental security.

The first distinction to be drawn is between those authors who consider population, in the population-agriculture-environment nexus, to be a causally important variable and those who do not. As Kates et al. (1993) note, each of these can further be divided into two opposing camps. Those considering population to be a determinant factor include neo-Malthusians, who consider it a negative force, and Boserupians, who consider it a generally positive factor. Jolly and Torrey (1993) point out that the

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argument that population growth is threatening because it presses against finite resources independently derives from two different scientific paradigms, classical economics, beginning with Malthus, and natural science, with the concept of carrying capacity.

Many other perspectives regarding population and environment also exist. Some consider population imbalance to be more an effect rather than a causal variable. These include neoliberal economists, for whom resource constraints tend to be limiting constraints to population growth. They consider that environmental pressure from population growth could be overcome by technical innovation, capital accumulation, and market substitution of abundant factors for scarce ones. On the opposite side of the ideological spectrum are neo-Marxists, whose focus is in the institutional environment and carry on the anti-Malthusian polemic of their intellectual forebears. According to this perspective, pressure on resources relfects the distortions of the market and structured inequality in access to resources, not population growth per se.

Other writers may acknowledge population variables to be of some importance, but at a secondary level with regard to the institutional context. Generally, population growth is seen only as at most aggravating a bad situation which is caused by other, underlying factors. Marquette (1994) labels this as a "multiplicative perspective". Finally, "mediating perspectives" assume that population acts in a synergistic fashion with other variables, with both positive and negative outcomes possible and depending upon varying resource and social-political context (Blaikie and Brookfield, 1987).

The writings of Thomas Malthus (1798) and Ester Boserup (1965,1981) are often taken as polar opposites in terms of analytical reasoning about population and agriculture (neither really deals directly with the environment). In fact, the two are in some ways more alike than they are dissimilar. It is true that Malthus was a gloomy pessimist while in comparison Boserup would seem to be a rosy optimist. Malthus is well known for his assertion that population growth if unchecked can be expected to outpace agricultural growth, resulting in dearth and famine. In contrast, Boserup is known for asserting that population growth is the driving engine behind agricultural intensification, resulting in a virtuous cycle of technological change and rising living standards. The primary substantive difference which accounts for their different conclusions is that Malthus was describing a preindustrial economy, whereas Boserup's main thesis occur in an industrialized economy.

Boserup's hypothesis postulates a connection between total fertility-mortality rates and food security. It says that increments in the population growth rates may lead to either a more extensive agricultural production system or to promote agricultural

intensification in order to meet subsistence needs. When there is available land, population growth that creates pressure over the land leads to the assimilation of unused land into the traditional farming system. Namely, there is an extension of the traditional production system in order to accomodate the food demands of the growing population. When there is not more available land, however, and when there is technical know-how, then the response to population pressure results in agricultural intensification.

Agricultural intensification indicates the adoption of new agricultural techniques that increases the productivity of labor per unit of time, or equivalently, the amount of output per unit of land. Agricultural intensification is not only a process whereby land becomes more intensively cropped, it is also a process that tends to require more labor effort per unit of time and more hours of work as to maintain soil fertility, including organic and inorganic fertilizer as well as anti-erosive measures.

Based on Robinson and Schutjer (1984) and Lipton (1990), figure 1 illustrates the Boserup model. The model assumes a subsistence community which main productive activity is agriculture and they produce a set of food products. The social stratification is not very unequal in terms of income and output per worker. Technical progress is endogenous and population growth is exogenous.

The community strives to maintain subsistence. In response to population growth, the community attempts to increase its food production. The line OA, in figure 1, is labelled a subsistence line which indicates a proportional level of food production that is required in order to keep a balance between population growth and food production; that is, no population pressure over land. The production of food follows a certain technique which transforms labor effort (input) into crop production (output). This initial production function is labelled Q(0), which can represent, for instance, a long fallow technique. Initially, the population index is at P(0). With the production function Q(0) and its required amount of labor effort, the production of food is indicated by N on this production function, which is above the subsistence line OA. Hence at N, there is not population pressure over land.

However, continuous increases in population can create population pressure over land. This is illustrated by movements along the production function Q(0). At point P, the production of food falls below the subsistence line OA and, therefore, there is population pressure over land. In this situation, movements along the same production function, which represent a technique, cannot be sustained by with continuous increases in the population. This can happen because, in the process of extension of the agricultural production system, land expansion may have incorporated land of with lower quality attributes, which in turn affect the productivity of labor and, therefore, the total increments in the

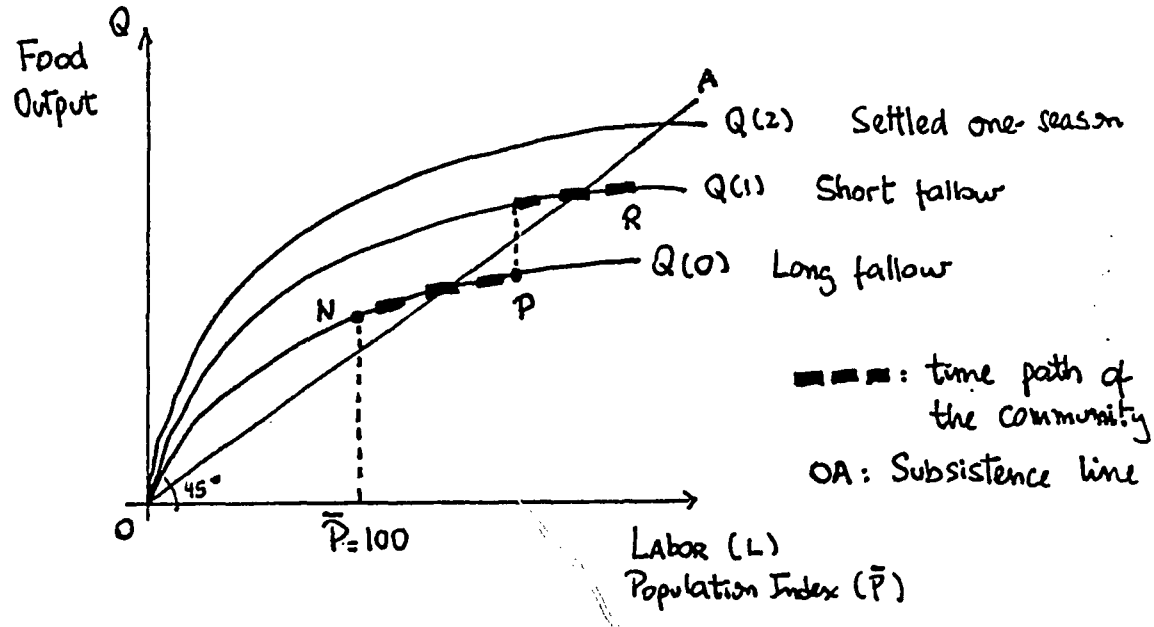

FIGURE 1: BOSERUP THRESHOLDS

production of food. The movement along the long fallow production function implies that some people are below the acceptable levels of food intake.

In figure 1, point P represents a threshold, P is a point in which the community is driven to adopt a different technology in order to restore subsistence levels. Hence, thresholds are situations in which the community cannot longer sustain more people under the food subsistence level. Q(1) is a different production function which renders more output with the same amount of labor effort, for example, a short fallow technique. If population growth continues, then the same described process will be repeated. Thus, point R represents population pressure over land under a short fallow production function. Then, according to Boserup's hypothesis, when thresholds are reached due to population pressure, there would be agricultural intensification.

Abundant evidence has been produced that increased population density is associated with increased frequency of cultivation, just as Boserup stated (e.g., Pingali et al., 1987). Consistent with Boserup's expectations, Ibo farmers in the area have coped in part with population increase by decreasing the duration of fallow and by expanding the extent and intensity of permanent cultivation on compound farms near the households (Goldman, 1992; 1993). The fact that these adaptations have not succeeded in maintaining crop yields, let alone increase them, is inconsistent only with Boserup's optimistic conclusions, and not with her theoretical perspective or historical events.

Other alleged examples of adequate Boserup processes are the well-known cases of small pockets of high population density which exist in isolated islands (e.g. Ukarara island in Lake Victoria) or mountainous regions (e.g. Jos Plateau of Nigeria and the Mandara mountains in Cameroon). Due to the protection afforded by the terrain from slave raids during the precolonial era, these small and isolated populations were obliged to adopt labor-intensive cultivation practices in order to feed themselves from scanty land resources. However, these examples are of little relevance to the evolution of adaptive agricultural strategies in large-scale populations living in open systems.

To clarify why Boserup's conclusion may not hold we come back to the process described by figure 1 which illustrate Boserup's hypothesis as a threshold mechanism. Threshold points are indicated by points P and R, and they indicated a disequilibrium situation. In the process of figure 1, however, there is implicitly an institutional context which constraints the behavior of the community. Hence, slow responses from the community to adapt a new production technology may cause inadequate technological adjustments to population growth, or there can even be an institutional inertia which could reverse the process; an

equilibrium situation may be converted into a disequilibrium situation.

An inadequate Boserup process is a disequilibrium situation, specifically, it is a situation in which a disequilibrium situation persists as a disequilibrium situation. On this regard, contrary to neo-Malthusians we should emphasize that a persistent disequilibrium situation does not necessarily imply a tendency towards a more severe population pressure over land or an impending environmental collapse.

Possible inadequate Boserup processes are illustrated in figure 2. In one possibility, the time path of the community is most of the time (as it happens in the case slow adjustment responses from the community) below the subsistence line. At some point in time, the adoption of a technology cannot overcome the problem of population pressure over land and, as a consequence, there is persistence of a food insecurity condition (a disequilibrium situation). In another possibility, point S in figure 2 represents a case in which a community with a growing population but with the possibility of migration ends up abandoning the use of a more intense agricultural technology (e.g. Netting et al., 1993; and possibly the aforementioned case of Ibo farmers which have had an increasing reliance on nonagricultural sources of income).

A situation in which there can be an inadequate Boserup process is raised by the criticisms that her model can be expected to work only under the slow population growth rates which have been observed historically. It is often questioned whether the speed of institutional and cultural adjustments required for truly intensive cultivation may be realized in just decades rather than over generations (Harrison, 1987; Pingali and Binswanger, 1988; Ho, 1990; Cleaver and Schreiber, 1993; Clay et al., 1993). This is an empirical question, and the evidence is mixed. In a number of cases, institutional context adjustments such as changes in the structure of land holdings, sex roles, and work patterns seem to have evolved quickly enough to allow agricultural intensification to keep pace with population growth.

In the case of land tenure, the emerging consensus seems to be that changes toward de factor individualized tenure are very widespread, presumably induced by land scarcity as a result of population growth and market demand (Migot-Adholla et al., 1991). With regard to the adoption of soil conservation practices, though spontaneous adoption appears to be too slow in most cases. Hence, a combination of economic incentives and diffusion of soil conservation practices could be neeeded (Harrison, 1987).

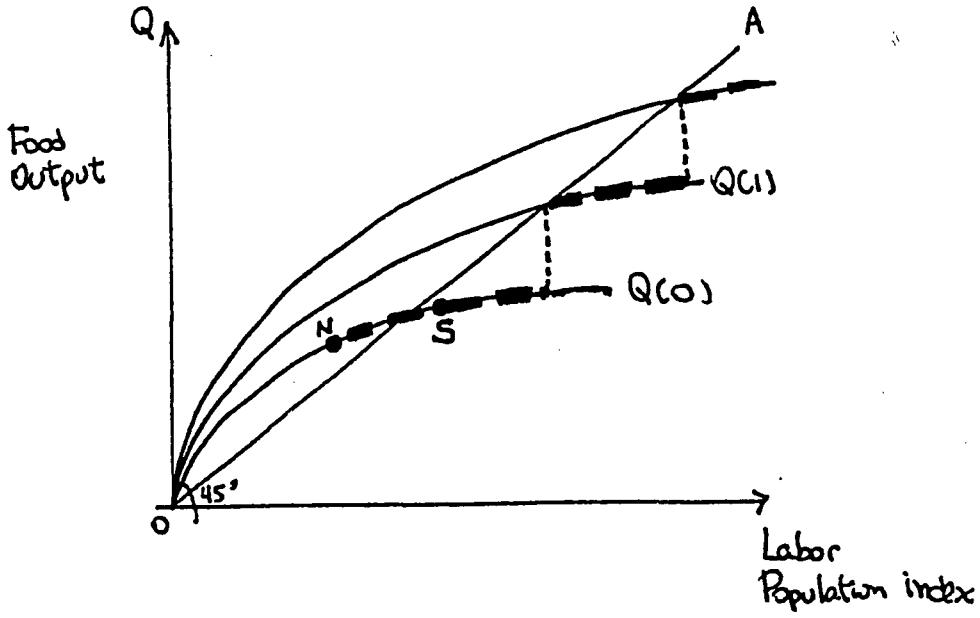

FIGURE 2: INADEQUATE BOSERUP PROCESS

Another example that highlights the importance of the institutional environment, which is associated with some of the worst environmental degradation in Africa, is found in southern Africa inareas set aside by British colonialists as labor reserves (Repetto and Holmes, 1983). Whether such severe degradation would have occurred in the absence of racial discrimination and oppression will never be known. What is known is that all local attempts at ecologically sustainable development were systematically squelched in order to oblige male populations to offer themselves as migrant wage laborers. To blame the resulting land degradation on population pressure is both partial and misleading. On the other hand, to blame the historical past without recognizing the overpopulated present can be dangerously myopic.

An important question is whether more intensive land use patterns allow for an improvement in living standards. Boserup (1965), Pingali and Binswanger (1988), Lele and Stone (1989) have argued that the availability of both industry and science based inputs and nonagricultural employment can help agricultural intensification to improve labor productivity and living conditions. Nonetheless, even under these circumstances, the institutional context should not be taken for granted.

In the absence of modern inputs, induced agricultural intensification is typically just a means for a population to tread water in terms of striving to keep up with demographic growth. In preindustrial societies, such as Java after 1800, intensification induced by population growth is noted by Boserup to have resulted in worsening living conditions and nutritional deterioration. Geertz (1963) made the same observation regarding Java, a situation which he referred to as 'agricultural involution'. Thus, contrary to a widespread misunderstanding, Boserupian intensification and Geertzian involution are not conceptually distinct phenomena.

Agricultural involution may occur even with agricultural intensification due, for example, to the lack of better irrigation technologies, land fertilizers, and resource management techniques. In this situation, not only there would not be a significant and sustainable improvement in the production of food, but also, there will be a decrease in the nutritional quality of the food produce. Lowering the nutritional value of agricultural products affects our perception of what amount of food that it is considered adequate to maintain a subsistance level. Thus, agricultural intensification is not incompatible with nutritional deterioration and it can actually exacerbate the problem of an inadequate Boserup process. On the other hand, the reverse is also possible. Agricultural intensification with the availability of modern inputs can improve the nutritional value of food production and, therefore, less the problem of an inadequate Boserup process.

Interestingly, Malthus (1798:24) also foresaw that increased population pressure generally results in more intensive forms of cultivation. And he foresaw a similar outcome as that described by Boserup under the same preindustrial conditions: technical change and land improvement could at best only keep up with population growth. Further, population growth under Asian conditions is said to have typically resulted in falling living standards and dietary degradation. What Malthus did not foresee was the industrial revolution.

Lagemann (1977), describes a situation of agricultural involution and slowly declining productivity in southeastern Nigeria. In this region, however, environmental collapse has not occurred despite numerous predictions over the las six decades that it would do so (Goldman, 1992). In fact, this situation is quite compatible with an inadequate Boserup process. Generally, an inadequate Boserup process or the persistance of a disequilibrium situation does not necessarily imply a tendency towards a more severe population pressure over land, an impending environmental collapse, or a health status improvement.

To illustrate the two possibilities of a disequilibrium situation with higher and lower health status we depict in figure 3a the case of nutritional deterioration which exacerbates the problem of an inadequate Boserup process, and in figure 3b the case of improving the nutritional value of food which lessen the problem of an inadequate Boserup process. The subsistence line OA is not independent of the quality of the inputs used during the production process. Thus, OB represents a subsistence line which worsens the problem of population pressure over land and, OC represents a subsistence line which moderates the problem of population pressure over land. In general, a deterioration in the quality of the resources used during the production process would affect both the subsistence line for a community and the productivity of a production technique. In turn, this latter assertion calls our attention over the other building block in table one, environmental security.

The stock and quality of resources could also create a disequilibrium problem. The output of a production function depends on the quantity and quality of the resources used as inputs. Then, production functions are not only dependent on labor, but also, on the stock and quality of the resources. With a decline in the quality of resources, the production function becomes less effective in terms of output produced and its nutritional value.

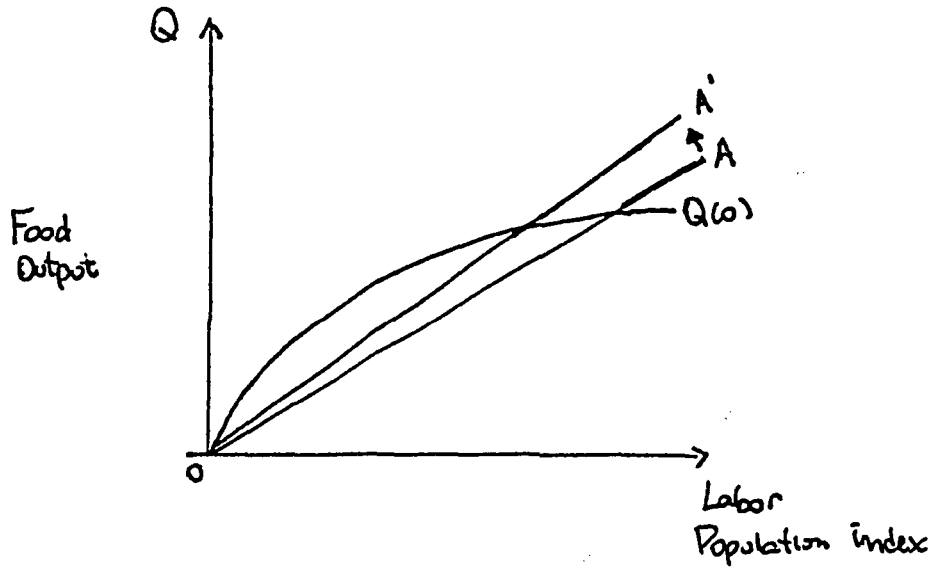

FIGURE 3a: health status deterioration

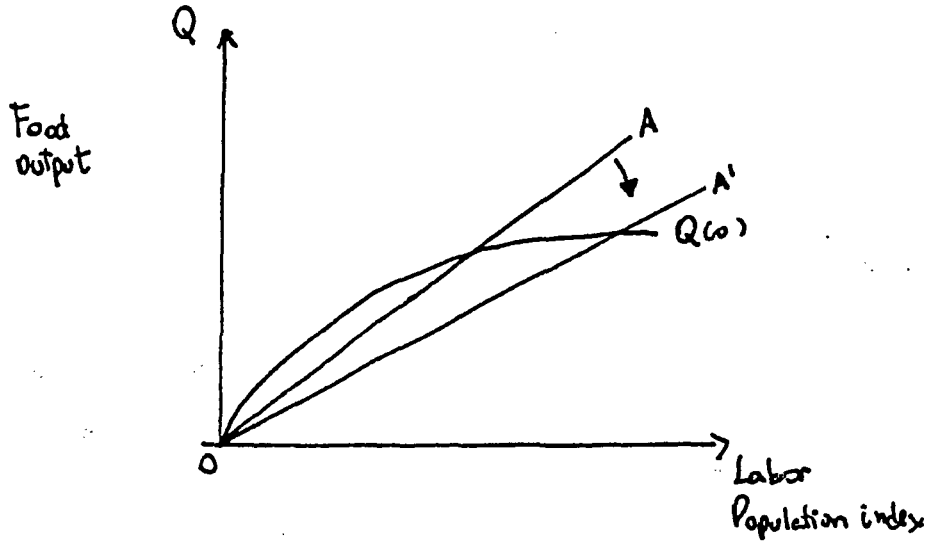

FIGURE 3b : health status improvement

The above situation is illustrated in figure 4. A lower nutritional value is reflected by OB, and the decline in the actual production by the breakdowns of the production function. For this case, the time path of the community can reach a disequilibrium point much faster than expected. Point T in figure 4 represents an inadequate Boserup process due to health status deterioration and lower output produce from the production function. Indeed, disequilibrium problems could further be aggravated by environmental security problems.

Contrary to deterministic models, we have tried to encompass different perspectives in one common analytical framework in order to avoid myopic and simplistic interpretations of the nexus experience. Different institutional contexts lead to different paths or distinct timing responses from the community. This finding highlights the importance of thresholds, disequilibrium situations, and institutional processes in the nexus among agriculture, environment, and population/health. This is relevant to the implementation of development projects because they affect, and are affected by, thresholds and processes, and because their unintended effects may create disequilibria in the system.

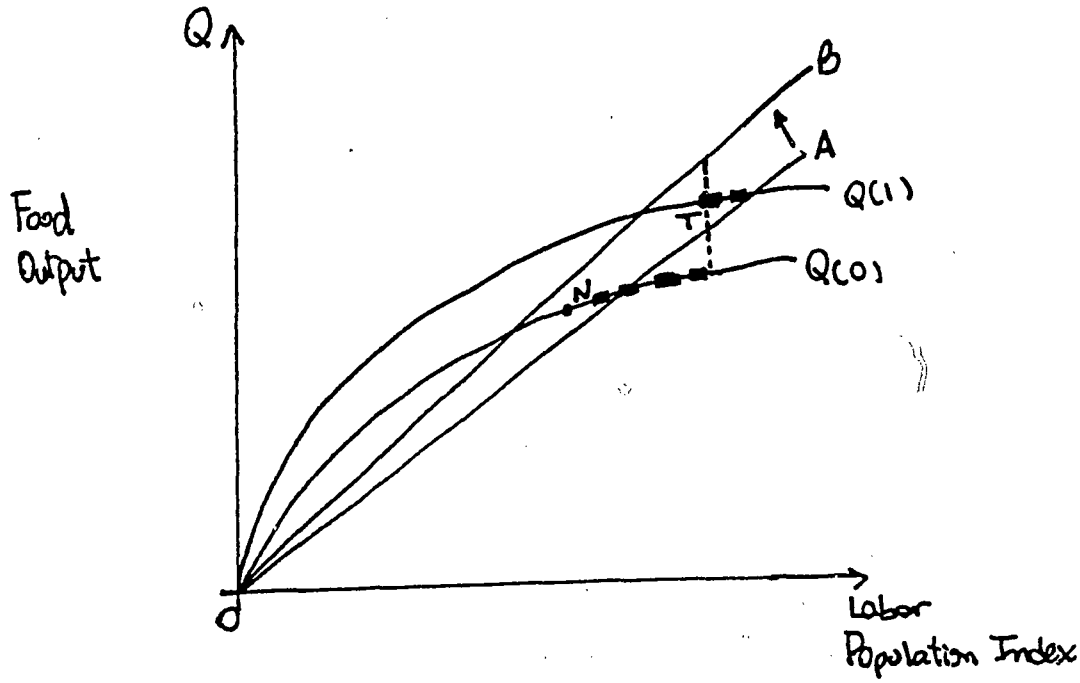

Figure 4 : Inadequate Boserup Process in the nexus of Population balance - Environmental Security and food security

APPENDIX C

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