THE LIMITS TO GROWTH DEBATE AND FUTURE CRISIS IN AFRICA: A CASE-STUDY FROM SWAZILAND

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ABSTRACT

Although projections of future human and environmental crisis in subSaharan Africa caused by population growth beyond resource limits are common, they are often criticized due to their weak empirical or theoretical basis. This paper attempts to predict whether in 2000 AD there will be adequate cropland, grazing land and fuelwood reserves for a study area located in rural Swaziland. The objective was to establish the likelihood of future crisis, as well as to provide empirical evidence pertinent to the underlying theoretical debate about the relative significance of physical limits to growth. Data used for the study include past and recent aerial photography and census information, plus a field environmental assessment and household survey. Based on this information, projected year 2000 resource constraints for the study area range from minimal (in the case of fuelwood reserves) to extreme (in the case of livestock grazing areas). Other factors, however, such as unequal cropland allocation, household shortages of labour, and privatization of fuelwood supplies, have been found either to exacerbate these constraints or hinder rural resource utilization in the absence of significant physical constraints. A comparison of this study with the United Nations' *Potential Population-Supporting Capacities of Lands in the Developing World* (see Higgins, *et al.*, 1983) suggests that the UN projections, based on highly optimistic assumptions and little empirical evidence, are essentially meaningless. Although the results lend some support to the application of the limits to growth scenario to rural Swaziland, the classic 'overshoot and collapse' trend associated with that scenario is called into question. The results ultimately suggest that neither the Malthusian emphasis on physical constraints nor the Marxian emphasis on social and political constraints can be dismissed outright in research and policy related to future crisis in subSaharan Africa.

KEY WORDS Limits to growth debate Crisis in Africa Population-resource projections Swaziland

INTRODUCTION

Overview

The limits to growth debate is not new: Malthus' 1798 *Essay on Population* has ignited controversy for years (Pavitt, 1973; McCutcheon, 1979; Woods, 1986; Wrigley and Souden, 1986), yet recent computer model-based projections of impending human and environmental crisis have certainly fanned the flames. The progenitor of these projection studies was published as *The Limits to Growth* (Meadows, *et al.*, 1972); a more recent example can be found in the United Nations' *Potential Population-Supporting Capacities of Lands in the Developing World* (Higgins, *et al.*, 1983). These, and related works, have provoked lively debate on their assumptions and implications (for example, see: Oltmans, 1974; Repetto, 1986), as well as critiques ranging from thoughtful (e.g. Freeman, 1973) to vehement (e.g. Simon and Kahn, 1984).

The limits to growth debate is particularly applicable to areas in the developing world such as subSaharan Africa, where local resources are still essential for the provision of basic human needs such as food and energy (UNEP, 1981), and where projected population growth rates up to and beyond the year 2000 are among the highest in the world, at 2·5 to 4·0 per cent per annum (World Bank, 1986). It is commonly claimed that population pressure on resources in Africa is already serious, and that human suffering and environmental degradation can only be expected to worsen in the future without immediate intervention (de Vos, 1975; Eckholm, 1976; Ahmad, 1985; Brown and Wolf, 1985; FAO, 1986). Yet few empirically based studies have been done to establish the likelihood of these ominous projections or to satisfactorily establish the role played by resource constraints in rural Africa.

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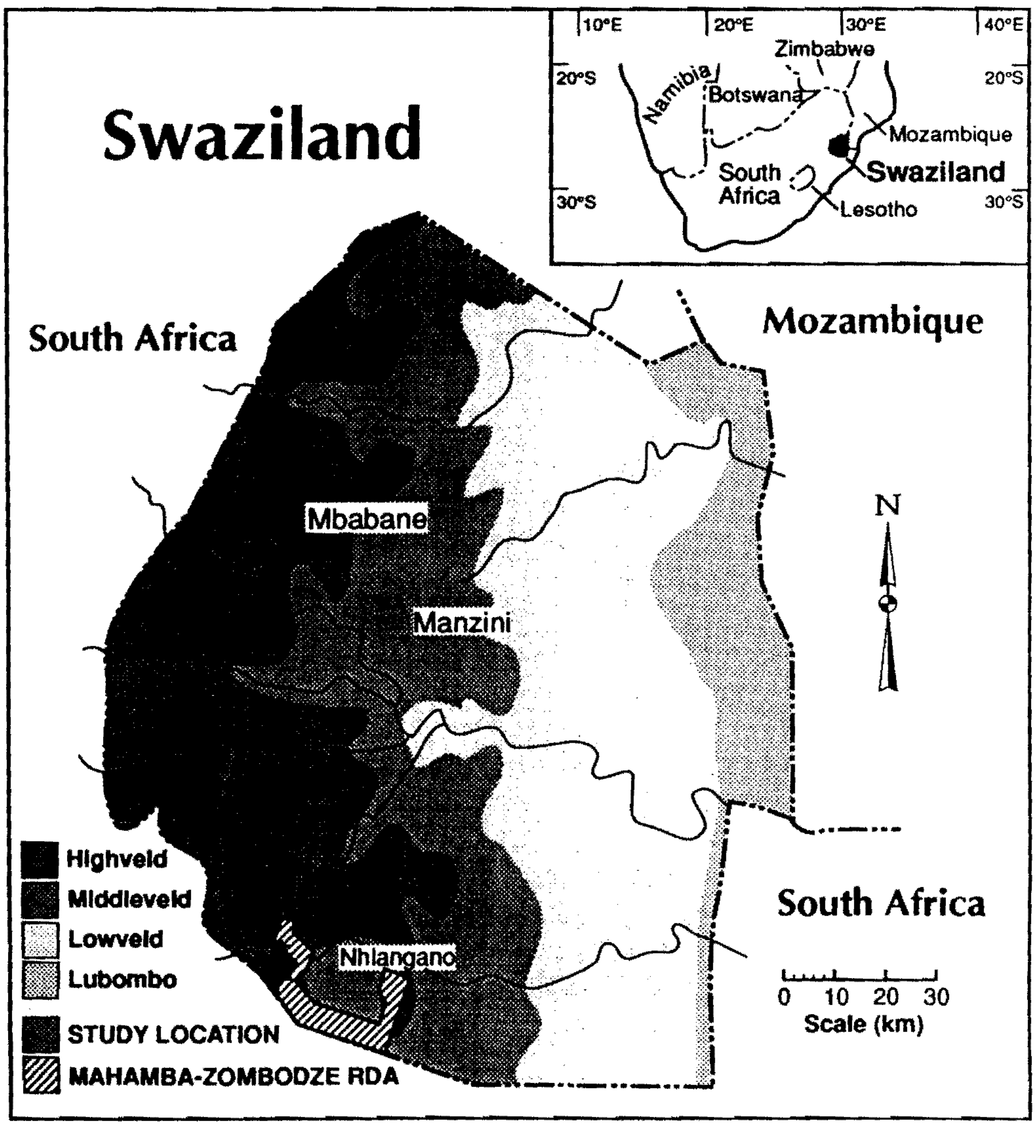
Swaziland is typical of subSaharan Africa: although severe, Ethiopian-scale problems have not been reported. Recent country-wide environmental assessments (USAID, 1980; UNEP, 1985) suggest that escalating demands have resulted in serious and widespread impacts on land-based resources essential to the rural economy. In addition, with a projected population growth rate of 3·3 per cent per annum (World Bank, 1986: 88), conditions in rural Swaziland will probably get even worse in the future. Is such a scenario of future crisis probable? How serious are these physical threats to the rural economy, given that pressing social and economic concerns will exist as well? The objective of this paper is to address the likelihood, and relative significance, of future crisis in rural Swaziland due to population growth beyond resource limits, and to use this information to reassess the limits to growth debate in the context of rural resource use in Africa.

Scope and methodology

The geographical scope of this analysis is quite limited, although the range of resources included is relatively broad. These two study characteristics require some explanation. First, even in a country as small and culturally homogeneous as Swaziland, the high degree of variety in physical conditions and settlement precludes any generalizable answer to the foregoing questions. This study focuses on a site in southern Swaziland (see Figure 1), chosen for its location in the upper Middleveld (one of Swaziland's regions of most concentrated rural settlement), and for the relative abundance of data collected for the site under the Swaziland Rural Development Areas Program, and because of my familiarity with the region arising from a US Peace Corps assignment in southern Swaziland in the early-1980s.



production, and ignore other critical land-based resources, as well as their interrelationships. In rural Swaziland, cropland, rangeland, and woodland resources are all important, and interact in significant ways. For instance, local fuelwood sources are essential for food preparation, and livestock grazing needs may compete with staple crop production on the limited land. All three resources are therefore included in this analysis.

Three methodological features should also be stressed. First, the study's future (year 2000) projections are based on known historic trends in settlement, land use and resource quality, arising principally from analysis of aerial photographs taken between 1947 and 1984, and population data for the five census enumeration areas comprising the study site for the period 1966–1986. Second, these projections are of two types: (a) *theoretical resource adequacy*, based on optimum land utilization and high resource productivity estimates, and (b) *realistic resource adequacy*, based on known land use and resource productivity. The difference between these two suggests limitations in existing resource-utilization practices, as well as indicating whether projections based on theoretical assumptions (such as those in Higgins, *et al.*, 1983) are realistic. Third, a field environmental assessment and household resource-use survey, conducted in a portion of the study area during July and August 1988, provides an empirical comparison with these projections as well as a check on several underlying assumptions; it also addresses the wider question of the significance of physical constraints to household resource utilization relative to perceived social and economic constraints at work in rural Swaziland.

BACKGROUND

The debate over limits to growth

The limits to growth scenario. A relatively consistent picture is presented in many discussions of population pressure on resources in the developing world. By focusing on demographic growth and associated demands on the natural environment, the limits to growth scenario implicitly ranks physical constraints above social or political factors affecting human uses of the environment. This scenario often predicts impending human and environmental crisis, arising from demands on resources in excess of their sustainable productivity.

The limits to growth scenario does not of course receive universal support. Opponents, who label this position as essentially neo-Malthusian, range from those who place faith in economic growth and human adaptation, to others who, from a very different (often Marxist) perspective, stress that economic and social forces are responsible for resource crises (Sandbach, 1980: 202–223). Despite their theoretical differences, however, these two extremes are uncomfortably united in their opposition to neo-Malthusian cries for population control and heavy-handed environmental management (Blaikie, 1986).

The global debate and local-level resource use. The limits to growth 'battle' has generally been fought at an extremely large scale: global projections such as *The Limits to Growth* and *Global 2000* have been met with counter-projections such as *The Next Two Hundred Years* (Kahn, *et al.*, 1976) and *The Resourceful Earth* (Simon and Kahn, 1984). While this scale of treatment may be useful in order to analyze components of the debate, such as the state of global mineral reserves, it is of little or no value when applied to rural resource use in the developing world, which requires that greater sensitivity be shown toward local physical and social conditions. Results obtained from large-scale analyses concerning the status of critical natural resources in the developing world tend to be true only at a general level (at best), and are practically un-applicable (Thompson, *et al.*, 1986). The debate over the relevance of physical limits to growth in the developing world will therefore probably never be resolved in some universally applicable way, since, in all likelihood, resource constraints play a greater role in some regions than others.

Population-resource projections for Africa

Early studies. Computer-based projections of population growth and future demand on resources have generally been global in scope, although they have advanced in complexity and regional specificity in recent decades. Three of the best-known studies dating from the 1970's include: *The Limits to Growth* (Meadows, *et* *al.*, 1972) and *Mankind at the Turning Point* (Mesarovic and Pestel, 1974) commissioned by the Club of Rome, and the Council on Environmental Quality and the Department of State's *Global 2000* study (1980). Although the latter two studies made dire projections of environmental and social crisis awaiting Africa in the twenty-first century, these projections were based on limited data input and therefore cannot be regarded as reliable.

Recent food projections. More detailed models of population and resources for Africa have been developed during the 1980s. The scope of these studies has generally been more limited, focusing on recent food production and consumption statistics in order to project future food sufficiency. Two notable studies concluded that Africa's rapid population growth rate will exacerbate existing food shortages by the twenty-first century, placing the continent in one of the world's worst positions in terms of food sufficiency (FAO, 1981a: Table 5; Paulino, 1986: 10–11). A more recent study (Mellor, 1988) demonstrated that a widening gap exists between human needs and food production in Africa. None of these studies, however, considers the impacts of escalating resource demand on the physical environment.

The UN study. Perhaps the most ambitious population – resource study to date is the United Nations' *Potential Population-Supporting Capacities of Lands in the Developing World* (Higgins, *et al.*, 1983). This study was intended to provide a relatively detailed theoretical projection of the adequacy of land resources to feed the growing human population until the year 2000. Soil and climate data were used to divide the developing world's land resource base into agro-ecological cells (over 35,000 for Africa). Potential crop productivity was then determined for each cell, assuming three levels of inputs, ranging from low (i.e., no fertilizers, pesticides, or mechanization) to intensive management. Results were aggregated for each country, and compared with food demands. Although the African land resource base was found to be adequate, to feed the continents' population projected for 2000 AD, even at low levels of inputs (assuming the availability of large food surpluses in sparsely-populated countries like Zaïre), the outlook changes dramatically when national self-sufficiency is considered. At low inputs the prediction is that 29 of the 51 African countries could not feed themselves by the year 2000 (only four would not be self-sufficient at high inputs).

Criticisms of population – resource projections. The aforementioned studies have not been without their critics (Cole, *et al.*, 1973; Cotgrove, 1982; Soroos, 1985), some of whom have countered with alternative optimistic future projections (Kahn, 1976; Simon, 1981; Simon and Kahn, 1984). The recent UN study (Higgins, *et al.*, 1983) has received mixed response: supporters include Hendry (1988: 17–18), who cited the study to bolster his hybrid neo-Malthusian/'technological fix' position on the limits to growth debate, and Srinivasan (1988: 11–14, 26), who, from a very different ideological perspective, argued on the basis of more optimistic results from the study that proponents of fertility control in the developing world were mistaken.

Critics of the UN study appear more numerous than supporters. In a review, Gilland (1984) found the analysis quite unrealistic, arguing that it assumed all potential cropland would be devoted to food production, that projected fertilizer application rates equal to five-times current world use would occur, and made use of dietary consumption estimates roughly half that of more conservative estimates. Hekstra and Liverman (1986) observed that while impacts on the environment, (particularly desertification), were not adequately modelled, the most serious problem involved a general lack of sophistication regarding social and economic constraints on food production, a criticism also made by Blaikie and Brookfield (1987: 29). Grosjean and Messerli (1988) proposed a modification of the UN study for mountainous regions of Africa: the general conclusion following their study was that, for much of the steeper-sloped regions of the continent, soil constraints render less land available/suitable for long-term cropping than was estimated in the UN study. These theoretical and methodological weaknesses severely limit the UN model's performance.

Future projections for Swaziland. Swaziland is typical of many developing countries, in that the only existing resource projections concern staple food (in this case maize) production. According to the UN study, 89 per cent of the projected 2000 AD population could be fed with low inputs to agriculture and 6·9-times the projected population could be fed if there were high inputs (Higgins, *et al.*, 1983: 137). These results should be compared with Grosjean and Messerli's analysis, which ranks Swaziland in the top 15 per cent of the continent for mountainous terrain. Following their methodology, only about one-third of Swaziland's land resource base can be seen as essentially constraint-free; fully 50 per cent must be removed at any one time for [illegible] productive (Grosjean and Messerli, 1988: 119). Thus, significantly less

Swaziland looked explicitly at the maize industry and food requirements up to the year 2000 (FAO, 1984), concluding that by the end of the twentieth-century production would meet only 92 per cent of the country's maize requirements, with large deficits in every ecological region except the Middleveld.

Several significant limitations plague these analyses. First, their emphasis on national-level self-sufficiency obscures household-level security, since it is not known whether fewer Swazi households will have to purchase maize in the future, even though there might be greater overall productivity. Second, other critical uses of the land resource base are not addressed. For instance, what constraints will be faced in the pastoral economy due to conversion of arable rangeland to cropping? Will fuelwood supplies be adequate, or will they suffer as a result of land clearance for cropping? And finally, the neglect of environmental impacts calls into question the estimates of long-term resource productivity. The future adequacy of Swaziland's rural resource base to meet critical human needs thus requires more clarification than has been provided to date.

ANALYSIS AND RESULTS

Study area: current conditions and historical changes

Location. The study area is a 37 km^2 portion of the Mahamba-Zombodze Rural Development Area (RDA), located in southern Swaziland in the Shiselweni administrative district bordering South Africa (see Figures 1, 2). The study area is divided into five separate enumeration regions used for the 1966, 1976 and 1986 population censuses as well as the 1983-84 nationwide agricultural census. A paved road runs through the study area connecting the nearby town of Nhlangano (population 3,600) to the Mahamba border post.

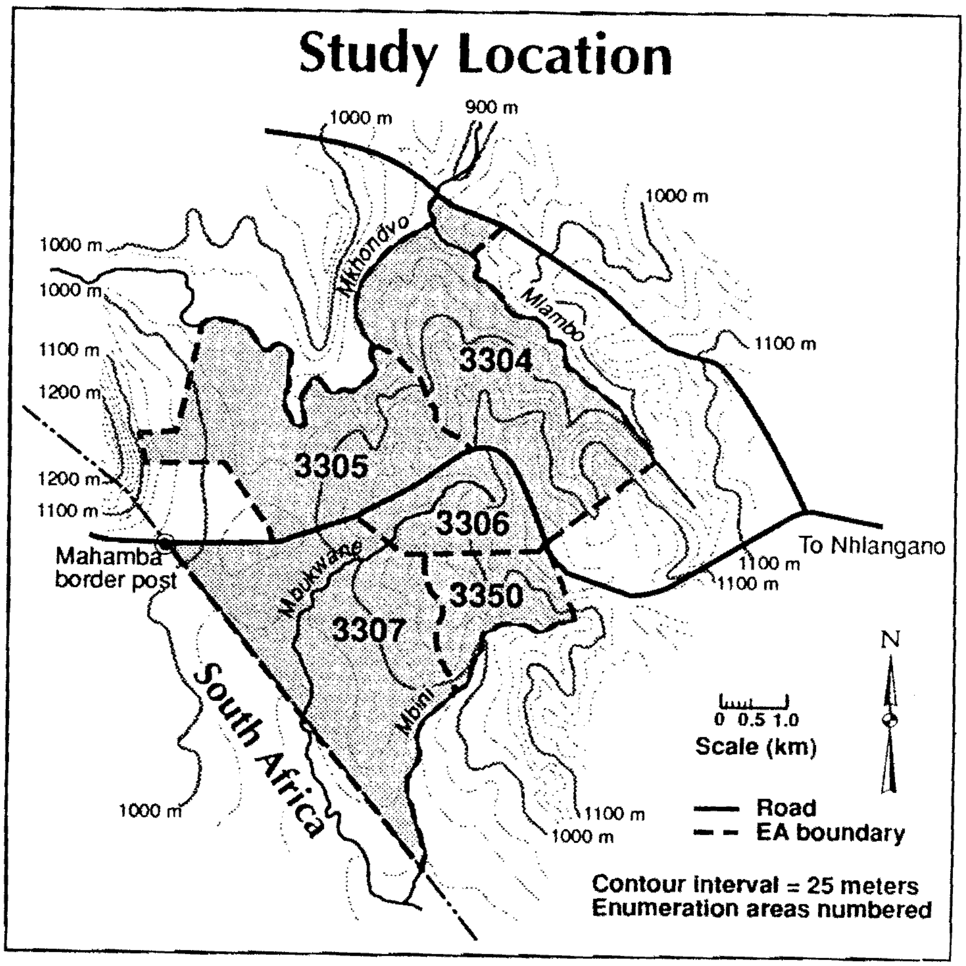


Figure 2. Study location, showing census enumeration areas (EA)

Nhlangano has grown considerably in recent years, and has attracted working-age migrants to the region (Van der Post, 1985). Absenteeism (chiefly due to male migrant labor in South African mines) is still high despite some decline over recent decades (Goudie and Price Williams, 1983: 48).

Physical characteristics. The study area lies on the Middleveld–Highveld boundary at an elevation of 920–1,180 m; it is largely underlain by granite and metamorphic Pongola Supergroup Quartzite (Hunter, 1966), which yield slightly acidic, shallow sandy soils (Murdoch, 1970: 15). The terrain is hilly with granitic rock outcrops common on summits; slopes range from 2·0 to 30 per cent. Figure 3 gives long-term monthly averages for precipitation and temperature at Nhlangano; the range in precipitation over the period 1935 to 1986 ranges from 505–1,474 mm per year. The study area is characterized by relatively low rainfall erosivity compared to other Middleveld and Highveld locations in Swaziland (Kiggundu, 1986).

Following the US Soil Conservation Service Land Capability Classification, 38 per cent of the study area contains land of either arable class I, II, III or IV with the remaining 62 per cent consisting of classes V, VI or VII (designated as non-arable). According to Young and Wright (1980), for the ferrasolic soils of the region, fallow requirements to maintain fertility are high: in general four years rest being required for every year cropped. The study area is classified as upland tall grassveld (I'Ons and Kidner, 1967), with generally open and 'sour' (i.e., relatively unpalatable in winter) grassland with an estimated carrying capacity ranging from 1·0 to 4·0 hectares per livestock unit (Swaziland Government, 1983: D20). Fuelwood potential is high: the study area falls within the productive wattle and eucalyptus plantation biomass class of the SADCC study (SADCC, 1987).

Current settlement and land use. Swazi rural settlements are generally dispersed and made up of extended family unit dwellings called homesteads. In the study area a total of 733 homesteads, with 4,487 residents, were counted during the 1986 census, yielding an overall population density of 123 persons km^2 (typical of Swaziland's more densely-settled rural areas). The study area has for years been an area of rural settlement and associated activities, including maize cropping and livestock grazing: in the partition of 1909 it was reserved as one of Swaziland's 31 'Native Areas' (Scott, 1951) which covered only 37 per cent of the total land area. Even today, rural settlement areas such as the study area comprise less than one-half of Swaziland: the remainder consists largely of private farms and agro-industrial holdings, leading Levin (1986) to assert that rural resource needs have suffered at the expense of economic development in Swaziland.

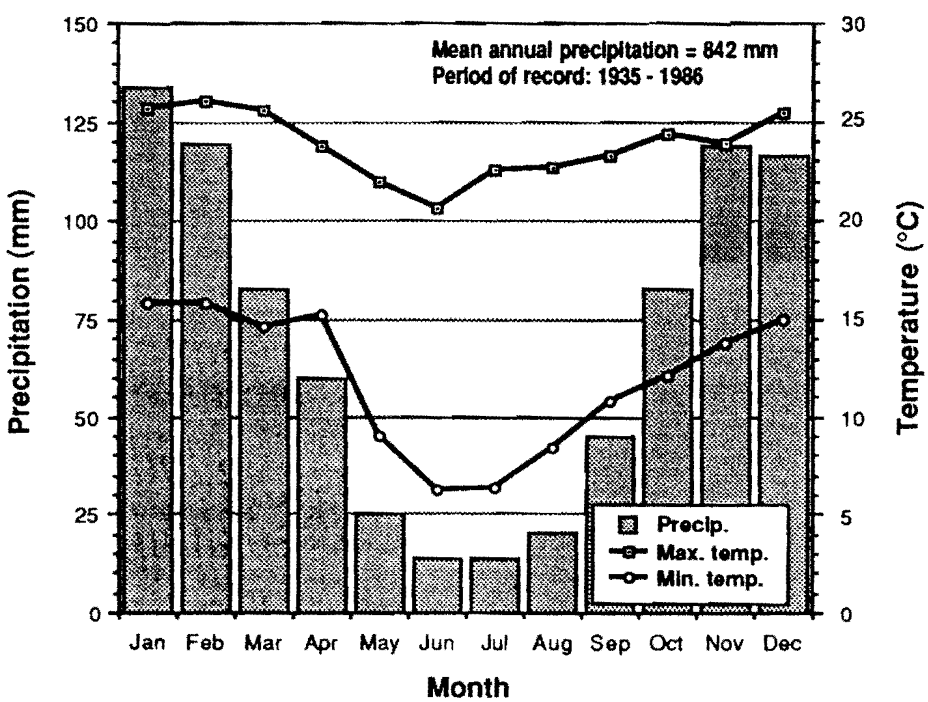


Figure 3. Long term mean monthly precipitation and temperature extremes, Nhlangano Station. Source:

cent devoted to grazing and 7·0 per cent occupied by forest. Agricultural plots, used for growing maize, have generally been aggregated and contoured as a part of the RDA program, with two-meter wide grass strips spaced approximately 30 m apart to counter soil erosion. Agricultural census results from 1983–84 established that regular household maize sufficiency was only 14 per cent. Murdoch (1977) speculated that long-term intensive cropping in this and other regions of Swaziland's upper Middleveld had depleted soils to the point where maize yields are roughly 25 per cent below expected values. Twenty-one per cent of the area's homesteads grow tobacco, a crop found in Swaziland mostly in the vicinity of Nhlangano.

Grazing land is largely unimproved; although a small amount of rangeland has been fenced into grazing camps for rotational management. Excessive grazing is evident on much of the range: grass cover is sparse and there is heavy infestation by non-palatable *Sporobolus* sp. Swaziland has one of the highest stocking densities in Africa (Swaziland Government, 1987b: 2) and overgrazing has generally been seen as the most serious problem facing the country's rural resource sector (Pim, 1932; I'Ons and Kidner, 1967; Roder, 1977; Doran, *et al.*, 1979; and Fowler, 1981). The study area's homesteads have relatively fewer livestock than those elsewhere in the country (with cattle per homestead averaging 5·5 compared with 9·1 nationwide), (Swaziland Government, 1986b).

Roughly 90 per cent of the forested area is wattle (*Acacia mearnsii*), which is found primarily in hilly areas and riparian sites, and has spread from plantations established for tannin extraction; the remainder consists of small stands of *Eucalyptus* spp. grown for sale as poles and mining timber. The relative abundance of fuelwood in the study area contrasts with much of Swaziland, where fuelwood availability is more critical (FAO, 1986: 26).

Linear valley-side gullying is evident in the study area (see Figure 6). Gullies most often extend along drainage routes up to rocky summits, where surface runoff is especially high. No good correlation exists between extent of gullying and soil type, although rill erosion is present on the clayey King Series soils found in the flat rangeland occupying census enumeration areas 3305 and 3307.

Some rural development occurred in the study area: from 1977 to 1982, Mahamba–Zombodze was designated as a 'maximum-input' RDA and qualified for extensive development assistance, including agricultural extension and credit services, livestock development, land development and conservation, and social infrastructure development. A generalized resettlement and land-use optimization plan for much of the study area was drafted as a part of the RDA program; yet, though some homestead relocation occurred, other anticipated results of resettlement, including land redistribution and fencing of grazing areas, did not. The overall failure of rural development efforts in Mahamba–Zombodze was unfortunately typical of the RDA program as a whole (see: Swaziland Government, 1983; de Vletter, 1984).

Historical changes. To determine recent changes in settlement, land use and resource quality in the study area, a series of aerial photos were used (nominal scale 1 : 30,000 — taken in June 1947, June 1961, October 1972, and July 1984). Homesteads were located and land use (cropland, rangeland, and woodland) mapped, as well as the extent of linear gullying. The resultant changes are shown in Figures 4, 5 and 6.

Population growth during the 37-year period (1947–1984) occurred at an average annual rate of 2·5 per cent. The overall annual growth rate in homesteads during the most recent period (1972–1984) was 3·0 per cent: this rate matches census results for the study area for the period 1966–1986, and is representative of Swaziland as a whole (which has had an average rate of 3·0 per cent per annum over the last two decades). Disaggregated population growth for each census enumeration district varies from 0·5–4·3 per cent, and reflects the impact of recent resettlement plans as well as per-capita arable land availability.

The greatest change in land use occurred in the period 1947 to 1961, when a large area of poorly drained agricultural land in areas 3305 and 3307 was abandoned to grazing. Most of this area had been cropped with sorghum, previously the staple food of much of Swaziland, as maize does not grow well in this high-clay content soil zone. In addition, the nationwide anti-erosion program, carried out from 1948 to 1956 involving the creation of contoured grass strips between fields (Murdoch, 1970: 267), can be clearly seen when comparing cropped areas in the 1947 and 1961 air photos. Following 1961, cropped land area has remained fairly constant at slightly over 50 per cent of total area, even though over that time period settlement increased. Grazing land area has decreased following large increases in the period 1947 to 1961 (after

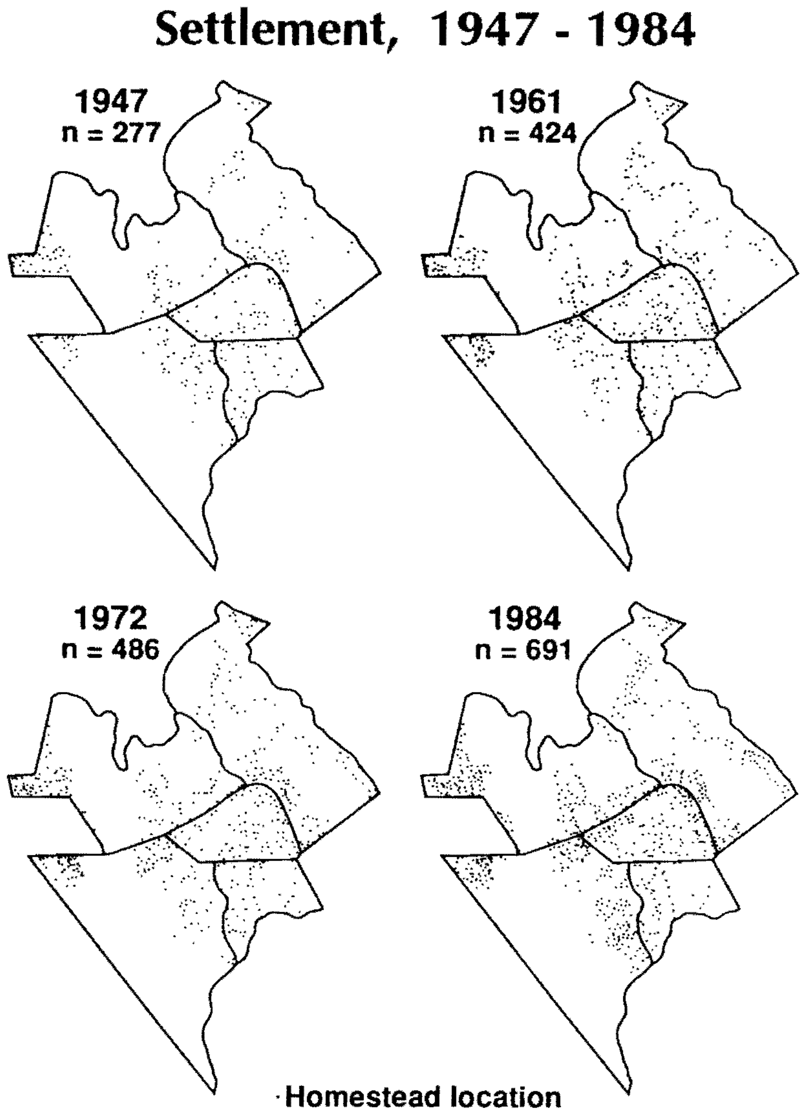


Figure 4. Settlement, 1947 to 1984. Adapted from site air photos

abandonment of agricultural land). There has been a land use shift to afforestation, since much of the abandoned grazing land was in hilly areas. Forest expansion, measured by its areal extent, has proceeded at an overall annual rate of 4·3 per cent per annum, with the area of woodland established in 1984 being nearly five-times that of 1947.

It is significant that no major increase of gully erosion occurred in the period 1947 to 1984; in fact, many gullies have been invaded by wattle, which should contribute to their recovery. The absence of additional gullying in the 1984 photos is striking, for Cyclone 'Domoina' had struck southern Africa only a few months before. The rill-eroded land of enumeration areas 3305 and 3307 appears to have recovered somewhat between 1947 and 1984, possibly due to the abandonment of agriculture in those areas. It is not known whether sheet erosion has caused a decrease in fertility of cropped land; however, no cropped land has been abandoned because of such erosion in the study area, and the widespread adherence to contouring and grass-stripping has probably minimized sheet erosion over the last thirty years. Fertility degradation cannot be easily determined from available information. Without adequate fertilizer use or fallow periods, however, depletion of nutrients in the study area's relatively infertile soils is likely, since maize makes heavy demands. Aerial photo evidence does not reveal major changes in grassland species composition. Although some woodland has been cleared for settlement or agriculture (see Figure 5), the high afforestation rates have resulted in a net increase in woodland.

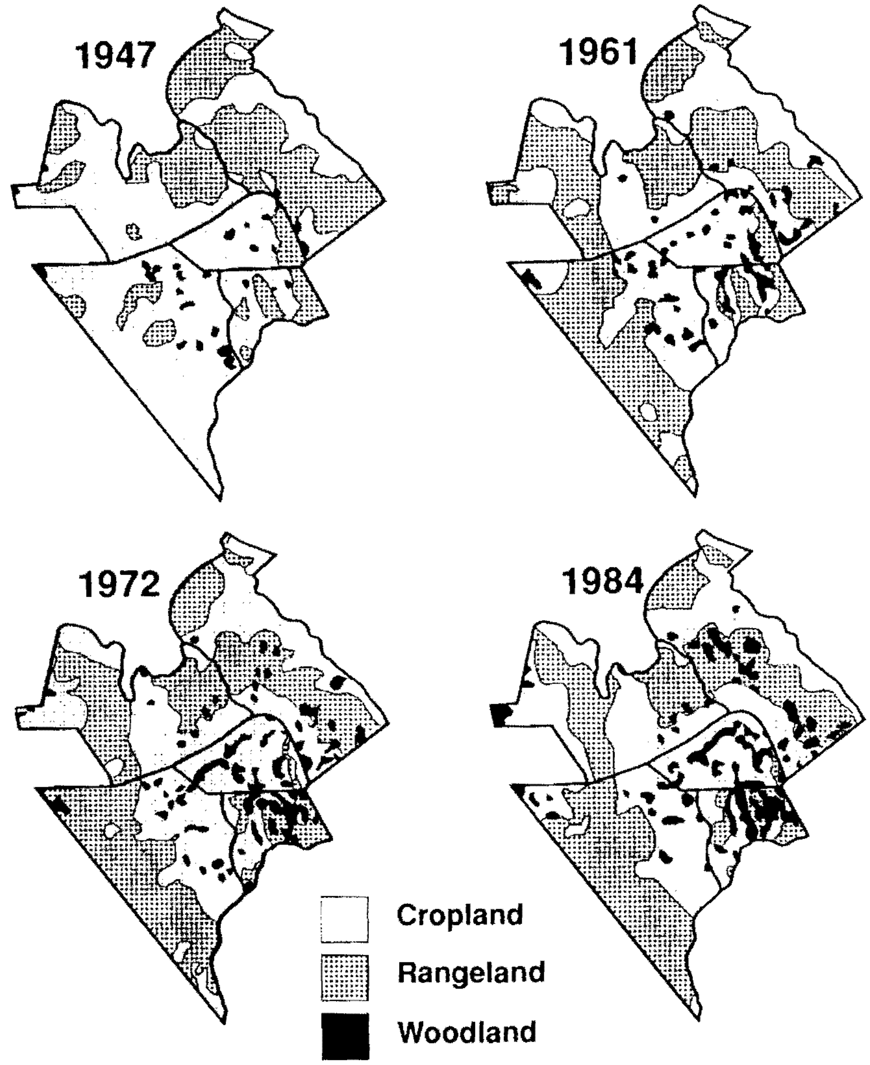


Figure 5. Land use, 1947 to 1984. Adapted from site air photos

Projected demand and resource adequacy

Introduction and methodology. In order to test the validity of the limits to growth scenario in the study area for the near future, it is crucial to establish whether demand on resources will exceed sustainable potential. If the resource base is found to be inadequate to meet increasing needs, then physical constraints may indeed loom large in the future. Conversely, if resources are determined to be adequate to meet aggregated demand, then the focus must shift to other potential constraints.

Two different types of projections are made, following two different sets of assumptions. (1) *Theoretical* adequacy projections draw upon land capability and high-estimates of maize production and rangeland carrying capacity, in order to set an upper limit on resource adequacy; this method is broadly similar to the high-input UN projections mentioned earlier. The assumptions underlying theoretical adequacy bear little relation to known land use or observed yields, and the resultant projections do not offer any real insight into the range of resource potential arising from different productivity estimates (e.g., rangeland carrying capacity) and inter-annual productivity variation (e.g., lowered crop yields due to drought). These considerations are included in type-(2) projections which have been termed *realistic* adequacy projections, and which are the second phase of the analysis.

Three years have been compared: (i) 1947, the baseline date; (ii) 1986, the date of the most recent census, and (iii) 2000 AD, the future projection date. Potential-to-demand ratios have been derived which estimate

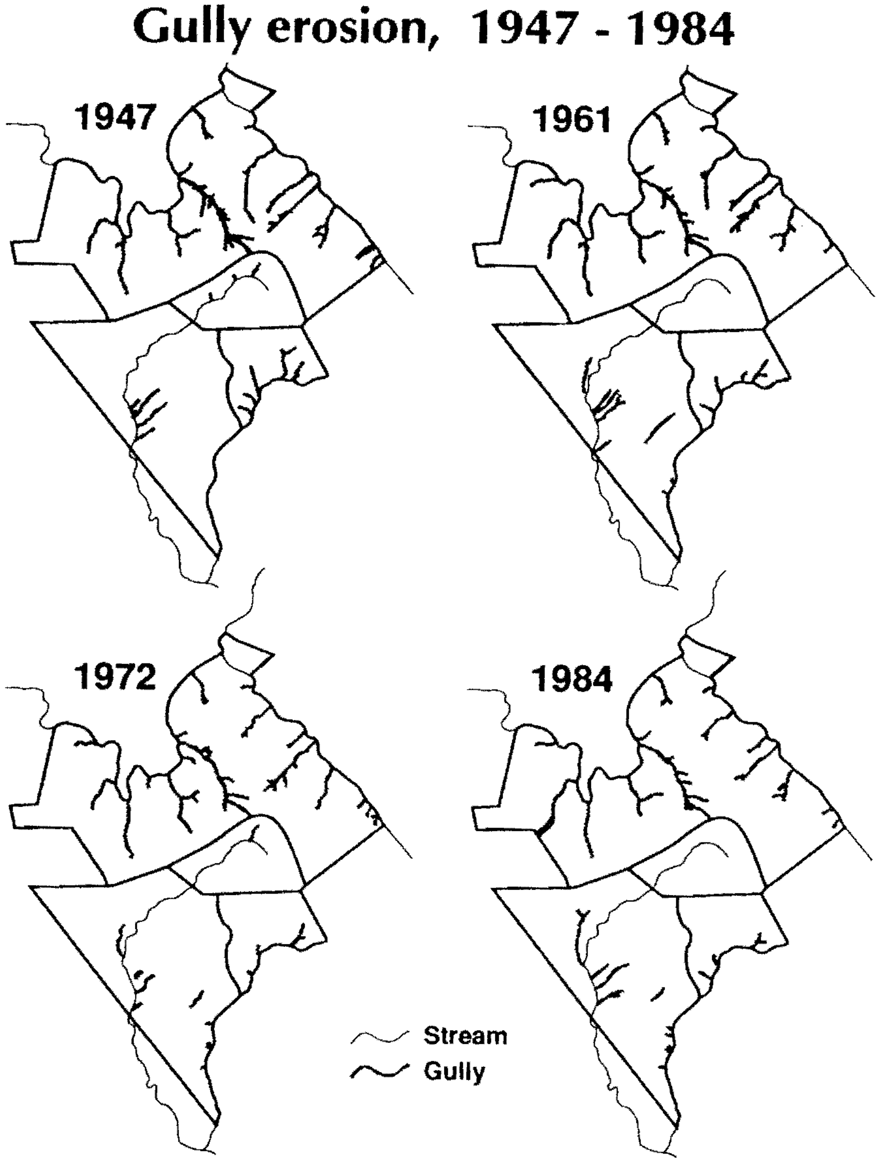


Figure 6. Gully erosion, 1947 to 1984. Adapted from site air photos

the adequacy of resources to meet household requirements: ratios of less than 1 : 1 suggest that sustainable resource potential is insufficient to meet aggregated demand.

Theoretical adequacy. Theoretical resource adequacy projections are based on the following assumptions:

1. *Population* estimates for the year 2000 assume a 3·0 per cent per annum overall growth rate, matching the known overall rate over the last two decades (determined from census and air photo data). Relative growth dynamics for each enumeration area between 1966 and 1986 are assumed to continue.
2. *Staple food* requirements were set at 200 kg person y^{-1}, the average of several estimates for Swaziland (FAO, 1981b: 9; FAO, 1984: 11; and Testerink, *et al.*, 1985: 15).
3. *Livestock* numbers for 1986 were derived from the 1983–84 agricultural census; historic livestock numbers for the study area were unavailable, but interviews with local residents suggest that the number of cattle per homestead has been steadily decreasing. The magnitude of this trend was estimated using data from Swaziland for the period 1946 to 1986 (see Figure 7), this was then extrapolated to 2000 AD. On this basis, the 1986 figure of cattle per homestead is multiplied by a factor of 1·9 for the year 1947, and 0·7 for 2000 AD.
4. For *land use,* it was assumed that class I to IV land is devoted to staple crop production, and class V to VII land is devoted to grazing. All homesteads, roads, paths, etc., are assumed to be located on the lower-productivity grazing land; an allowance of 0·2 ha per homestead is made for these uses. No provision is made [illegible] growth and utilization data. A very critical

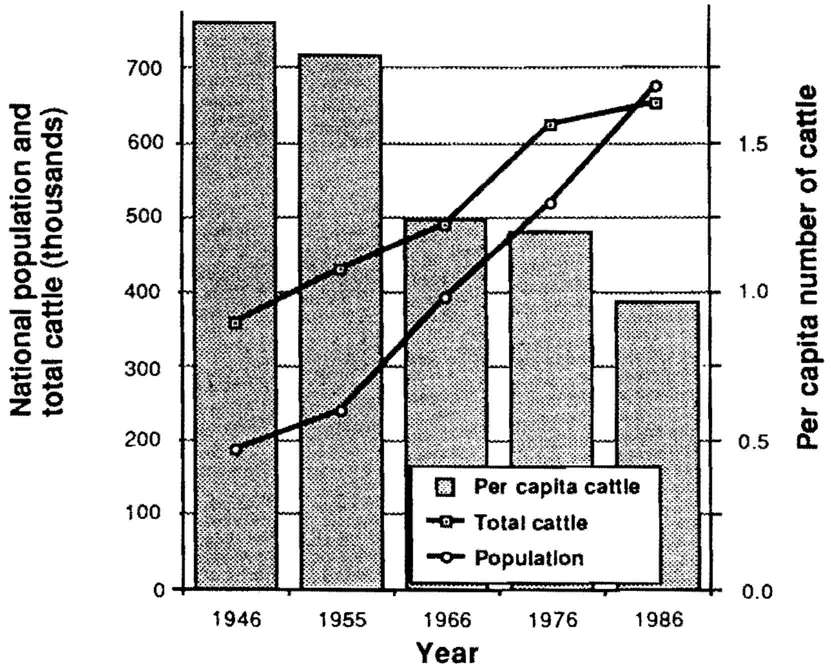


Figure 7. Per capita number of cattle for Swaziland, 1946 to 1986. Source: Murdoch (1970); Swaziland Government (1986a, 1987b, 1988)

assumption is that cropland allocation is uniform amongst all inhabitants of the study area. Another general assumption is that homesteads rely primarily on resources confined to their enumeration area; this assumption will be modified in the following section, drawing on empirical evidence.

5. For 1986 and 2000 AD, the maximum potential *staple crop yield* is set at 3,500 kg ha^{-1}, consistent with the maximum yield range of three to four t ha^{-1} set recently by the Swaziland Ministry of Agriculture's Research Division (Swaziland Government, 1987a: 56), though lower than that which was considered possible in the FAO maize study (FAO, 1984: 7). The 1947 estimate assumes use of non-hybrid seed; higher-yielding hybrid varieties were not common in Swaziland until the early-1960s (Murdoch, 1970: 223). Judging from current yields for Mahamba-Zombodze RDA, using non-hybrid seed (Swaziland Government, 1983: 104), and assuming that recent sorghum and maize yields are similar (see Swaziland Government, 1973: 111), the maximum potential yield for 1947 was set at 2,000 kg ha^{-1}. These yields are assumed to decrease with successively lower land capability classes, according to research compiled by Murdoch (1970: 229), such that class I and II yields are equivalent to the maximum, class III yields are 97 per cent of the maximum, and class IV yields 88 per cent of the maximum.

6. *Rangeland carrying capacity* was set at 1·0 ha per 350 kg livestock unit, which represents the high end of the range of values found in the literature for upland tall grassveld-type vegetation (Swaziland Government, 1983: D20).

7. *Fallow requirements* to maintain cropland fertility are derived from estimates for ferrasolic soils provided by Young and Wright (1980). Their findings suggest that these soils may be cropped under low inputs only one year in five, whereas under high inputs (i.e. with fertilizer application) they may be cropped three years out of four. It is assumed in this analysis that the high-input option exists only for the years 1986 and 2000 AD; it is also assumed that fallow agricultural land is devoted to grazing.

Theoretical adequacy results are given in Figure 8. The increase in theoretical cropland adequacy gained by the advent of high-input management between 1947 and 1986 is offset by population growth following 1986, though the results suggest generally adequate arable land for the near future, assuming there are high-input conditions. Rangeland adequacy dropped markedly between 1947 and 1986, since less fallow land is assumed to exist for grazing under the high-input cropping assumptions of the latter year. Theoretical rangeland adequacy for 2000 AD is however only slightly lower than for 1986 despite homestead growth, since livestock holdings per homestead are projected to drop during this period. The results suggest that rangeland is generally insufficient to meet demand, in part due to competition from arable agriculture: the marked

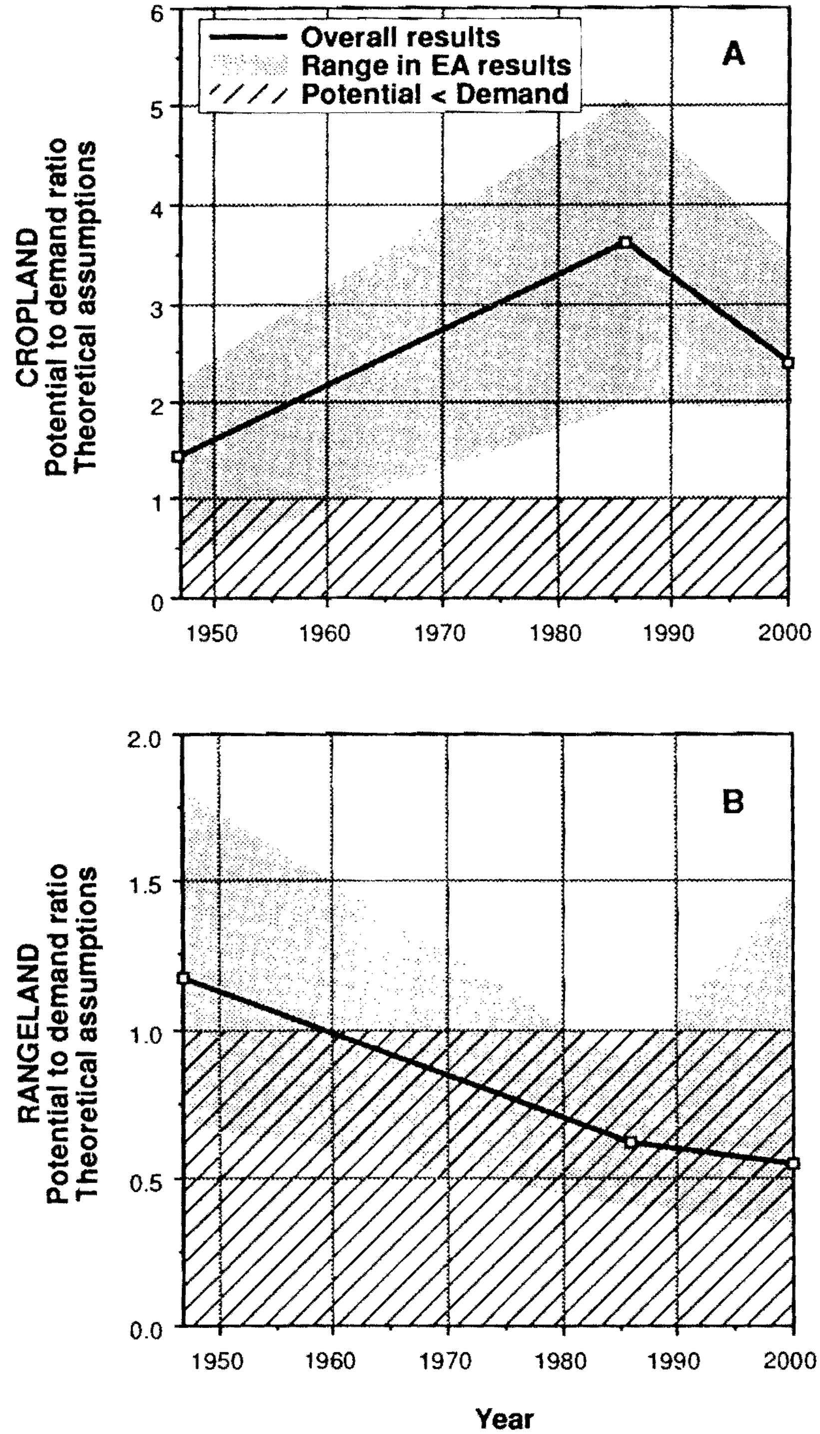


Figure 8. Adequacy of (a) cropland and (b) rangeland resources under theoretical assumptions

decrease in rangeland adequacy accompanying the increase in cropland adequacy between 1947 and 1986 serves as a striking illustration.

Cropland and rangeland results vary according to enumeration area, due to site-specific differences. For example, enumeration area 3350's status is low compared to others, yet improves through time due to slow growth during the period 1947 to 1986, and a decrease in settlement from 1986 to 2000 AD. In contrast, resource adequacy for enumeration area 3307 is high relative to the study area as a whole, reflecting its comparatively large per capita land area, although adequacy drops markedly during the period of inquiry due to rapid growth.

In order to improve theoretical grazing adequacy, the preceding analysis was modified such that only the ... would be devoted to agricultural use, with the rest given over to grazing. The results of these revised calculations showed only slight improvement. It therefore does not appear possible to meet both cropland and rangeland demands overall, even with the ideal assumptions underlying these theoretical projections.

Realistic adequacy. Assumptions underlying realistic resource adequacy projections are as follows:

1. *Demand* for food and grazing follow the assumptions given in the previous section. Fuelwood demand cannot be estimated due to a lack of appropriate data for the area, but per capita fuelwood availability was determined.
2. *Land use* for 1947 and 1986 is determined from air photo evidence; land use for 2000 AD is projected from trends between 1961 and 1984 for each enumeration area (see Figures 5, 9). Air photos indicate that approximately 25 per cent of cropland area is devoted to settlement, space between fields and other non-agricultural uses; this fraction was subtracted prior to analysis. The assumption that cropland allocation is uniform applies to this analysis. Following field survey results (see the next section), it was assumed that all cropland was devoted to staple food production and that no cropland was devoted to fallow. In addition, rangeland for enumeration units 3306, 3307 and 3350 is combined for this analysis, since grazing land is known to be shared amongst these areas.
3. Lower and upper bounds were set for *crop yields*, representing realistic low and high yields occurring due to variability in physical conditions (e.g. rainfall) or management (e.g. fertilizer application). For 1947, yields of 250–1,000 kg ha^{-1} were used (see Holleman, 1964: 215; Swaziland Government, 1973: 112–113), whereas for 1986 and 2000 AD yields of 500–2,000 kg ha^{-1}, derived from actual measured yields for Mahamba–Zombodze RDA for the period 1977–78 to 1983–84 (Swaziland Government, 1983: C14), were applied.
4. Lower and upper bounds of four and one hectares per 350 kg livestock unit were also set for *rangeland carrying capacity* (Swaziland Government, 1983: D20).
5. All *woodland* coverage was assumed to be harvestable as fuelwood.

Realistic adequacy results are summarized in Figure 10. Cropland adequacy decreases from 1947 to 2000 AD; in addition, since no allowance is made for fallow, the status of cropland can be expected to drop even more in the future due to fertility degradation. Results indicate that cropland resources are generally adequate under optimum physical conditions and management, but inadequate under sub-optimum conditions such as drought or low fertilizer use. Rangeland adequacy was found to drop from 1947 to 2000 AD, due to increased livestock, although this was mitigated somewhat by the decreasing number of cattle per

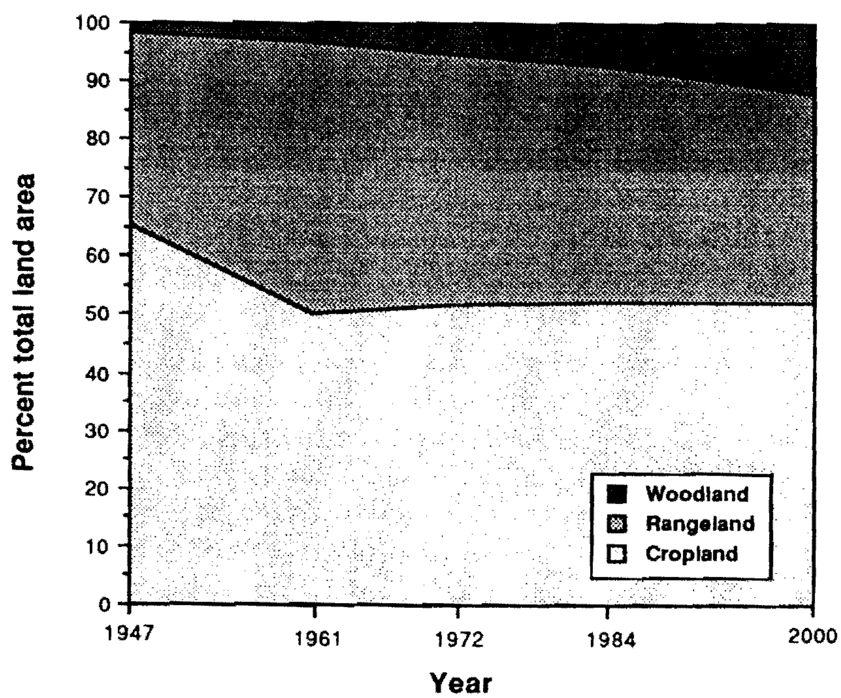


Figure 9. Historical and projected land use, prepared from site air photos

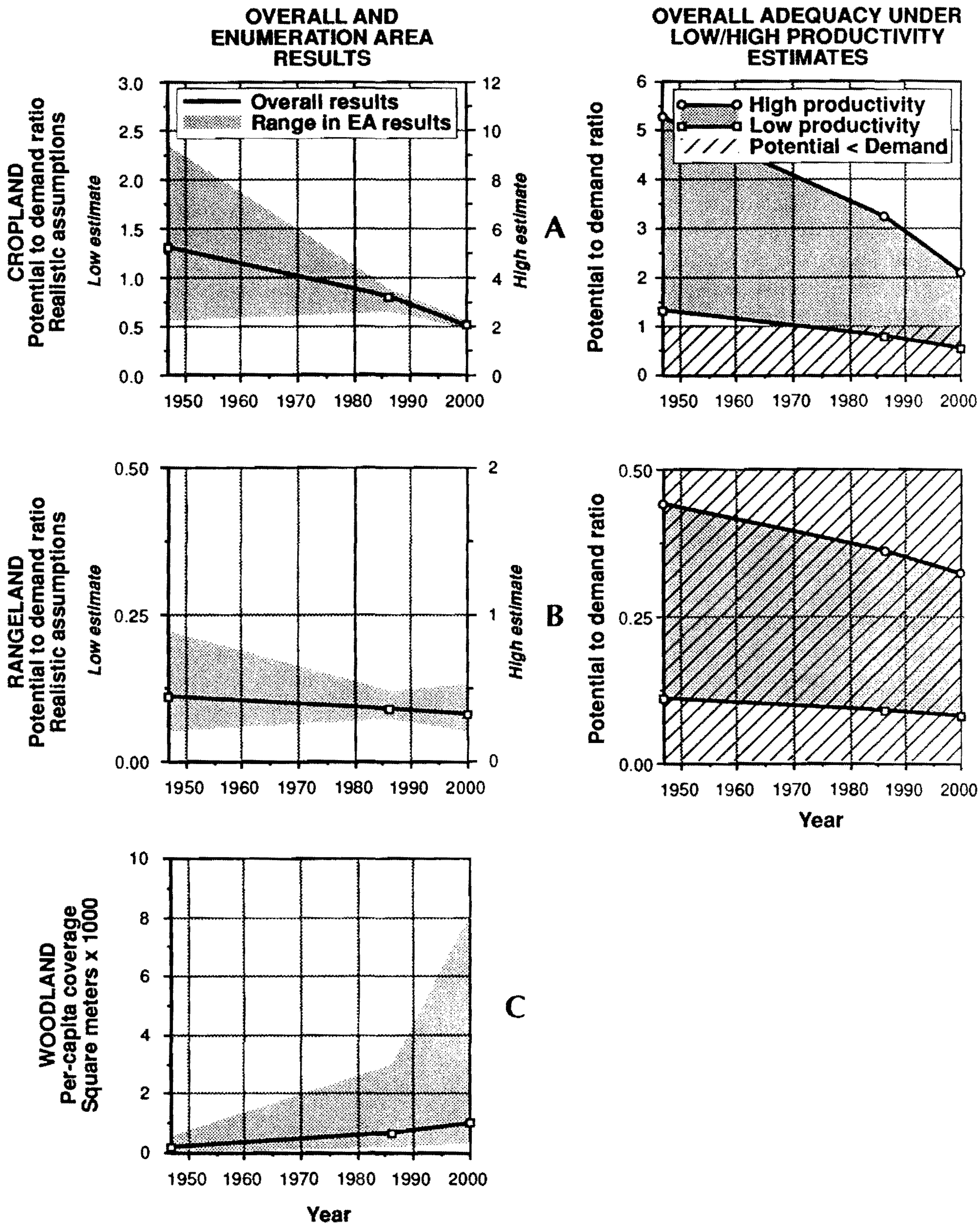


Figure 10. Adequacy of (a) cropland and (b) rangeland resources under realistic assumptions, including low and high estimates of productivity, and (c) per capita woodland area

homestead. Rangeland appears from this analysis to be grossly inadequate for the entire study area: even following the best estimate of rangeland carrying capacity, cattle numbers would have to be reduced by 70 per cent in 2000 AD in order to match rangeland potential. This overstocking condition is not just recent as it was apparent even for the year 1947. The long term stressed condition of rangeland suggested by this analysis agrees with historical air photo evidence of gullying (possibly due to high runoff from poor ground cover) as well as surveys of current range conditions. The high afforestation rates between 1947 and 1986 result in projected greater per capita fuelwood availability during this period. Per capita reserves are also expected to increase during the period 1986 to 2000 AD, since forest coverage is projected to increase at an average annual rate of 3·4 per cent.

Several results at the enumeration area-level are noteworthy. Variability in cropland results among enumeration areas is reduced during the period 1947 to 2000 AD, due to increased settlement in areas possessing the greatest relative endowment of cropland. Rangeland adequacy in combined enumeration areas 3306/3307/3350 actually increases between 1947 and 1986 due to the conversion of cropland to rangeland in enumeration area 3307 during that period, and continues to increase up to and beyond 2000 AD due to slow population growth. Variability in fuelwood availability increases up to and beyond 2000 AD due to differing rates of afforestation (which range from 0·1 ro 5·6 per cent) coupled with differing rates of population growth.

Comparison of theoretical and realistic adequacy. Three important points become apparent from a comparison of the foregoing results. First, both theoretical and realistic projections for the study area suggest that rangeland is far less adequate to meet local needs than cropland, although the adequacy of both will decline in the future. Second, it should be noted that the projected year 2000 realistic (high yield estimate) cropland adequacy is almost as high as theoretical cropland adequacy. This optimistic result is based on the assumption that there will be continuation of unsustainable current land-use practices such as cropping fragile, non-arable class VI land and foregoing fallow periods in order to compensate for lower yields. These practices (understandable given the significance of basic food needs) not only affect cropland quality but rangeland adequacy as well, and this results in a marked range reduction under realistic assumptions, since less land is deemed available for grazing than would be the case under theoretical assumptions. Clearly, insufficient land exists to meet both staple food and livestock grazing needs in the study area.

Third, and more generally, the disparity between theoretical and realistic estimates for maize production and rangeland carrying capacity suggests that resource utilization is far from optimum. Whether resource management practices can realistically be improved to approach the optimum is uncertain. Resource adequacy estimates based on theoretical assumptions are therefore in this case relatively meaningless.

The overall results demonstrate the existence of resource constraints in the study area: for instance, cropland adequacy under realistic assumptions is marginal, and will deteriorate in the future due to increased demand. The results, however, vary from resource to resource: in the case of rangeland, a longstanding condition of inadequacy is apparent, whereas in the case of fuelwood supplies, per capita allotments are probably adequate. These results, however, paint only a partial picture of actual conditions faced by households in the study area; some further knowledge of the relative significance of resource constraints in the context of local resource utilization is required. The following section addresses this concern.

Household resource-use survey

Introduction. One portion of the study area, (enumeration area 3306) was selected for an in-depth household survey; the choice of 3306 was based primarily on the interest of/and willingness of the residents to participate. Eighty-one per cent of 3306's total area of 3·2 km^2 is cropped, with only 3·0 per cent devoted to grazing and the remainder forested (see Figure 5). The topography is gently rolling, consisting of an interior drainage to the Mbukwane River, a perennial stream originating in the area. Although population density in area 3306 has been high for some time (Murdoch, 1970: 62), it has continued to grow at 3·0 per cent over the last decade, and the 1986 density was 224 persons km^2. Enumeration area 3306's current cropland adequacy is typical of the study area as a whole, as is the adequacy of the rangeland it shares with enumeration areas 3307 and 3350. Fuelwood reserves for 3306 are higher than for the study area as a whole (see Figure 10), standing at 1,220 m^2 per capita in 1986.

Enumeration area 3306 homesteads were surveyed to obtain information on the distribution and perceived adequacy of resource holdings, non-physical constraints to household resource utilization (such as labor and financial limitations), and attitudes toward the significance of resource-related constraints in the area relative to other perceived problems. A random sample of twenty-eight homesteads (about one-out-of-five) was selected for the interviews. The results follow.

Resource distribution and adequacy. Cropland holdings from the survey are summarized in Figure 11a. Distribution is skewed (similar to much of Swaziland: see Testerink, *et al.*, 1985), with the majority of holdings under 0·5 ha per homestead. Unequal cropland distribution is actually even worse than the survey indicates — since a number of absentee-controlled plots larger than 3·0 ha exist in the area — and is certainly a significant contstraint to staple food security for many homesteads: only one homestead in four felt its holdings were adequate to provide for its maize requirements (see Figure 12).

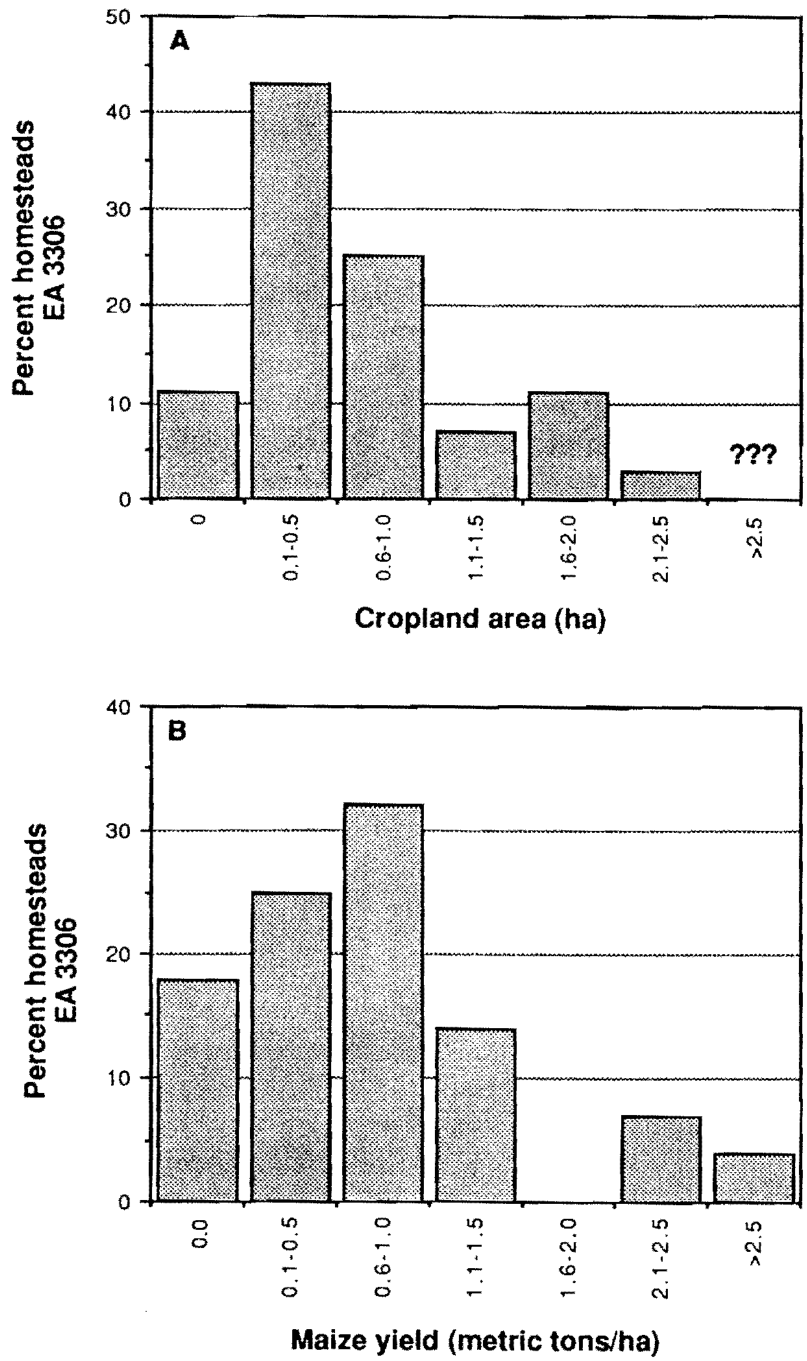


Figure 11. (a) Homestead cropland holdings and (b) maize yields (1987–88 season) for enumeration area 3306

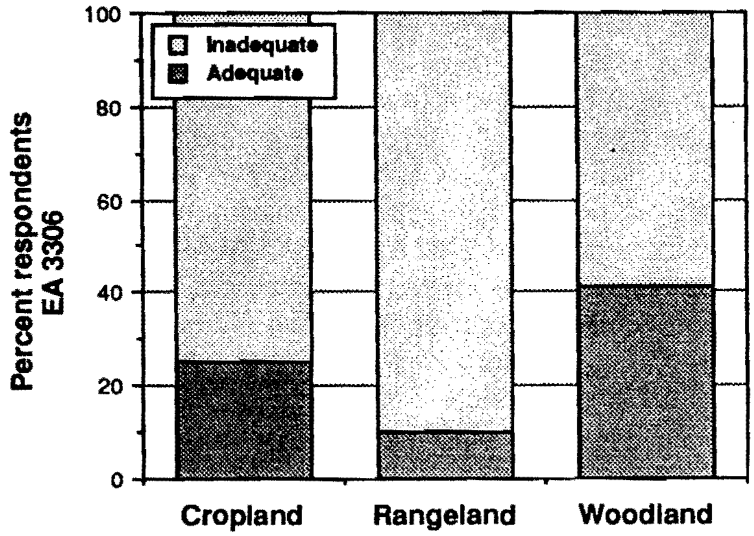


Figure 12. Perceived adequacy of allocated cropland, rangeland, and fuelwood resources, enumeration area 3306

Ninety-six per cent of the total cropland surveyed was devoted to maize (compared with 80 per cent for Swaziland as a whole); the remainder was used for cash-crops such as tobacco. None of the land had been in fallow during the last cropping season. These results confirm assumptions used in the foregoing resource adequacy projections, and suggest both the significance of staple food production in the local agricultural economy and the intensity of cropland use (another pattern reflected throughout much of Swaziland: see Testerink, *et al.*, 1985).

Maize yields, as shown in Figure 11b, are poor and exacerbate the effects of inadequate holdings. The mean yield for 1987–88 — a good rain year — was only 770 kg ha^{-1}. Nearly one homestead in five ate their maize green during the cropping season due to inadequate food stores; none was left to harvest at the end of the season. Fully 75 per cent of the homesteads surveyed claimed that their maize harvest would not feed their family for the coming year.

Differences in maize yields appear to arise from variation between households in labor and economic endowment. Those few homesteads who did well credited their good harvests to intensive management, including early planting and high levels of fertilizer use. On the other hand, many of the homestead residents who reported poor yields mentioned that they planted too late to take advantage of early rain; reasons given included difficulties in renting tractors (few homesteads in this area possess sufficient oxen for plowing), or because home labor was unavailable.

Access to rangeland was similar amongst the homesteads surveyed, although cattle holdings differed widely. Only one homestead in ten felt that rangeland was adequate to meet grazing demand. In addition, 64 per cent reported that their stock suffer from poor health.

One-half of the homesteads surveyed reported that they regularly purchased fuelwood in nearby Nhlangano, claiming that forest reserves had been increasingly privatized in recent years, creating problems of access to much of the area's fuelwood supply. This finding contradicts the preceding section's analysis, which suggested that fuelwood resources are abundant for the area, and again underscores the significant role of allocation and access in resource utilization.

Household constraints. Labour migration is severe in enumeration area 3306: fully 64 per cent of the total adult workforce consisted of absentees working in other parts of Swaziland or in South Africa. Virtually all homesteads interviewed agreed that adult labor is generally insufficient for such critical activities as early planting and weeding of maize, and careful management of rangelands. Although financial constraints were not quantified in the survey, the prevailing opinion amongst poorer homesteads was that insufficient cash was available to purchase necessary crop inputs such as fertilizer or to support livestock health through veterinary care. Household constraints thus appear to play a significant role in limiting adequate resource utilization in area 3306.

Perspectives on resource and other constraints. Respondents were asked to state current and anticipated future difficulties facing their communities. The most common responses concerning current problems included: (a) the lack of government assistance to promote land redistribution, improve rangeland, or create local income opportunities (mentioned by 50 per cent of the respondents); (b) the severity of resource degradation and the inadequacy of resource allotments due to over-population and unequal land distribution (mentioned by 43 per cent of the respondents); and (c) the lack of employment in the area (mentioned by 21 per cent of the respondents). Many respondents expressed a total absence of hope for the future of the area given the inadequacy of the resource base necessary to support basic human needs, as well as the scarcity of local jobs. Apparently, both physical and non-physical constraints are keenly felt among the residents of enumeration area 3306.

Summary. It would be hard to overstate the crisis being experienced in enumeration area 3306. The current picture is grim: after a good rain year, only one homestead in four claims that its maize yield will feed the household; livestock are thin and grass is virtually non-existent; fuelwood is abundant but one-half of the families living in the area must regularly purchase this basic source of energy. It would be equally hard to overstate the likely future condition of this community: residents know their children will be forced to leave in search of a more secure means of living (which they are not likely to find) at destinations such as Manzini or Johannesburg. It is shocking that, in this 'maximum-input' Rural Development Area, such basic constraints as unequal resource allocation and limited local income opportunities have apparently not been seriously addressed, in addition to the very real inadequacies of the resource base necessary to support basic human needs. The crisis in enumeration area 3306 is thus not likely to solve itself, even if resources were adequate to meet human needs — a perspective which must be appreciated fully in order to understand the limits of limits to growth projections.

CONCLUSION

Summary and comparison of results

Resource adequacy results. General results from the foregoing analysis are summarized in Table I. Although *cropland* appears to be theoretically adequate to meet year 2000 staple food needs in the study area, its status becomes more marginal under realistic assumptions, and is clearly inadequate for many homesteads given actual conditions such as small land holdings. The results are more consistent in the case of *rangeland*, which has been unable to meet grazing needs for some time. Both cropland and rangeland adequacy are deteriorating over time, in contrast to *woodland*; yet access to the latter is reduced by privatization, in spite of its relative abundance. The results suggest that, unless appropriate remedial action is taken, Swaziland's more densely settled rural areas will suffer an escalating crisis in supply of basic resource needs in the near future.

Comparison with UN projections. The United Nations' *Potential Population-Supporting Capacities of Lands in the Developing World* addresses only cropland adequacy under theoretical assumptions; yet some comparison can be made. The results of the foregoing theoretical analysis indicate that under high-input conditions, 2·4-times the projected 2000 AD population can be fed in the study area; this figure falls within the UN's projected carrying capacity range for southwestern Swaziland (see the Africa map supplement to

Table I. Resource adequacy results

resource	theoretical adequacy				realistic adequacy (high/low estimates)				household survey (1988)
	1947	1986	2000	trend	1947	1986	2000	trend	
cropland	Y	Y	Y	(−)	Y/Y	Y/N	Y/N	(−)	N
rangeland	Y	N	N	(−)	N/N	N/N	N/N	(−)	N
woodland								(+)	N

key: Y = adequate; N = inadequate;
(−) = decrease in adequacy over time
(+) = increase in adequacy over time

Higgins, *et al.*, 1983). Yet as has been argued earlier, these theoretical results are essentially meaningless: the realistic adequacy results indicate that only one-half the projected year 2000 study area population can be fed under adverse climatic or management conditions, even assuming equitable cropland distribution. The results of this study therefore corroborate the criticisms of the UN study summarized earlier.

Comparison with the limits to growth scenario. Although the results suggest that resource constraints may play a significant role in Swaziland's rural economy, the limits to growth scenario's classic 'overshoot and collapse' dynamic — according to which resource demands increase until limits are reached, resulting in catastrophe — is not entirely supported. The results from this case-study suggest instead an alternative, though no less serious, dynamic for critically deficient resources. Rangeland results serve as the clearest example: under low carrying capacity estimates (likely given the degraded state of the range), rangeland has been seriously overstocked in the study area throughout the period of analysis (see Figure 10b). Evidence of this longstanding crisis includes an extensive gully network, the current degraded range condition and reported poor cattle health. Certainly, 'overshoot' (in the sense of growth beyond sustainable limits) has occurred at some time in the distant past; yet total rangeland collapse is not evident, and range grass is sufficient to maintain (barely) the cattle in the study area.

The resultant trend is one of long-term 'low equilibrium', induced by overstocking in the more distant past, and maintained by overstocking in the present. This 'overshoot-low equilibrium' dynamic may also be applied to cropland fertility degradation (see Murdoch, 1977). In both cases, the implication is that long-term low resource potential plagues provision of critical basic needs in the study area and can be expected to do so in the near future. It should however be stressed that the limits to growth scenario is incomplete and therefore potentially misleading, given its emphasis on physical constraints alone.

Physical and other threats to rural resource utilization. Both the physical constraints emphasized by adherents to the Malthusian position on the limits to growth debate, and the social and economic constraints emphasized by their opponents, are clearly at work in rural Swaziland. Examples of resource constraints identified in this study include the longstanding and serious shortage of rangeland, demonstrated by its current highly degraded condition, and increasingly marginal reserves of cropland, which likely suffers from acute fertility degradation due to heavy use without fallow or fertilizer to replenish nutrients. These shortages are in most cases exacerbated by social and economic forces: examples include the unequal allocation of cropland to homesteads and the effect of household limitations of labor and cash. In other cases, however, these latter factors act entirely in the absence of resource shortages: one example is provided by the fuelwood crisis in enumeration area 3306, where unequal access has deprived many homesteads of an abundant supply.

Implications for policy and research

The most critical research and policy implication to be distilled from these results is that neither physical nor social and economic constraints to rural resource utilization in Swaziland can be ignored: extremes in Malthusian and Marxian positions would be equally guilty on this count. Perhaps it is ideological conflict more than empirical evidence that supports their mutual exclusiveness? At any rate, policy and research addressing future security of resource access in subSaharan Africa cannot afford to ignore either position, nor simply to collapse one under the other. Taking Swaziland as an example, critical policies that need to be investigated range from the extreme centralization of economic development and the availability of less than one-half of the country for rural settlement, to the haphazard nature of rural resource planning and the absence of concerted population planning. Additional research in this field must therefore be built on an inclusive theoretical basis akin to what Blaikie and Brookfield (1987) have termed regional political ecology. The limits to growth debate has very real implications for future social and environmental conditions in subSaharan Africa; it will be resolved less by theoretical posturing than by informed empirical research.

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