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DEMOGRAPHIC PRESSURE, AGRICULTURAL PRODUCTION SYSTEMS AND LAND DEGRADATION IN SWAZILAND

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Executive Summary

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Background and Objectives of the Study

Arable land is one of the most important renewable resources possessed by developing nations. With large segments of their populations dependent upon agriculture, this resource is not only essential in meeting national goals of food production, but is also critical to the employment and income opportunities of rural populations throughout the world. Increasing the productivity and efficiency of agriculture are major goals of agricultural development policy. Achievement of these goals is threatened by problems of resource degradation such as deforestation, desertification and soil erosion which have reached major proportions in a number of nations.

Problems of environmental degradation are further exacerbated by rapid rates of population growth which place additional pressures upon renewable resources such as arable land. Although the connections between population growth and environmental degradation are widely discussed in both the environmental and population literature, comparatively little empirical research has attempted to directly examine their interrelationships. Connections between population growth and environmental degradation are often phrased in global terms at the societal level, although both processes are in large part the outcome of decisions made by individual

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couples, families and households. In order to understand the aggregate level relationships between these phenomena, it is necessary to understand the relationships among farm household demographic circumstances, the agricultural production systems they employ, and the impact of these factors on land degradation.

Swaziland currently faces many of these issues. It is a predominantly rural, agricultural nation, characterized by high fertility and rapid population growth. Its population contains a large proportion of subsistence and semi-subsistence farmers whose production decisions and agricultural practices will largely determine the future of land resources. Moreover, Swazi Nation Land (SNL), which contains the majority of the rural population, is held in trust by the King and administered by tribal chiefs. The communal nature of the land system is thus not atypical of that found elsewhere in sub-Saharan Africa.

The objectives of this study were to describe and examine the relationships among farm homestead demographic characteristics, the agricultural production practices they employ, and the impact of these factors on land degradation (soil erosion) in Swaziland. These relationships were thought to be conditional upon the agroclimatic and socioeconomic environments in which homesteads operate. Consequently, aspects of this broader environment were included in the models developed.

Design of the Study

Data for the study were drawn from two sources. The primary source of data was an ongoing cropping systems project in Swaziland funded by USAID and jointly implemented by The Pennsylvania State University and Tennessee State University in cooperation with the Swaziland Ministry of Agriculture

and Cooperatives. The Swaziland Cropping Systems Research and Extension Training Project (SCSRET) has among its major objectives understanding the expressed needs of Swazi Nation Land farmers and identifying constraints to their productivity. As part of that effort, several surveys of Swazi Nation Land farmers were conducted. These surveys provided basic data on homestead demographic characteristics and agricultural production practices. In addition, secondary data on the socioeconomic and agroclimatic environment of sample homesteads were made available by members of the SCSRET team.

Data on land degradation were obtained from a special purpose survey of SNL homesteads by a soil scientist commissioned specifically for this task. This involved measurement and construction of a series of indicators on the soil conditions, slope, rainfall patterns and other agroclimatic characteristics that were not available through the SCSRET Project. These data served as the major resource for description and estimation of land degradation on arable land in Swaziland.

Descriptive findings on homestead size and demographic composition, agricultural practices and the socioeconomic and agroclimatic environments were used to develop regression models of sheet and gully erosion. These models were inductively derived and included factors representative of each of the four major sets of variables examined: demographic characteristics, agricultural practices, and agroclimatic and socioeconomic characteristics.

Findings

Perhaps the most encouraging finding from the study was the moderate degree of soil erosion found on this sample of Swazi Nation Land homesteads. Although the overwhelming majority of homesteads were found to

have some sheet erosion in which the A-horizon was eroded sufficiently that tillage implements reached the underlaying horizon, this was not deemed to be a serious problem negatively affecting land quality. The major reasons for the lack of more serious problems appeared to be the widespread practices of grass stripping and contour plowing.

Rills were present on almost three-fourths of the homesteads but were also judged to not be of such severity to seriously limit land quality. About one-fourth of homestead land contained shallow gullies between 31 and 100 centimeters in depth, most of which were created by the 1984 cyclone in which the usually effective conservation practices were ineffective. Deep gullies over 100 centimeters in depth were not found on any homesteads surveyed and gully erosion was judged to be a serious problem on less than 10 percent of homesteads.

Findings with regard to the erosion susceptibility of Swazi Nation Land were similarly encouraging. Over 80 percent of arable holdings fell in the low to moderately low susceptibility categories. Undoubtedly, the concentration of arable landholdings on lands of relatively low susceptibility contributed to the modest amount of erosion found on homestead land.

These generally positive findings must be qualified by the recognition that they apply only to arable holdings among a relatively small sample of Swazi Nation Land farmers located in the Highveld and Middleveld regions. Extension of the research to include the Lowveld and Lubombo regions is needed. However, the largest omission is the absence of information about soil conditions on communal grasslands. While systematic data on the condition of these lands are lacking, they appear to be much more seriously

eroded than arable holdings.

Homesteads varied markedly in size and demographic composition. The average homestead contained between 9 and 10 resident members, was headed by a male and consisted of a single household. In almost one-third of homesteads the head was employed off-farm, and over 80 percent of all homesteads had at least one worker employed off-farm. Although agriculture was a major source of income for these families, they were clearly involved in both the traditional and nontraditional sectors of the economy. Rural and agricultural policies, including those dealing with conservation, must be informed by this basic fact. Similarly, recognition of the central role played by women in crop production is important. Women accounted for over half of all labor devoted to maize production, the staple food crop in Swaziland.

Homestead population size was not directly related to the degree of agricultural commercialization. Almost all homesteads had sufficient labor to devote to agricultural production. Commercial and non-commercial homesteads had approximately equal numbers of production units. However, they differed markedly in their land resources. The size of holdings was positively related to the degree of agricultural commercialization. These findings suggest that the decision to become a commercial or non-commercial producer was not determined primarily by the availability of homestead labor. Instead, the ratio of labor to available land appeared to be much more important. Thus, continued rapid population growth and the resultant increase in average homestead size is likely to place growing pressure on available land resources, and may possibly influence the process of agricultural commercialization by altering the population/land ratios.

Homesteads that used more hired, invited or exchange labor, rather than relying more on homestead labor, that were more commercial in orientation, that used tractors, that had more members and that farmed larger holdings were more likely to farm wider panels and fewer panels per hectare. Homesteads farming larger panels were more likely to experience sheet erosion. Agroclimatic characteristics were unrelated to panel width or panels per hectare, suggesting that decisions on the width of panels or number of panels to cultivate were largely unrelated to the erodibility of the soil, rainfall patterns or degree of slope of the land.

The regression models revealed that agricultural practices were the most important set of factors affecting erosion. Those homesteads most active in utilizing their land and labor to maximize yields (i.e., grew a larger number of crops, devoted more hours to maize production and used more homestead labor rather than hired or exchange labor), were more likely to experience sheet erosion. Demographic variables as a set had little direct impact, although homesteads with a high ratio of labor to land were also more likely to have sheet erosion.

Implications

The moderate amounts of soil erosion found and the low susceptibility to erosion of most SNL holdings reflect both past efforts at conservation such as grass stripping and contour plowing, as well as favorable characteristics of the physical environment. While the low susceptibility of most holdings to erosion decreases the probability of soil losses, it does not preclude land degradation if the width of panels increase, steeper slopes are brought under cultivation or if the contour grass strips are removed. Changes in technology, continued rapid population growth and

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increased agricultural commercialization appear to be forces that may possibly influence these conservation-related practices.

Since the allocation of additional land to existing homesteads, as well as the distribution of land to newly created homesteads, is under the control of local chiefs, future conservation policies and programs could profitably incorporate this group to insure that policies are effectively implemented. Measures that would avoid the cultivation of marginal lands and land on slopes above a given percent could be codified before increased population pressure results in their cultivation. Such preventive measures would likely be more effective than ex post programs designed to cope with the rapid degradation possible if marginal lands are brought under cultivation.

The potential impact of increasing commercialization will be more difficult to deal with. Current agricultural development policies are aimed at increasing agricultural productivity and commercialization on Swazi Nation Land homesteads. The policy of self-reliance in maize and the desire to reduce food imports will place increasing pressure on the commercial agriculture sector. If increasing commercialization is associated with increased width of panels and the removal of grass strips, as these data suggest, alternative conservation measures must be developed if future soil losses are to be prevented.

Fortunately, Swaziland has an established tradition of soil conservation with active participation by the government and the Monarchy. Swazi Nation Land farmers are also aware of the necessity to protect their soil and most already are taking steps to prevent its degradation. Given this level of awareness by farmers, the Ministry of Agriculture and

Cooperatives, through the Agricultural Extension Service and other agencies, could be utilized to deliver appropriately designed information and educational programs.

The findings of this study strongly support the need to develop models of land degradation which integrate traditional approaches, involving physical and climatological factors, with social, economic, demographic and agricultural factors. The results argue against simple interpretations of the impacts of these forces on land degradation. Aggregate level statements about the impact of population growth and environmental degradation cannot be made in the absence of knowledge about the organization and type of agriculture being practiced, the demography of farm households or national policies on conservation.

Acknowledgments

A number of persons contributed substantially to the completion of this project. The active support and encouragement of Mr. Chris Nkwanyana, Chief Research Officer at the Malkerns Agricultural Research Station, Ministry of Agriculture and Cooperatives, was essential in obtaining needed data. Ms. Millicent Malaza made a number of helpful suggestions and conducted the environmental survey. Ms. Pindele Malaza provided much needed assistance with the soil survey in which information on land degradation was obtained.

The primary data for the study were provided by the Swaziland Cropping Systems Research and Extension Training Project. Without the cooperation and support provided by members of the team, this research would not have been possible. Dr. J. Dean Jansma, Director, Office of International Agricultural Programs, The Pennsylvania State University, provided needed logistical support and assistance.

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Chapter 1

Introduction

Rapid population growth and stagnant or declining agricultural production continue to be major obstacles to social and economic development in sub-Saharan Africa. The region has the highest fertility and population growth rates in the world. A population growth rate of almost 3 percent per year compounds the already formidable problems of social and economic development. These problems are further exacerbated by the failure of food production to keep pace with population growth. Sub-Saharan Africa remains as the only major region in the world in which per capita food production declined over the past two decades.

Juxtaposition of these two trends, rapid population growth and declining agricultural production, has been interpreted to indicate that population pressure is a primary cause of the growing food deficit. This is not the case. While a rapidly growing population has placed additional pressures upon the agricultural sector, sizable amounts of arable land remain available for cultivation. One estimate is that only about 6 percent of the total land area of the region is presently cultivated, while 33 percent is potentially cultivable (Faruqee and Gulhati, 1983). Thus the constraint to additional production is not the exhaustion of the land frontier but rather the inadequacy of producer incentives, a shortage of extension, credit and marketing support, the unavailability of appropriate technology and the legacy of traditional systems of land tenure which can inhibit agricultural development. Although additional arable land is available, much of it cannot currently be reclaimed at acceptable economic costs. Consequently, preserving and improving the existing land base is important.

Although issues of population growth and environmental degradation are often phrased in global terms at the societal level, both processes are in large part the outcome of decisions made by individual couples, families, and households. An understanding of the impact of population growth on environmental degradation necessitates an explanation of the connections between the dominant economic system in relation to its environment. In a predominantly rural, agricultural society the relationships among farm household demographic circumstances and the agricultural production systems they employ are crucial in determining the future course of land degradation.

Swaziland is characterized by many of these conditions. It is a predominantly rural nation, characterized by high fertility and rapid population growth. Its current rate of growth is estimated at 3.1 percent per year, implying a doubling time of approximately 22 years. In addition, it contains a large population of subsistence and semi-subsistence farmers whose production decisions and agricultural practices will largely determine the future of land resources. The objectives of this project are to examine the relationship between population growth and environmental degradation with the context of a homestead model. Specifically, the objectives are:

1. Describe variation in homestead demographic characteristics, agricultural production patterns and land degradation.

2. Analyze the impact of homestead characteristics on the utilization of alternative agricultural production systems.

3. Examine the mitigating influence of agroclimatic and socioeconomic

factors on the relationship between homestead demographic characteristics and agricultural production patterns.

4. Estimate the relationships among each of the sets of factors and their resultant impact on land degradation.

The purpose of this study then is to examine the relationships among farm homestead demographic characteristics, the agricultural production systems they employ, and the impact of these factors on land degradation in Swaziland. Homestead demographic characteristics are likely to influence the type of agricultural production systems utilized. These relationships, however, are conditioned by the specific agroclimatic and socioeconomic environments in which homesteads earn their livelihood. Analyses of the impact of different production practices on agricultural land must take this broader environment into consideration.

As the list of objectives makes clear, land degradation is not merely the outcome of a set of physical processes. In the case of soil erosion, for example, it involves characteristics of the physical environment such as the erosivity of rainfall and/or the erodibility of soil (Hudson, 1981). Land degradation is also influenced by the social and economic system in which it occurs (Blaikie, 1985). Omission of either set of factors leads to an incomplete analysis.

Physical characteristics of the land such as the slope, soil composition, vegetative cover, and climatic factors such as the erosivity of rainfall are the proximate determinants of soil erosion. An understanding of these factors is fundamental to explaining soil erosion in a given locality. Yet, without examining the social and economic system within which soil erosion and land degradation occur, we are left with a

technical explanation of soil erosion with little guidance as to how it might be slowed, reversed or otherwise altered. The dominant cropping patterns and management practices are heavily influenced by the economic and social systems in which they are located. It should be emphasized that management practices represent the area of the greatest possible policy intervention and potential impact. Hudson (1977:173), for example, estimates that the power of erosivity to produce variation in erosion within a country is on the order of a ratio of 5:1, channel terraces altering topography and runoff might have an effect of 2:1, but "...land and crop management techniques could result in the erosion changing by a ratio of 1,000 to 1." Consequently, cropping patterns and land management techniques must be carefully examined.

Data for the project were drawn from two sources. First, is the ongoing cropping systems project funded by USAID and jointly staffed by The Pennsylvania State University and Tennessee State University in cooperation with the Ministry of Agriculture and Cooperatives of Swaziland. The Swaziland Cropping Systems Research and Extension Training Project (SCSRET) began in April 1982 and has been extended to September of 1988. One of the major objectives of this project is to understand the expressed needs of Swazi Nation Land (SNL) farmers and to identify the constraints which impede their productivity. As part of this effort, a series of surveys of SNL farmers was conducted. These surveys provided basic data on homestead demographic characteristics and agricultural production practices. In addition, data on the socioeconomic and agroclimatic environment of the homesteads were available.

Information on land degradation was not available from these sources. Consequently, a special purpose survey by a soil scientist was commissioned to obtain the necessary data on land degradation. This involved a series of indicators on the soil conditions, slope, and rainfall patterns that were not available through the SCSRET Project. These data serve as the major resource for estimation of land degradation on arable land in Swaziland and, to our knowledge, constitute the first detailed, homestead-level information on soil erosion available. Although the total sample size is comparatively small, the Middleveld and Highveld regions in which most maize in Swaziland is grown are well represented.

The following chapter describes the study methodology in some detail, including the sample and measurement procedures utilized, and outlines the general analytic approach taken. Chapter 3 presents descriptive findings on household demographic characteristics, agricultural production practices and land degradation in Swaziland. The focus is on the homestead demographic composition of SNL farmers, the relationship between these characteristics and their agricultural practices, and finally, on the nature and extent of soil erosion on Swazi Nation Land. Communal grazing lands were not part of the study and the findings are restricted to land currently being farmed by Swazi Nation Land farmers.

Chapter 4 develops and estimates several models of soil erosion and focuses attention on those management practices that appear important to future conservation efforts. Finally, the findings are placed in the policy context within which soil conservation efforts in Swaziland will likely take place.

Chapter 2

Research Procedures

Data for the study were collected by the Socioeconomic Section of the Swaziland Cropping Systems Research and Extension Training Project during the 1985-86 cropping season. The original sample consisted of 120 homesteads drawn from 20 sub-areas of ten rural development areas (RDAs). Due to limitations of time and personnel, this study was further restricted to 95 homesteads located in 16 sub-areas in eight RDAs. These RDAs represent the Highveld and Middleveld regions of Swaziland in which most maize in the country is grown. The Lowveld in which cotton and irrigated sugar cane predominate had to be excluded.

The sample was drawn using a random cluster technique with replacement. Extension workers' lists of farmers formed the initial sampling frame. In the Northern, Mahlangatsha, Central, Ngwempisi, Bhekinkosi and Southern RDAs, 24 farmers were chosen using a table of random numbers. Research assistants administered a cooperator identification questionnaire to each of these farm families. This questionnaire provided general information on household size, composition, resource endowment, equipment ownership and general farming practices. This information was used to assist the project in selecting a cooperator for the trial, and in no way determined selection for the labor and input study sample.

The first 12 homesteads in random order were chosen, six from each of two areas within the RDA. Homesteads which had indicated during the interviews an unwillingness to participate were removed from the selection sequence, and were replaced by the next homestead in the random order.

Interviews in the sample RDAs began during the first week of November, 1985. They continued weekly until all the fields of the homestead had been harvested. For some cotton farmers, this meant that the interviews continued until June of 1986. Research assistants interviewed one informant weekly in each homestead to obtain recall information on the number of hours spent in productive tasks on fields cultivated by the homestead during the week prior to the last visit. Labor hours were recorded according to three categories: adult males, adult females, and children less than 15 years of age. In addition, all labor inputs were classified into homestead labor, exchange labor, invited labor (lilima) and wage labor. The type of equipment and inputs used in each activity were obtained for each homestead, e.g., fertilizer and pesticide usage, seeds, and so forth.

The same random selection procedure was used to select 8 and 15 homesteads in Hluti and Sandleni/Luqolweni, respectively. However, data collection in the Hluti and Sandleni/Luqolweni RDAs was begun about four weeks later in December of 1985. By this time much of the plowing and planting of maize and other crops had been completed. Despite attempts to recover data on these tasks from follow-up interviews, much of these data were lost. The estimates for total hours plowing and planting for these RDAs are undoubtedly underestimated. In addition, equipment ownership had to be estimated from the cooperator farmer survey questionnaires, rather than from the weekly interview data set. Consequently, the data in these categories for Hluti and Sandleni/Luqolweni must be interpreted with caution. Fortunately, for purposes of this study, these data are not crucial to the central issues being examined.

Data were entered on an IBM XT microcomputer at the Malkerns Research Station using the dBaseIII data base management package. Summary totals of labor and inputs used in maize production for each homestead were constructed through a series of dBaseIII programs and stored in summary files. Basic descriptive statistics were obtained through a Lotus Symphony worksheet. Although records for 95 homesteads were available in the eight RDAs covered by the original labor input and utilization surveys, an additional five households had dropped out of the sample by the time the follow-up survey on land degradation was carried out. Consequently, the analysis is based on 90 households scattered throughout the Highveld and Middleveld (Figure 1). These households are located in both the wet and dry portions of the Middleveld and thus represent a variety of agroclimatic conditions.

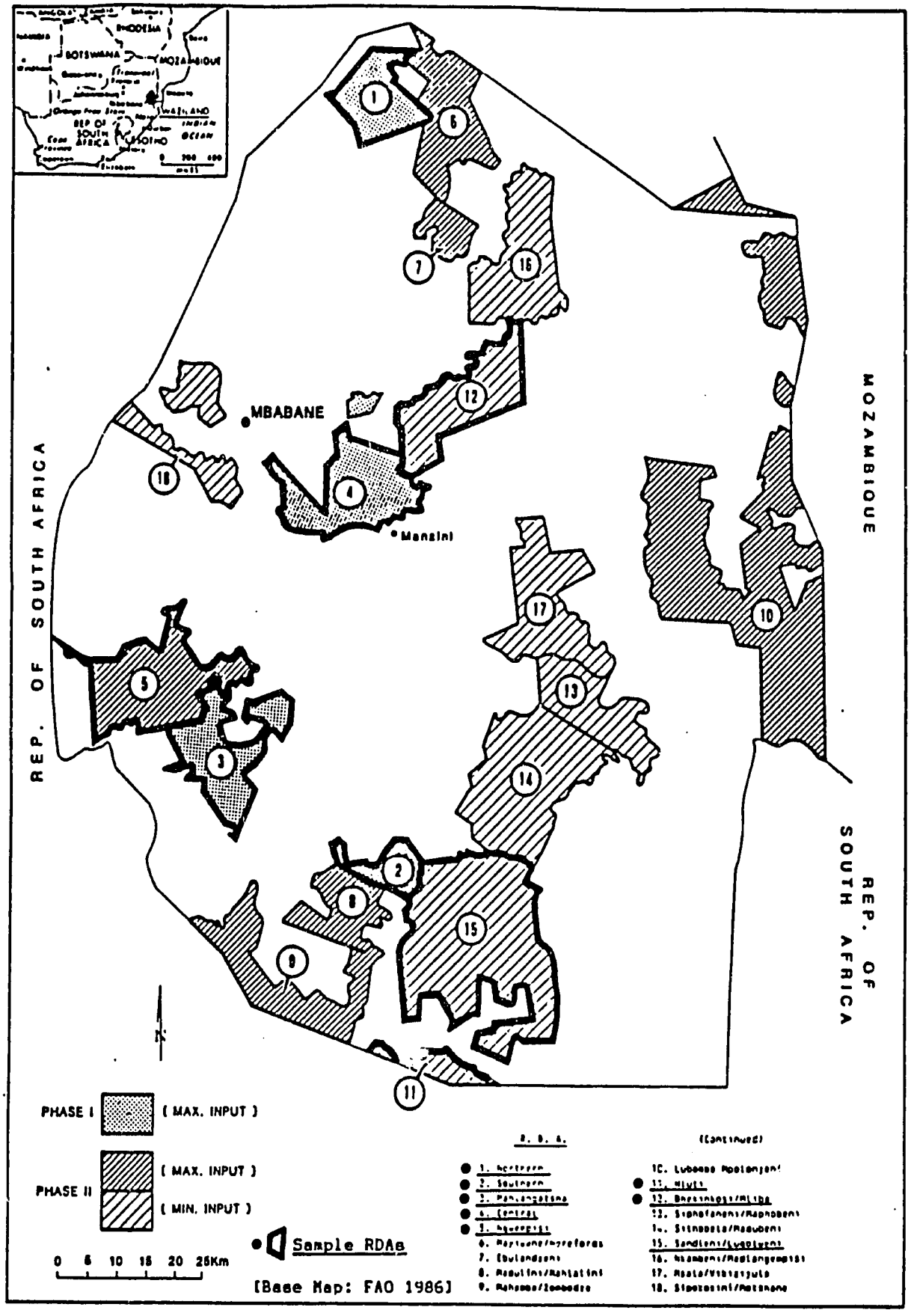
Data from these labor input and utilization surveys were summarized into yearly totals by Dr. John Curry of the Socioeconomic Section of the SCSRET Project. These summary data were used to create a file containing the homestead demographic characteristics, the agricultural production practices and selected socio-economic characteristics of the homesteads. These files were transferred to The Pennsylvania State University where the data analysis was completed.

Measurement of Variables

Measures were developed for five major categories of variables: (1) homestead demographic characteristics, (2) agroclimatic characteristics, (3) the socioeconomic environment, (4) agricultural practices and (5) land degradation. Multiple indicators were examined within each category of factors.

Figure 1

Location of Sample RDAs in Swaziland



Homestead demographic characteristics

Homestead demographic factors are the outcome of past population trends and reflect homestead and household decision making with regard to family size, migration and employment patterns. These characteristics represent the homestead-level analogue to macro-level demographic trends and are a key focus of this study. Homestead-level demographic variables include the size of homestead, the number of households on the homestead, the number of adult males and adult females, the number of children under 15 years of age, the number of adult males and females employed off the farm, and the subsistence orientation of the household. Clearly, many of these factors are highly interrelated and cannot be incorporated in the same analysis. Preliminary analyses focused on selecting those factors best representing household resources available for labor either on the homestead or employed elsewhere.

Agroclimatic characteristics

Agroclimatic factors are represented by the major geographic and climatic zones of Swaziland. The nation is divided into four major regions: the Highveld, the Middleveld, the Lowveld, and the Lubombo region. The Highveld covers approximately 29 per cent of the country. It is the wettest and coolest part of the country with average elevations between 1,050 and 1,400 meters. Rainfall varies between 1,000mm and 1,500mm but with some areas experiencing as much as 1700mm. The Middleveld contains about one-fourth of Swaziland's land area and is the most densely populated region. Elevations range between 300 and 1,050 meters. The rainfall declines from west to east but average precipitation falls between 760 and

1,000mm per year (Goudie and Williams, 1983). The Middleveld is the dominant agricultural area of Swaziland.

The largest area, the Lowveld, contains almost 40 percent of the land area but lies at elevations between 150 and 300 meters. Precipitation is generally low, temperatures are high and variable, and the drought risk makes the area unsuitable for maize production. The Lubombo is the smallest area consisting of a small strip of land separating Swaziland from its eastern neighbor, Mozambique.

Because of the expense in gathering homestead-level data on land degradation, the sample homesteads in the two RDAs located in the Lowveld were eliminated. These homesteads were located the greatest distance from the research base at the Malkerns Research Station. Moreover, with maize as the principal staple crop of Swazi Nation Land farmers, the focus was directed toward the dominant type of farmer and crop. The two regions, Highveld and Middleveld, are quite diverse in agroclimatic conditions. In addition, the Middleveld was further sub-divided into dry and wet portions.

In addition to classifying homesteads by their veld location, soil erodibility and erosivity characteristics were also obtained (see Appendix A). The steepest slope gradient of homestead land provided information on topographical conditions. These measures reflect the physical and climatological characteristics influencing land degradation. Although these factors were not of primary analytic interest to this study, their influence must be taken into account when examining the independent impacts of agricultural practices and land management techniques.

Socioeconomic environment

Four indicators of the socioeconomic environment were developed in consultation with members of the Swaziland Cropping Systems Research and Extension Training Project. Agricultural activities in any locality are influenced by the social and economic environment in which they occur. This is particularly important for nations such as Swaziland. Its small size and comparatively well-developed transportation system makes off-farm employment, and labor and product markets much more accessible than is the case in many nations. The presence and location of these factors can influence the nature and type of farming activities, land management practices, and ultimately, land degradation.

The four indicators of the socioeconomic environment were: (1) distance to product markets which, in this case, was measured by the distance in kilometers from the RDA in which a household was located to Manzini, the commercial and transportation center of Swaziland, (2) access to factor markets, measured as the distance in kilometers from the RDA center to the nearest central place, (3) RDA center access, measured as the distance in kilometers from the household to the RDA center and (4) employment opportunities. This latter variable was derived by dividing the nation into six regional labor markets: north, south, west, east, central and northeast. The distance from each RDA to each of the six regional labor markets was calculated and ranked from most accessible to least accessible. Summing the ranks provided an index, albeit crude, of the accessibility of an area to employment opportunities.

Agricultural production practices

Swazi Nation Land farmers have usufructuary rights to land held in trust for them by the King and administered by local chiefs. The average size of holding is small, grazing is free on communal land and cattle are viewed as a store of wealth (Booth, 1983:126; Doran et al., 1979). Some chiefs are said to view improvements in land as a threat to their authority. Thus the tendency is to invest more in cattle than in land augmenting factors such as fertilizers and seed. Even when such investments are made, they are often intended to increase yields for homestead subsistence needs, rather than producing a surplus for sale (Low, 1986). Moreover, off-farm employment opportunities provide attractive, and often superior, income-generating possibilities, further competing for the homestead labor supply (de Vletter, 1983).

Under these conditions, it is not surprising that cropping patterns and productivity vary widely even within a fairly small geographic area. A number of indicators of agricultural production practices were examined. These include: numbers of crops, size of cultivated area, number of fields or panels on the homestead, maize yields, homestead hours spent in maize production, percent of hours in maize production contributed by homestead members, equipment usage, animal ownership, number of panels per hectare, width of widest panel and average width of panels. These practices encompass a range of activities with varying potential for influencing land degradation. Although additional indicators would have been helpful, the purpose of the SCSRET Project surveys was not to measure factors related to land degradation. Within the limitations imposed by secondary data, these indicators appear to tap a number of important dimensions.

Land degradation

Data on land degradation were gathered through a soil survey commissioned for this purpose. Ninety of the 95 potential homesteads were visited by a soil scientist who evaluated the landholdings of each homestead. A large number of quantitative and qualitative measurements were made (Appendix A). For purposes of this investigation, the primary measures of land degradation were twofold: sheet erosion and rill or gully erosion. Sheet erosion refers to the detachment of soil particles through the impact of rain drops and their downslope transport in thin sheets rather than in defined channels. In contrast, rill erosion refers to localized small washes, defined as channels of 30 centimeters or less in depth and small enough to be eliminated by plowing. Gully erosion refers to the removal of soil through large established channels greater than 30 centimeters in depth and which cannot usually be crossed by farm implements.

Each homestead was classified on the extent to which sheet, rill and/or gully erosion was present on their landholdings. If rills and gullies were present, their depth and the distance between them was also recorded. Sheet erosion was classified into four levels ranging from (1) no evidence of erosion, well-developed A-horizon, (2) A-horizon partially eroded, tillage implements reach underlaying horizon, (3) A-horizon very thin, underlaying horizon at surface in places, to (4) A-horizon eroded, parts of underlaying horizon eroded. Rills and gullies were classified into three ordinal categories: (1) rills of 5 to 30 centimeters in depth, (2) shallow gullies of between 31 and 100 centimeters depth, and (3) deep gullies from 101 to 300 centimeters in depth. Although the distance

between rills or gullies was recorded, the variation was insufficient to warrant further analysis.

Additional measures of potential degradation were included but revealed little variation among homesteads. For example, the soil effective depth was greater than 50 centimeters in all but 21 of the 112 fields examined. The most important omission was the inability to measure land degradation on communal grazing land. The original intention was to include data on the erosion occurring on grazing lands utilized by each homestead. However, in many areas, grazing lands were not adjacent to homesteads but located some distance away. The practice of grazing animals at some distance from the homestead, often in the care of other persons, speaks to the pressure on available grazing lands. Casual inspection of these areas appears to support the widely held view that grazing lands are seriously over-utilized and many are badly eroded (Booth, 1983; Roder, 1977, as cited in Blaikie, 1985).

Each of the five major sets of variables--homestead demographic characteristics, the agroclimatic environment, the socioeconomic environment, agricultural production practices and land degradation--is discussed more fully in subsequent chapters as the findings are presented. A detailed discussion of each indicator is also included. The full set of indicators obtained in the soil survey are included as Appendix A. These indicators represent one of the first homestead-level data bases on land degradation in Swaziland.

The analytical strategy employed is to first describe homestead demographic and agricultural characteristics and the extent of land degradation on SNL homesteads. This descriptive information provides the

base for developing regression models of homestead demographic characteristics and agricultural practices thought to influence land degradation. These models focus on the impact of demographic factors, agricultural production practices, agroclimatic conditions, and socioeconomic factors on sheet, rill and gully erosion. After identifying those demographic and agricultural practices associated with land degradation, and estimating several models of soil erosion, the analysis focuses on conservation-related agricultural practices because many of these have potentially important impacts on land degradation. Moreover, an understanding of these practices is crucial to future policy efforts directed at conservation.

Chapter 3

Homestead Composition, Agricultural Practices and Land Degradation in Swaziland

Rural Swazi homesteads resident on Swazi Nation Land control 56 percent of the total land area and contain over 80 percent of the nation's population (de Vletter, 1983). Although these homesteads produce maize and other crops primarily for home consumption, the majority have non-resident workers employed for wages off the homestead, and over one-third have wage earners living on the homestead (Low, 1986). The homesteads included in the SCSRET Project sample share these characteristics. While approximately one-fourth of the homesteads can be classified as non-commercial (subsistence) maize producers, most have some members, either resident or non-resident, employed for wages.

While there is debate over the proper unit of analysis, the homestead or the household (de Vletter, 1983; Russell, 1983), for purposes of this study the homestead is used. The primary justification for this lies in the focus on land degradation. Although consumption of homestead production takes place within households, production is largely a homestead operation (Russell, 1983). Moreover, the land allocated to a given homestead is located within a limited geographic area. The management practices and cropping patterns used on this resource base are not determined by a single household, but by the size and composition of the households located on the homestead. The total number of adults available for productive labor on the homestead, for example, is likely to influence the number of crops grown and the amount of land cultivated.

Homestead demographic characteristics are discussed first in the descriptive findings since the relationship between homestead demographic

factors and land degradation is of primary analytic interest. Homestead size and composition are related to the organization of work activities both on and off the homestead. Thus agricultural practices and the resulting impact on land degradation are viewed as partially dependent upon homestead size and composition.

Homestead Demographic Characteristics

Descriptive characteristics on the demographic composition of sample homesteads are given in Table 1. Homestead size is an important factor in determining one major productive resource of rural homesteads--labor availability. Average homestead size including both resident and nonresident members was slightly greater than 12 persons per homestead. Homesteads had an average of 2.5 persons living elsewhere, yielding an average resident population between 9 and 10 persons. The range in homestead size was from a low of three persons to a high of 37. Most homesteads contained a single household (73%), but slightly more than one in four had two or more households, with the largest homestead consisting of six households.

The average homestead size of this sample was larger than that reported by de Vletter (1983) or Low (1986), although the average number of nonresident members was quite similar. Restriction of the sample homesteads to the High and Middleveld contributed to this finding since homesteads in these regions are slightly larger than those in the Lowveld and Lubombo regions. More importantly, the decision rules utilized to include or exclude absentee members can markedly influence homestead statistics (Russell, 1983), and the SCSRET sample data appear to inflate the average size of homestead.

Table 1. Selected Demographic Characteristics of Swazi Nation Land Homesteads, 1985-1986 Cropping Year

Characteristic	Average or Percent	Standard Deviation	Minimum	Maximum
Number of Households in Homestead	1.48	0.97	1.00	6.00
Total Homestead Population	12.13	6.43	3.00	37.00
Total Resident Population	9.64	4.96	2.00	26.00
Non-Resident Population	2.49	2.49	0.00	13.00
Resident Adults	4.07	2.73	1.00	18.00
Resident Children < 15 Years	5.58	3.45	0.00	16.00
Persons in Off-Farm Work	2.23	2.14	0.00	9.00
Head Employed Off-Farm (%)	30.00	na	na	na
Persons in Off-farm Work	2.23	2.14	0.00	9.00
Male Head of Homestead (%)	83.33	na	na	na

Source: Swaziland Cropping Systems Research and Extension Training Project, Highveld and Middleveld Homesteads.

The typical homestead was headed by a male (83.3%) and had 2.2 members employed off-farm for wages. In almost one-third of the homesteads (30.0%), the head was employed off-farm. Less than one homestead in five (16.7%) had no one employed off-farm. Thus, with more than eighty percent of homesteads containing members employed off-farm, Swazi Nation Land homesteads were actively involved in both the traditional and nontraditional sectors of the economy. Policies in the rural and

agricultural sector, including land conservation policies, must contend with this basic fact.

Homesteads appear to allocate labor between farm production and off-farm employment based upon their size, composition and the availability of off-farm employment opportunities. Males were more likely to work off-farm for wages, while females remained primarily responsible for agricultural production on the homestead (Table 2). Homesteads had an average of 1.6 males working off-farm for wages, but less than one female per homestead (0.6) was engaged in off-farm work. Information on the educational and employment experience of homestead members was not available for this sample. Consequently, it was not possible to examine the characteristics of those employed off-farm in comparison to those remaining on-farm. Given that homesteads had approximately equal numbers of male and female adults, 3.3 and 3.2, respectively, males clearly predominate in off-farm employment. This most likely reflects lower female opportunity costs in the off-farm sector than their male counterparts and thus their concentration on agricultural production.

Although homestead size provides the basic labor resource, how the labor is allocated is important to the nature and extent of agricultural production activities on the land. Table 2 includes data on two additional measures of household demographic composition: production units and consumption units. Production units were calculated using the resident population of the homestead. Adult males and adult females were each counted as 1.0 units, children 10 to 14 years of age were considered to be .80 units, children 5 to 9 years were given a value of .25, while children less than 5 were counted as 0.0 production units. The range in production

units was from 1.80 to 20.9 units, with a mean of almost 6 units per homestead.

Homesteads are considered the primary unit of production for purposes of this analysis. However, they also are the physical location of much consumption, although consumption may vary substantially among households on a given homestead. The number of consumption units supported by each homestead was calculated by counting adult males as 1.0 units, adult females and children 10 to 14 as .75 units, children 5 to 9 as .50 units, and children less than 5 as .20 units. Homesteads averaged just over 6 consumption units even though the average resident population was 9.6. The youthful age composition of the Swazi population, reflecting the pattern of high fertility accounts for this finding.

The average age of the homestead head reflects the dual involvement of most homesteads in both the traditional and nontraditional sectors of the economy. Heads varied in age from 30 to 79 years of age with a mean age of 51.5 years. As Low (1986) and others have noted, Swazi households not only change in size over the course of their life cycle, but also in their producer/consumer ratio. Many young Swazi males work off-farm during their early adult years and return to their homesteads at a later time. The relatively small number of cases in this sample precluded an examination of homesteads by stage of the domestic development cycle, but the data appear consistent with those of Low (1986) and others.

TABLE 2. Homestead Age and Sex Composition, Number of Production and Consumption Units and Off-Farm Employment by Sex, Swazi Nation Land Farmers, 1985-1986 Cropping Year

Characteristic	Average	Standard Deviation	Minimum	Maximum
Age of Homestead Head	51.54	11.56	30.00	79.00
Adult Males	3.31	2.29	0.00	14.00
Adult Females	3.24	2.21	1.00	11.00
Children Age < 5 Years	1.88	1.83	0.00	8.00
Children Age 5-9 Years	1.91	1.63	0.00	8.00
Children Age 10-14 Years	1.79	1.50	0.00	7.00
Production Units	5.98	3.34	1.80	20.90
Consumption Units	6.13	3.22	1.50	19.35
Male Adults in Off-Farm Work	1.61	1.57	0.00	9.00
Females in Off-Farm Work	0.62	1.00	0.00	4.00

Source: Swaziland Cropping Systems Research and Extension Training Project, Highveld and Middleveld Homesteads.

Although all of the homesteads included in this sample are involved in agriculture, not all homesteads and their constituent households can be considered to be farmers. As Testerink (1984) notes, not all Swazi households that produce agricultural commodities are engaged in farming. Homesteads in which the head works off-farm for wages and who produce far less than their subsistence needs are more properly classified as gardeners rather than farmers.

Testerink's (1984) classification scheme was employed to classify homesteads into three categories of agriculturists: commercial, semi-

commercial and non-commercial. His scheme is based on the argument of Hinderink and Sterkenberg (1980:11, as cited in Testerink, 1984:1):

> "agricultural commercialization involves deliberate action on the part of the agricultural producers...to use the land, labour, implements and annual inputs...in such a way that a greater or smaller part of the crops produced...is for exchange or sale. Incidental sales due to emergencies or accidental surpluses that are marketed should not be considered a form of agricultural commercialization."

Since maize is the principal staple crop, subsistence needs were calculated for each homestead assuming that annual per capita requirements for adults was 250 kg and 125 kg for children. These subsistence needs were then compared to the expected output of maize. Given the area under maize cultivation, the plant population, the location of the household and other agricultural characteristics, the expected output could be calculated.

Given the vagaries of agricultural production, most homesteads would logically aim for some surplus to provide a margin of safety. The ratio of expected maize output to homestead needs provided the primary basis for classification. When this ratio was 2 or greater, that is, the intended production was 200 percent or more of subsistence requirements, the homestead was considered to be a commercial producer. If the aim was between 125 and 199 percent of needs, the producer was classified as semi-commercial. An aim of less than 125 percent resulted in assignment to the non-commercial (subsistence) category.

Of course, maize is not the only crop grown by Swazi Nation Land farmers. Under appropriate agroclimatic conditions, a homestead might produce a smaller amount of maize in order to concentrate its agricultural production on cash crops which could then be sold to purchase maize. In

order to account for these contingencies, the following criteria were used to classify homesteads into one of three groupings.

Commercial Farmers

A farmer was classified as commercial if any of the following conditions were met:

a. Maize output aim was greater than or equal to 200 percent of homestead requirements.

b. Legume output aim was greater than or equal to 150 percent of homestead needs.

c. Fifty percent or more of arable land or 2.5 hectares in cotton.

d. Twenty-five percent or more of arable land or greater than one hectare in tobacco.

Semi-Commercial Farmers

Semi-commercial farmers were those meeting the following criteria:

a. Maize output aim was at least 125 percent but less than 200 percent of homestead requirements.

b. Legume output aim was at least 125 percent but less than 150 percent of needs.

c. Produce some cotton but on less than 50 percent of arable land.

d. Produce some tobacco but on less than 25 percent of arable land.

Non-Commercial Farmers

Non-commercial farmers were those who met none of the above criteria but land was not a constraint (Testerink, 1984:5). Although Testerink excluded homesteads with insufficient land from his typology, they are included in this analysis due to the small number of cases in the total sample. Most households had sufficient land to meet subsistence needs.

In addition to these conditions, any homestead that met any two of the criteria for semi-commercialization, were classified as commercial. Although these categories are somewhat arbitrary and alterations in the definitions would yield different results, it was felt that they did

identify homesteads with different orientations toward agriculture. Homesteads seeking to produce 200 percent of needs are likely to engage in different farming practices than those simply seeking to meet subsistence needs. Moreover, the different uses of land and associated cropping patterns might result in differential land degradation, the major focus of this study.

Approximately 50 percent of sample homesteads were classified as commercial farmers, while roughly one-fourth each fell in the semi-commercial and non-commercial categories (Table 3). This sample contains almost twice as many commercial homesteads as found by Testerink (1984). Whether this difference is due to restriction of the sample to the Highveld and Middleveld and/or to RDA homesteads could not be determined.

Table 3. Agricultural Commercialization of Swazi Nation Land Homesteads, 1985-1986 Cropping Year

Farm Category	No. of Homesteads	% of Homesteads
Non-Commercial	22	24.44
Semi-Commercial	22	24.44
Commercial	46	51.11
Total	90	100.00

Source: Swaziland Cropping Systems Research and Extension Training Project, Highveld and Middleveld Homesteads.

Homestead demographic composition by degree of agricultural commercialization is shown in Table 4. Interestingly, commercial homesteads had the smallest total population, the smallest resident population and the fewest number of resident adults. This observation is consistent with Testerink's (1984) findings, but runs counter to Low's (1982a) suggestion of a positive relationship between household size and maize self-sufficiency.

Not surprisingly, similar results obtained when the number of production units was utilized as the measure of labor availability. Commercial and non-commercial homesteads had approximately equal numbers of production units, 5.42 and 5.88 units, respectively. Semi-commercial units had an average of 7.23 production units, reflecting greater labor availability than either commercial or non-commercial homesteads.

Table 4. Homestead Demographic Characteristics by Agricultural Commercialization Category, Swazi Nation Land Homesteads, 1985-1986 Cropping Year

	Farm Category			
Characteristic	Non-Commercial	Semi-Commercial	Commercial	Total
Resident Adults	4.00	5.18	3.57	4.07
Resident Children < 15 Years	5.91	6.82	4.83	5.58
Resident Persons	9.91	12.00	8.39	9.64
Consumption Units	6.13	7.48	5.49	6.13
Production Units	5.88	7.23	5.42	5.98
Persons in Off-Farm Work	3.27	2.82	1.46	2.23
Total Homestead Population	13.50	15.09	10.07	12.13

Source: Swaziland Cropping Systems Research and Extension Training Project, Highveld and Middleveld Homesteads.

Non-commercial (subsistence) producers had the largest average number of persons employed in off-farm work, 3.27 per homestead. Commercial farmers, in contrast, had about 1.5 workers on average involved in off-farm work. As most observers of Swazi Nation Land farmers have noted, virtually all homesteads have some workers in off-farm employment. These findings support Testerink's (1984) conclusion that the decision to become a commercial or non-commercial producer is not primarily determined by the availability of homestead labor. Commercial homesteads actually had the least labor available and had the fewest number of workers employed off-farm. They also had the smallest number of consumption units per household--5.49.

Agricultural Characteristics of Homesteads

Although homestead labor resources are fundamental to agricultural production on Swazi Nation Land, the availability of land is equally important. All Swazis are entitled to their portion of Swazi Nation Land. Ngubane (1983:103) notes, for example, that:

> "Every Swazi is entitled as of right to reside on Swazi Nation Land and to derive from it a living, whether by cultivation or by pasturing livestock or both. He is thus assured always of having somewhere to stay and also at least minimally of the means of life. He cannot be made homeless or destitute by foreclosure on his house or property if these are on land which belongs not to him outright but to the Swazi nation, whose resources as a Swazi he is entitled to share. This entitlement he possesses not as an abstract individual member of the nation but as belonging to a particular umuti (homestead) which in turn belongs to a particular chiefdom subordinate to the King."

Although each Swazi is entitled to a portion of Swazi Nation Land, and the allocation of land by local chiefs is responsive to the creation of new households on homesteads and increasing homestead populations, not all homesteads have access to the same quantity or quality of land. Landholdings are smaller in some areas than in others and land availability

is influenced by population density, the historical pattern of land settlement, including the notorious concessions (Booth, 1983), as well as a host of other factors. Because of its fundamental importance, the discussion of agricultural characteristics begins with an examination of landholdings.

While labor resources are not a constraint to commercial production among most SNL farmers, the same cannot be said of land resources. Almost half (45.4%) of non-commercial homesteads had access to less than one hectare of land, compared to less than five percent of commercial farmers (Table 5). Conversely, 60 percent of commercial homesteads controlled two or more hectares, compared to only 18.1 percent of non-commercial producers. Semi-commercial farmers were of intermediate size, although much closer in size to commercial than to non-commercial operations. The average size of holdings varied from 1.36 hectares among non-commercial farmers, to a high of 2.56 hectares for commercial farmers. Semi-commercial homesteads were quite similar (2.54 hectares) to commercial farmers.

The overwhelming majority of land controlled by the homestead was under cultivation in all three categories of producers. Non-commercial homesteads cultivated just over one-and-a quarter hectares of land. Commercial and semi-commercial homesteads farmed almost twice as much land, 2.48 and 2.43 hectares, respectively. The availability of land does appear to influence household decision making with regard to commercial production. Interestingly, semi-commercial homesteads had almost the same amount of land as commercial producers, but with significantly more labor available for homestead use. These homesteads apparently either have opportunities available to them that are not available to commercial

producers, or have different human and/or physical capital endowments that lead to different agricultural production goals. For whatever reasons, these homesteads utilize their labor in off-farm employment to a much greater extent.

Table 5. Size of Land Holdings by Agricultural Commercialization Category, Swazi Nation Land Homesteads, 1985-1986 Cropping Year

	Farm Category							
	Non-Commercial		Semi-Commercial		Commercial		Total	
Hectares	No.	%	No.	%	No.	%	No.	%
Under .5	1	4.55	1	4.55	0	0.00	2	2.22
0.5 - 0.9	9	40.91	2	9.09	2	4.35	13	14.44
1.0 - 1.9	8	36.36	10	45.45	16	34.78	34	37.78
2.0 - 2.9	3	13.64	6	27.27	15	32.61	24	26.67
3.0 - 3.9	0	0.00	0	0.00	8	17.39	8	8.89
4.0 - 4.9	1	4.55	0	0.00	2	4.35	3	3.33
5 & over	0	0.00	3	13.64	3	6.52	6	6.67
Total	22	100.00	22	100.00	46	100.00	90	100.00
Mean size of holding (ha.)		1.36		2.54		2.56		2.26
Mean size cultivated (ha.)		1.28		2.43		2.48		2.18

Source: Swaziland Cropping Systems Research and Extension Training Project, Highveld and Middleveld Homesteads.

Differences in land availability are perhaps most clear when the ratio of landholdings to household consumption and production units is examined (Table 6). For the entire sample, approximately .4 hectares of land were available per consumption unit. Among the non-commercial producers, this was only .25 hectares of land per consumption unit. Although semi-commercial homesteads control almost as much land as commercial homesteads, their larger size produces only .32 hectares of land per consumption unit. Commercial growers have over one-half hectares (.52) of land per consumption unit. This larger land base per consumption unit enables commercial producers to exceed homestead subsistence needs by considerable margins. Moreover, the larger landholdings per homestead member allows labor resources to be more profitably employed on the farm, while limiting the number of persons available for off-farm employment.

The location of the homestead in relation to off-farm employment opportunities is also important to this relationship. Middleveld homesteads, particularly those in the Central RDA, have perhaps the greatest access to off-farm employment opportunities and are also the largest homesteads. These opportunities are described later in this chapter under the section entitled Socioeconomic Environment.

Table 6 includes data on the number of production units per hectare of land. These data are consistent with the homestead composition findings. Commercial homesteads had an average of 2.36 production units per hectare of land. This is approximately half the number of production units per hectare available on non-commercial holdings--5.70. Semi-commercial homesteads occupy an intermediate position with 3.34 production units per hectare.

Table 6. Land Ratios by Agricultual Commercialization Category, Swazi Nation Land Homesteads, 1985-1986 Cropping Year

Ratios	Farm Category			
	Non-Commercial	Semi-Commercial	Commercial	Total
Total Land/ Consumption Units	0.25	0.32	0.52	0.41
Cultivated Land/ Consumption Units	0.24	0.31	0.51	0.39
Production Units/ Total Land	5.70	3.34	2.36	3.42
Production Units/ Cultivated Land	5.89	3.63	2.43	3.57
Consumption Units/ Total Land	5.90	3.66	2.40	3.56
Consumption Units/ Cultivated Land	6.09	3.99	2.47	3.73

Source: Swaziland Cropping Systems Research and Extension Training Project, Highveld and Middleveld Homesteads.

The population/land ratios do appear to be related to the subsistence (non-commercial) orientation of the homestead. Commercial homesteads have the largest absolute holdings, although only marginally larger than semi-commercial homesteads. However, when the ratio of production or consumption units per hectare of land is examined, commercial homesteads are markedly different than either semi- or non-commercial homesteads. They have twice as much land per consumption unit, but contain only half the productive units per hectare that subsistence homesteads have. Semi-commercial homesteads have average holdings quite similar to commercial growers, but their larger size households greatly reduces the available land per worker or consumer.

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While the size and distribution of landholdings are important, how the land is used in the production of crops and livestock is of primary importance in land degradation. Land management and cropping patterns have great potential to influence the extent of soil erosion. The importance of maize in Swaziland is revealed by the data in Table 7. One hundred percent of sample homesteads had some land planted in maize, although two homesteads failed to produce any maize. Over eighty percent of the cultivated holdings were planted in maize. An average of 1.78 hectares were planted in maize out of a total average cultivated holding of 2.18 hectares.

From the perspective of its potential impact on land degradation, the number of maize fields[1] may be more important than the total hectares devoted to maize. The average homestead had just over seven fields (7.14) planted in maize. Dividing the average hectares in maize by the number of fields yields an average size maize field of approximately .25 hectares. This reflects the Swazi practice of breaking the length of the slope by the insertion of grass strips or channel terraces. Grassed waterways are also used to divert runoff from the fields. The use of grass strips, plowing along the contour and the diversion of runoff undoubtedly have had a major impact on limiting soil erosion on Swazi Nation Land (Reij, 1984).

Although maize is the principal staple crop among these homesteads, they produce a variety of other crops as well. In addition to the fields planted in maize (many of which were intercropped), homesteads averaged two additional fields planted in other crops. Data on seven crops are presented in Table 7. Other than maize, beans were the most commonly grown

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[1]It is common usage in Swaziland for plowed contour strips to also be referred to as panels. The terms panel and field are used interchangeably in this report.

crop with almost one-third of homesteads (31.1%) growing beans. Beans were followed in frequency by sweet potatoes (23.3%) and ground nuts (22.2%). Cotton was grown by only 14 percent of respondents. Clearly, a much larger percentage of homesteads in the Lowveld produce cotton, but this region was not represented in the sample. Only three percent of homesteads produced tobacco and 5.6 percent produced sorghum.

The data in Table 7 describe crop production patterns as measured by the number of fields or panels planted in a given crop. Patterns of intercropping are not included in these data. For example, intercropping of pumpkins or beans in fields primarily devoted to maize production, a common practice in Swaziland, is not reflected in these data. Inclusion of such practices, however, would not markedly alter these results.

The demographic composition of homesteads, presented in Tables 1 through 4, indicated substantial variation in the size, composition and employment patterns of homesteads. While most homesteads had some members employed off-farm, they differed substantially in the degree to which they utilized their labor resources in agricultural production. These differences are most clearly revealed when actual labor utilization patterns are examined. Patterns of labor utilization in maize production are given in Table 8.

Homesteads varied markedly in the number of hours devoted to maize production. The average number of hours in maize production was 564 per homestead, with a standard deviation of 537. One homestead had over 3,000 hours invested in maize production, while at the other extreme, another homestead expended only 41 hours. The extent to which maize production was dependent upon the labor of women is apparent in Table 8. Women

Table 7. Cropping Patterns and Land Use on Swazi Nation Land Homesteads, 1985-1986 Cropping Year

	Average or Percent	Standard Deviation	Minimum	Maximum
Total Hectares Arable Land (incl. fallow)	2.26	1.65	0.28	10.77
Hectares Cultivated Land	2.18	1.60	0.28	10.77
Number of Fields	9.63	5.23	1.00	26.00
Number of Fallow Fields	0.28	0.45	0.00	1.00
Hectares in Fallow Fields	0.09	0.22	0.00	1.13
Number of Crops Grown	2.80	1.49	1.00	7.00
Percent Planting Maize	100.00	na	na	na
Maize Hectares as % of Total Hectares	81.61	19.76	15.45	100.00
Number of Fields in Maize	7.14	4.33	1.00	26.00
Hectares in Maize	1.78	1.26	0.28	7.06
Maize Yield (Kg./Ha.)	2104.34	904.20	0.00	6348.00
Percent Planting Cotton	14.44	na	na	na
Number of Cotton Fields	0.76	2.40	0.00	16.00
Hectares in Cotton	0.21	0.63	0.00	3.71
Percent Planting Beans	31.11	na	na	na
Number of Bean Fields	0.47	0.77	0.00	3.00
Hectares in Beans	0.06	0.11	0.00	0.43
Percent Planting Sweet Potatoes	23.33	na	na	na
Number of Sweet Potato Fields	0.29	0.59	0.00	3.00
Hectares in Sweet Potatoes	0.03	0.07	0.00	0.39
Percent Planting Sorghum	5.56	na	na	na
Number of Sorghum Fields	0.09	0.47	0.00	4.00
Hectares in Sorghum	0.02	0.14	0.00	1.17
Percent Planting Groundnuts	22.22	na	na	na
Number of Groundnut Fields	0.33	0.76	0.00	4.00
Hectares in Groundnuts	0.06	0.16	0.00	1.19
Percent Planting Tobacco	3.33	na	na	na
Number of Tobacco Fields	0.03	0.18	0.00	1.00
Hectares in Tobacco	0.01	0.06	0.00	0.51

Source: Swaziland Cropping Systems Research and Extension Training Project, Highveld and Middleveld Homesteads.

contributed over half the total number of hours expended on maize. The remaining hours were almost equally divided between adult males and children, with males contributing just over one-fourth of the total hours spent on maize. Children less than 15 years of age were not an insignificant resource in maize production, expending an average of 123 hours, over one-fifth of the total labor in maize.

As expected, most labor in maize production was contributed by members of the homestead. Over eighty-five percent of all labor in maize was by homestead members. This varied from just over 20 percent on one homestead to 100 percent on others. Exchange labor and hired labor combined comprised approximately 10 percent of total maize hours with an average of 31.6 and 26.4 hours, respectively.

Weeding and thinning of maize required substantial labor inputs, second only to harvesting in terms of total hours. The data suggest that maize production continues to be a labor intensive activity on Swazi Nation Land. Approximately 37 hours were spent on the average in hand planting. In contrast, an average of between four and five hours were spent planting using animal planters, and only one-tenth of an hour using tractor planters.

The importance of cattle to SNL farmers is illustrated by the percent reporting ownership of some cattle (Table 9). Approximately three-fourths (76.67%) of homesteads reported owning cattle. Although the number of cattle owned was asked of homestead informants, missing data and inaccurate reporting of numbers owned precluded use of this information. Many homesteads' cattle were held under the <u>sisa</u> system in which cattle are lent to others who have access to them for draft, manure, milk and some of the

Table 8. Labor Utilization in Maize Production, Swazi Nation Land Homesteads, 1985-1986 Cropping Year

	Average	Standard Deviation	Minimum	Maximum
Male Hours in Maize Production	130.69	143.54	6.98	937.37
Male Hours as % of Total Hours in Maize	26.10	16.33	1.94	83.00
Female Hours in Maize	307.94	305.31	5.00	2003.00
Child Hours in Maize	123.36	263.42	0.00	1785.00
Homestead Hours in Maize	505.60	542.24	28.00	3279.00
Exchange Hours in Maize	31.59	48.66	0.00	296.07
Hired Hours in Maize	26.45	62.90	0.00	420.10
Total Hours in Maize	563.64	536.99	40.96	3279.00
Homestead Hours as % of Total Hours in Maize	85.82	18.64	21.00	100.00
Animal Plow Hours in Maize	9.03	16.68	0.00	133.00
Tractor Plow Hours in Maize	2.91	3.58	0.00	16.58
Land Preparation (Hand) Hours	1.01	9.07	0.00	86.00
Animal Plant Hours in Maize	4.66	8.60	0.00	61.00
Tractor Plant Hours in Maize	0.10	0.57	0.00	4.32
Hand Plant Hours in Maize	36.87	60.64	0.00	360.60
Weeding/Thinning Hours	193.42	190.93	0.00	1025.00
Interrow Cultivation Hours	6.84	12.31	0.00	79.00
Harvest Hours in Maize	249.65	357.04	0.00	2880.00
Hours on Other Tasks	20.56	35.68	0.00	178.00

Source: Swaziland Cropping Systems Research and Extension Training Project, Highveld and Middleveld Homesteads.

offspring. Although there are a variety of reasons for placing animals in sisa, a major motivation in some areas appeared to be the lack of quality pasture nearby. This practice greatly complicated accurate collection of data on the number of animals owned by homesteads and precluded the collection of data on the quality of pasture (i.e., the extent of grassland degradation) available to each homestead in this study.

Data on the use of animal and mechanical power are also given in Table 9. The emphasis of the data is on the use patterns of animal and/or mechanical power, rather than on ownership. Thus if a homestead owned, borrowed, or hired an animal or a piece of equipment, it was coded as using that particular item. The importance of animal power to SNL farmers is apparent. Almost eighty percent of homesteads (78.9%) used oxen to plow their land. Interestingly, the use of oxen and tractors were not substitutes in land preparation. Sixty-nine percent of homesteads used tractors to plow at least some of their land. Thus, in land preparation, the majority of homesteads employed both oxen and tractors. Oxen tend to be owned by the homestead, while tractors were often hired for land preparation.

Tractor usage for tasks other than plowing was not widespread. Oxen were much more likely to be used. Two-thirds of homesteads used oxen for cultivation, compared to two percent who used tractors. Ox planters were used by 45 percent of homesteads, over 10 times the rate of tractor planters. Comparatively smaller percentages used either oxen or tractors for harrowing or transporting products or equipment. The picture of animal and equipment usage that emerges is one in which the use of oxen dominates

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the use of mechanical power, and with sizable amounts of human labor still involved in activities such as planting, weeding and harvesting.

Table 9. Animal Ownership and Use of Animals and Mechanical Power on Swazi Nation Land Homesteads, 1985-1986 Cropping Year

	Percent
Percent Owning Cattle	76.67
Percent Using Ox Plow	78.89
Percent Using Tractor Plow	68.89
Percent Using Ox Harrow	24.44
Percent Using Tractor Harrow	11.11
Percent Using Ox Ridger	5.56
Percent Using Tractor Ridger	1.11
Percent Using Ox Sledge	24.44
Percent Using Tractor Cart	4.44
Percent Using Ox Planter	45.56
Percent Using Tractor Planter	4.44
Percent Using Ox Cultivator	66.67
Percent Using Tractor Cultivator	2.22
Percent Using Any Type of Tractor Equipment	74.44
Percent Using Any Type of Ox Drawn Equipment	96.67

Source: Swaziland Cropping Systems Research and Extension Training Project, Highveld and Middleveld Homesteads.

The use of agricultural chemicals to promote plant growth and control both insect and weed problems has increased in recent years (Low, 1986). Eight out of ten homesteads reported use of basal fertilizer during the 1985-1986 cropping year (Table 10). About one-third of homesteads applied top dressing and slightly more than one-third (37.8%) used insecticides. Herbicides were used less often with only about 13 percent of homesteads reporting use. Moreover, even this level of herbicide use may be influenced by the participation of homesteads in on-farm trials. Some homesteads reported no use of any type of agricultural chemical, while others indicated they used each of the four types. The average use was less than two per household.

TABLE 10. Agricultural Chemical Use on Swazi Nation Land Homesteads, 1985-1986 Cropping Year

Chemical Use	Percent or Average	Standard Deviation	Minimum	Maximum
Percent Using Basal Fertilizer	83.33	na	na	na
Percent Using Topdressing	31.11	na	na	na
Percent Using Herbicides	13.33	na	na	na
Percent Using Insecticides	37.78	na	na	na
Number of the Above Chemicals Used	1.66	1.01	0.00	4.00

Source: Swaziland Cropping Systems Research and Extension Training Project, Highveld and Middleveld Homesteads.

Cropping patterns, use of animal and mechanical power, the nature, extent and type of agricultural chemicals used, and the intensity with which land is cultivated, all have the potential to influence land degradation. Although these factors are individually and collectively important, land management practices are perhaps even more influential. Fortunately, Swaziland has an established record of conservation policies designed to promote good land management. Between 1949 and 1960, more than 70,000 miles of contour grass strips were demarcated (Reij, 1984). These strips separate adjacent panels and were laid out along the contour, impeding the downslope transport of soil.

An important issue in future conservation efforts in Swaziland centers around preserving the extant grass strips (or establishing comparably effective practices that would be as widely adopted), in view of increasing pressures to remove them. Such pressures can arise from a variety of sources such as, increased population pressure on homesteads, changing technology, and increased agricultural commercialization of Swazi Nation Land. Some information on this dimension of homestead land was available in the SCSRET Project data and was supplemented by the soil survey commissioned for this study.

Three measures of the width of panels are given in Table 11. These refer to the width of panels on the downslope. The importance of the length of slope (called width in this report) to soil erosion is well documented (Wischmeier and Smith, 1978; Hudson, 1977; 1981). The first measure refers to the widest <u>single</u> slope measurement on any panel of homestead land. This measure was gathered as part of the soil survey conducted for this project. Homesteads varied considerably in the width of

their largest panel. The largest slope width was 110 meters; the smallest was 10 meters. The average of this variable was 37 meters. Larger panels, particularly if they are on much slope, have a great potential for runoff and soil loss. In addition, very large panels often can only be created by the removal of grass strips, further increasing the likelihood of soil erosion.

TABLE 11. Panel Widths and Panels Per Hectares on Swazi Nation Land Homesteads, 1985-1986 Cropping Year

	Average	Standard Deviation	Minimum	Maximum
Width of Widest Panel (meters)	37.09	20.72	10.00	110.00
Average Maximum Panel Width (meters)	23.13	11.92	8.75	92.00
Average Panel Width (meters)	20.45	10.87	8.42	85.33
Panels Per Hectare	5.23	2.74	0.88	14.29

Source: Swaziland Cropping Systems Research and Extension Training Project, Highveld and Middleveld Homesteads; and Soil Survey conducted Spring 1987.

The other two measure of width of slope show less variation than the largest slope, as expected. These measures were calculated from SCSRET Project data on the number and size of panels on each homestead. As the data in Table 7 indicate, homesteads had an average of between 9 and 10 fields, with a range from one to 26. The second variable in Table 11 refers to the average maximum width <u>within</u> the homestead, i.e., the maximum width of <u>each</u> panel was divided by the number of panels on the homestead to

obtain the average. This measure had a mean of 23 meters and a range from 8.75 to 92, less than the longest slope, but still indicating substantial variation in size of panels.

The average width of panels was calculated by summing three width measurements on each panel to determine the average width per panel. These averages were themselves averaged across all panels on a homestead to indicate the average width of slope on homestead panels. This procedure produced a mean width of approximately 20 meters, but with a range from 8 to 85 meters. Although the average size of holding is relatively small, with just over two hectares per homestead, there is wide variation in the manner in which homesteads divide up land into panels for cultivation.

An additional indicator of homestead land use is the number of panels per hectare (Table 11). This measure reflects the average size of panels and indirectly indicates the presence (or absence) of grass strips. Homesteads with fewer panels per hectare farm larger plots with fewer grass strips as protection against erosion. The typical homestead had about five panels per hectare with a standard deviation of 2.7. The range was from less than one panel per hectare (.88) to more than 14 per hectare. These differences were thought to be related to variation in other farming practices, e.g., the degree of commercialization of the homestead, and to different demographic circumstances.

Land Degradation in Swaziland

In order to examine the influence of demographic factors on land degradation, choices must be made as to the type of land degradation to be studied. Several kinds of land degradation have been recognized: water erosion, wind erosion, excess of salts, chemical degradation and biological

degradation (Hudson, 1981). It has proven difficult to specify which type of degradation is most serious because the answer to this question depends upon the reasons for controlling erosion. As Hudson (1981:44-45)notes:

> "If the problem is that the production of food crops is jeopardized by erosion then splash erosion and rill erosion on arable lands are the most important. If, however, the problem is that a high sediment load in streams and rivers threatens to silt up the storage dams required for an irrigation scheme, then the most important source of this silt will probably be gully erosion or streambank erosion. This is because the soil eroded by these forms goes immediately and wholly into the stream, whereas it is possible for soil to be lost in large quantities from arable lands but trapped in vegetation or deposited in ditches before it reaches the stream."

Given the primary focus of this study on the impact of demographic factors and agricultural practices on land degradation on Swazi Nation Land, and the importance of agricultural production to national development, soil erosion on arable land (sheet, rill and gully) was selected as the form of land degradation to be examined. The original intention was to include erosion on communal grasslands. However, since many homesteads' grazing land was located at some distance from the homestead itself, this was not possible. Even if the grazing lands used by each homestead could be identified, the additional expense in collecting data on the extent of grassland degradation was beyond the resources of this project.

The extent to which soil erosion is a problem in Swaziland has provoked debate. Observers of Swazi agriculture disagree on the nature and extent of soil erosion. Reij (1984:2) states that an answer to the problem of soil erosion in Swaziland is not easy since "soil erosion and runoff have never been measured in Swaziland...." Reij contrasts the estimates of Spaargaren who found that certain soils were being lost at the rate of 25

to 35 tons per hectare per year, with the Hunting Report on the Rural Development Area Program (1984), which found little erosion on arable land. The Hunting Report's conclusion was not based on systematic data on soil erosion, but on a review of factors in the Universal Soil Loss Equation. This review led to the following conclusions (Reij, 1984:5-7):

> "a. erosivity of rainfall (R) is not as high as might be expected for the altitude and latitude of Swaziland;
>
> b. erodibility of Swaziland soils (K) is generally low, that is, they have good resistance to erosion;
>
> c. topography (LS) of arable land in SNL is unlikely to lead to severe erosion;
>
> d. the principle of not cultivating steep slopes is well-established and the length of slope is nearly always broken by either grass strips or channel terraces giving low values of (P) representing good conservation practice."

While noting that erosion on arable land did not appear to be extensive at the time of their work, the Hunting Report did point out the high stocking rate and low level of grass cover on communal grazing lands. Such an observation does not automatically imply that sheet erosion is widespread on grasslands, although some severe localized erosion was noted. Drawing upon data on river sediment from South African and other sources, the Report suggests that erosion is much less severe than estimated by Spaargaren.

One problem with this debate is the preponderance of rhetoric in comparison to data on factors affecting soil erosion in Swaziland, although some recent work is beginning to address this gap (Kiggundu, 1986). Other than some hydrologic information gathered from secondary sources inside and outside of Swaziland, little systematic data appear to have been collected that directly measure the extent of soil erosion on arable land. Table 12

presents information on the extent of sheet erosion on sample homesteads. Although the sample is too small to permit generalization to the nation as a whole, or even to the RDAs, the data represent one of the first attempts to gather systematic information on soil erosion from Swazi Nation Land homesteads.

Sheet erosion was measured by classifying land into one of four ordinal categories based upon widely accepted standards (see Appendix A for detailed information on the soil survey). Sheet erosion is defined as the detachment of soil particles through the impact of rain drops and their downslope transport in thin sheets rather than in defined channels. Four possible categories of sheet erosion were utilized: (1) no evidence of erosion, well-developed A-horizon, (2) A-horizon partially eroded, tillage implements reach underlaying horizon, (3) A-horizon very thin, underlaying horizon at surface in places, and (4) A-horizon eroded, parts of underlaying horizon eroded.

Evidence of sheet erosion was present at most homesteads. Eighty-eight percent of sample homesteads were classified as having partially eroded A-horizons in which tillage implements reach the underlaying horizon (Table 12). Although most homesteads gave evidence of sheet erosion, this was not deemed to be a serious problem negatively affecting land quality, particularly under practiced conservation measures of contour plowing and grass stripping. No homestead land was classified in the two more severe sheet erosion categories.

Data on rill and gully erosion were also obtained in the soil survey. Rill erosion refers to localized small washes in defined channels of no more than 30 centimeters in depth and which are small enough to be

eliminated by plowing. Gully erosion refers to more significant loss of soil through large, established channels more than 30 centimeters in depth and which cannot usually be crossed by farm implements.

Table 12. Sheet Erosion on Swazi Nation Land Homesteads, 1985-1986 Cropping Year

Sheet Erosion Category	Number	Percent
No Evidence of Erosion Well Developed A-Horizon	11	12.22
A-Horizon Partially Eroded, Tillage Implements Reach Underlaying Horizon	79	87.78
A-Horizon Very Thin, Underlaying Horizon at Surface in Places	0	0.00
A-Horizon Eroded, Parts of Underlaying Horizon Eroded	0	0.00
Total	90	100.00

Source: Soil Survey conducted Spring 1987.

Rills were present on almost three-fourths of the homesteads, but these were not of sufficient severity to seriously limit land quality evaluations. About one-fourth of homestead land contained shallow gullies between 31 and 100 centimeters in depth. Respondents indicated that these gullies were created during the cyclone of 1984 which led to conditions in which the usually effective traditional conservation measures were not effective. Deep gullies were not found on any sample homesteads, and

shallow gullies were judged to be severely limiting land quality on less than 10 percent of homesteads (Appendix A, Tables 8 to 15).

Table 13. Rill and Gully Erosion on Swazi Nation Land Homesteads, 1985-1986 Cropping Year

Rill/Gully Erosion	Number	Percent
Rill (Depth 5-30 cm)	66	73.33
Shallow Gully (Depth 31-100 cm)	24	26.67
Deep Gully (Depth 101-300 cm)	0	0.00
Total	90	100.00

Source: Soil Survey conducted Spring 1987.

These data support the conclusion of the Hunting Report (1984) that soil erosion on arable land is not currently a serious problem in Swaziland. However, this could change rapidly if current conservation practices are altered. For example, increasing the slope length of fields by removing and/or reducing the number of grass strips, or plowing down the slope would substantially increase soil erosion. Similarly, if increased population pressure on the land resource base results in the cultivation of steeper slopes, greater soil erosion will occur. The distribution of landholdings by percent of steepest slope is discussed in the section on Agroclimatic Conditions. It is worth noting at this point that almost half of all homesteads farmed some land with at least ten percent slope.

The two indicators of soil erosion described in Tables 12 and 13 constitute the basic measures of land degradation and serve as the primary dependent variables for the analysis in Chapter 4. These two indicators

are thought to reflect the erosion hazard, i.e., the actual damage done to the land by erosion as evident at present. These measures then focus on the actual erosion that has already occurred. In contrast, one additional measure was constructed to reflect erosion susceptibility. Erosion susceptibility refers to the risk of erosion likely to take place now and in the future under given climatic, landform and soil conditions, as well as under traditional farming practices.

The measure of erosion susceptibility was based on the "Soil Loss Estimation for Southern Africa" (SLEMSA) methodology developed in Zimbabwe (see Appendix A for a detailed discussion of procedures). The technique has been applied to a number of countries in southern Africa including Swaziland (Nkambule et al., 1987). The SLEMSA method calculates erosion susceptibility using the formula:

$$\text{Erosion Susceptibility} = Ib \times C \times X$$

Ib represents the erosion index which is determined by rainfall erosivity (E) and soil erodibility (F). This index refers to a standard plot of bare soil with a 4.5 percent slope and 30 meters in length. C represents the soil loss ratio which is determined by the density of vegetation cover intercepting rainfall. X represents the soil loss ratio which is determined by slope steepness (s%) and slope length (sm).

The measure of erosion susceptibility was calculated for each homestead using the SLEMSA formula and data to reflect homestead conditions. The erosion susceptibility index has a theoretical range from 0 to 1,000. Index values of ten or less are considered to reflect a low degree of susceptibility, values between 11 and 50 are adjudged to be moderately low, scores between 51 and 200 are considered high erosion

susceptibility, while values over 200 reflect very high susceptibility. The distribution of landholdings across the erosion susceptibility categories is given in Table 14.

Table 14. Erosion Susceptibility on Swazi Nation Land Homesteads, 1985-1986 Cropping Year

Erosion Susceptibility Class	Number	Percent
Low Susceptibility	41	45.56
Moderately Low Susceptibility	34	37.78
High Susceptibility	15	16.67
Very High Susceptibility	0	0.00
Total	90	100.00

Source: Soil Survey conducted Spring 1987.

Approximately half (45.6%) of homestead land was classified in the low susceptibility category. Just over another third (37.8%) fell in the moderately low category, while roughly one homestead in six (16.7%) was classified in the high susceptibility range. None of the land fell in the the very high susceptibility category. This distribution is reassuring to conservation efforts since over eighty percent of holdings are in the low to moderately low category. Undoubtedly, the concentration of landholdings in the low to moderately low susceptibility range is a major factor accounting for the rather modest amounts of erosion found on homestead land. Yet, with one homestead in six falling in the high category, the potential for erosion is not insignificant, particularly if grass stripping is reduced or eliminated on these latter holdings.

The finding of modest amounts of soil erosion on arable land should not be taken to imply that conservation efforts are not needed. The present moderate to low levels of soil erosion could change rapidly if traditional practices are not maintained. Kiggundu (1986), for example, estimates that a Middleveld household cultivating 50 meter panels on a 10 percent slope, and with tillage up and down the slope, would lose over eight tons of soil per hectare per year, over two-and-a-half-times the tolerable annual loss of three tons per year. Changing to tillage along the contour and inserting grass strips at 30 meter intervals rather than 50 meters would reduce soil losses to acceptable levels.

It should be noted that the data on size of panels and maximum widths of panels revealed an average maximum width of 37 meters. Over fifty percent of the largest panels exceeded 30 meters in width, and approximately one-fifth were 50 meters or larger. Whether these measures reflect increasing size of panels cannot be determined from cross-sectional data such as these. However, the size of panels and the distance between grass strips should be a source of concern in future conservation efforts. While data on changing patterns of panel numbers and size were not available, factors that influence the extant size and number of panels on homesteads are examined in Chapter 4. As noted earlier, increased commercialization of agricultural production, increasing population pressure, and changing technology can all influence how the land is farmed. Monitoring of these trends and their impact on homestead land use patterns would appear warranted.

A major unanswered question not addressed by any of these concerns is the extent of land degradation on communal grazing lands. While virtually

every observer comments on the overstocking of livestock on Swazi Nation Land, the low off-take rate of livestock, and the presumed negative effects of these patterns on grasslands, almost no systematic data have been gathered on the extent of soil erosion on communal grazing land. Until systematic information on this subject is generated, the design of effective policies to address the putative problem is precluded.

Chapter 4 develops and estimates models of soil erosion on homestead land. Primary emphasis is given to the impact of demographic factors and agricultural practices on soil erosion. In addition, those agricultural production practices found to influence erosion, or deemed to be directly related to future conservation efforts, particularly the size of panels and number of panels, are examined in some detail. Before turning to an examination of these models, two additional sets of variables are briefly described. These are the agroclimatic conditions found in the different velds of Swaziland and the socioeconomic environment which influences off-farm employment, and thus indirectly influences the nature and type of agriculture practiced on the homesteads.

Agroclimatic Characteristics

The importance of agroclimatic factors to soil erosion are well-established and supported by several decades of systematic empirical research (Wischmeier and Smith, 1978; Hudson, 1981). Applications of these models and findings to southern Africa, and particularly to Swaziland, are still relatively infrequent, although research is beginning to appear (Elwell, 1978; Kiggundu, 1986; Nkambule et al., 1987). As noted earlier, Swaziland is a geographically and climatically diverse nation, especially for one whose total land area is small. The major variation is represented

by the three major velds discussed in Chapter 2. The distribution of homesteads across these major regions and the slope characteristics of homesteads are presented in Table 15. (Additional information on soils, suitability ratings of land for maize cultivation, and numerous other land characteristics are contained in Appendix A.)

The sample homesteads were located in the Highveld and Middleveld regions of Swaziland. Approximately one-fourth were located in the Highveld, while the remaining 75 percent were Middleveld homesteads. The latter were further subdivided into the drier and wetter portions of the Middleveld. Almost half of the sample homesteads were located in the wetter portions of the Middleveld. Temperature, soil composition, rainfall and topography, as well as other physiographic characteristics vary across these regions. These variations are associated with different cropping patterns, agricultural practices and varying degrees of land degradation. Consequently, their influence was examined in the various models estimated in Chapter 4.

The effect of slope on soil erosion has been defined mathematically in the Universal Soil Loss Equation. Moreover, empirical research has established that degree of slope is more important than length of slope in soil loss (Hudson, 1977:177). The topography of Swaziland is such that much of the arable land is on slope. Approximately one-fifth of the sample homesteads (22.2%) farmed land whose steepest slope was 5 percent or less. About 50 percent of homesteads' steepest slopes fell between 6 and 10 percent, with 10 percent slope being the most frequently occurring value in this category (22.2%), i.e., roughly one-fifth of homesteads farmed some land with 10 percent slope (data not shown). The remaining one-fourth of

homesteads farmed land whose steepest slope was greater than 10 percent. Two homesteads farmed land with a slope of 18 percent, the greatest slope found in the sample.

Table 15. Regional Location and Slope Characteristics of Swazi Nation Land Homesteads, 1985-1986 Cropping Year

Location and Slope	Number	Percent
Located in the Wetter Portion of the Middleveld	43	47.78
Located in the Drier Portion of the Middleveld	24	26.67
Located in the Highveld	23	25.56
Percentage of Steepest Slope		
5 Percent and Under	20	22.22
6 - 10 Percent	46	51.11
11 Percent and Over	24	26.67
Total	90	100.00
Mean Percentage of Steepest Slope		8.76

Source: Soil Survey conducted Spring 1987.

Socioeconomic Environment

The small size of Swaziland, coupled with its relatively well-developed transportation system, facilitates the integration of the rural and urban sectors. The maximum distance from north to south is roughly 180 kilometers and east to west about 130 kilometers. Consequently, an understanding of the homestead economy, including agricultural production

patterns and land use, is incomplete unless the larger economic and social systems in which agriculture takes place are included.

Four indicators of the socioeconomic environment of homesteads were developed for this study. These indicators were designed to measure the availability of off-farm employment, the distance to product and factor markets, and the location of the homestead in relation to the RDA center. Each of these measures was designed to reflect the access of homesteads to the respective centers. Direct measures of job openings, employment rates, use of the RDA center tractor pools, and the like were not available. Hence, these measures indicate the accessibility of the homesteads to factor and product markets, employment opportunities and agricultural facilities of the RDA center. While direct measures of off-farm employment opportunities and utilization of RDA facilities would be preferable, these measures appear to tap several important characteristics of the socioeconomic environment and are likely to be highly correlated with more direct indicators of these phenomena.

The access of homesteads to off-farm employment opportunities was measured by dividing the nation into six regions, each with significant opportunities for wage employment. The six regions were the north, south, east, west, central and northeast. Opportunities in these regions include activities such as citrus, timber and asbestos mining in the north, industrial and fruit processing facilities in the central region, sugar estates in the south and coal mining in the east. The distance from each RDA to each of the six regional labor markets was calculated and ranked from most accessible (1) to least accessible (8). The rank assigned to the

RDA was then added to the homestead data file. Thus all homesteads within a RDA were given the same employment opportunity rank.

Table 16. Access to To Employment Opportunities, Factor and Product Markets, and RDA Centers of Swazi Nation Land Homesteads, 1985-1986 Cropping Year

RDAs Ranked by Distance To Employment Opportunities	Employment Opportunity Rank
Central	1.0
Bhekinkosi	2.0
Ngwempisi	3.0
Northern	4.5
Mahlangatsha	4.5
Southern	6.5
Sandleni/Luqolweni	6.5
Hluti	8.0
Mean Distance in Kilometers	
To Nearest Factor Market	31.73
To Nearest Product Market	72.15
To Rural Development Center	2.49

Source: Constructed from secondary data and maps of the Swaziland Cropping Systems Research and Extension Training Project, Highveld and Middleveld Homesteads; and Soil Survey conducted Spring 1987.

The rank of the eight RDAs is given in Table 16. Not surprisingly, the Central and Bhekinkosi RDAs had the greatest access to employment

oppportunities. These areas are centrally located in the country and are close to the Manzini/Matsapha industrial area, including the nation's major airport. In addition to industrial employment, wage employment is also available in the Malkerns valley fruit processing sector, and Mbabane, the capital, is within commuting distance. Hluti RDA was ranked the most distant from employment opportunities within Swaziland, although residents of this area, as well as those in the Sandleni/Luqolweni RDAs, are closer to South Africa and some persons undoubtedly seek employment there.

Although this measure is somewhat crude, its correlation with independent measures of off-farm employment suggests that it does partially reflect wage opportunities. For example, the employment opportunities rank was correlated significantly with the total number of homestead members working off-farm (r=-.28) and the number of females working off-farm (r=-.35). Interestingly, it was not significantly related to the number of males working off-farm (r=-.16), reflecting the greater tendency for males to be involved in wage employment, regardless of the location of such activities. Females were most likely to be involved in wage employment when such opportunities were located near the homestead.

Access to factor markets was measured as the distance in kilometers from the RDA center to the nearest central place. This located the homestead in relation to capital and labor markets. Once again, the value given to the RDA in which a homestead was located was assigned to all homesteads within the RDA. The average distance to factor markets was about 32 kilometers (Table 16), with a range from 12 to 61 kilometers.

The importance of Manzini as the major product market in the nation was recognized in the measurement of product market accessibility. This

was measured by calculating the distance in kilometers from the RDA center to Manzini. This variable ranged from a low of 12 kilometers to a high of 130, with an average value of 72 kilometers. Clearly, some areas possess a sizable comparative advantage in terms of their proximity to Manzini.

The final measure of the socioeconomic environment of the homestead was its location in relation to the RDA center. The RDA centers were designed to offer technical assistance to farmers, as well as serving as a source of seed, fertilizer, and mechanical power. Theoretically, homesteads located closer to the center would have greater access to extension services, input supplies, the machinery pool, as well as other facilities and information. This measure was obtained as part of the soil survey. The distance in kilometers from each homestead to the RDA center was recorded. On average, homesteads were located approximately 2.5 kilometers from the RDA center. The closest homestead was only .10 kilometers from the center, while the most distant one was not quite 10 kilometers away.

The socioeconomic environment was thought to be important to the allocation of labor between agricultural activities on the homestead and off-farm employment. Differences in homestead agricultural practices, in turn, were posited to influence land degradation on the homestead. The pathways through which such influences might flow are complex. For example, homesteads with multiple persons employed off-farm are more likely to have capital available for the purchase or hiring of mechanical power to use in homestead production. Conversely, homesteads with few workers off-farm and/or those with larger landholdings might concentrate on homestead production and farm more intensively. The impact of these factors on land degradation is the focus of Chapter 4.

Chapter 4

Factors Affecting Soil Erosion in Swaziland

The previous chapter described soil erosion on arable landholdings among Swazi Nation Land farmers. These results supported earlier analyses which suggested, but did not document empirically, that soil erosion on arable land was not a serious problem in Swaziland. Although the vast majority of homesteads were found to have sheet and rill erosion, the extent of soil losses were judged to be modest. About one-fourth of sample homesteads contained shallow gullies between 31 and 100 centimeters in depth, yet in less than 10 percent of homesteads were these considered to seriously affect land quality.

Findings such as these are encouraging, particularly in a region of the world in which many nations' land resources have been severely degraded. A complete explanation of the rather modest amounts of soil erosion found on arable land in Swaziland would include detailed evidence on the erosivity of rainfall, the erodibility of soils, and topography, as well as agricultural production patterns and land management practices. In addition, characteristics of the social and economic system which determine how land is used should be included.

Such an explanation was clearly beyond the scope and resources of this study. The primary focus of this research was on agricultural production patterns, including land management practices, and the determinants of these practices, particularly homestead demographic factors. Although limited empirical evidence was available, established conservation practices such as contour plowing, avoiding cultivation of steeper slopes and the use of grass strips to separate fields on the slope have undoubtedly been of major importance. Continuation of these practices in

the face of increasing pressure to change them appears to be an important future policy focus.

One qualification to this generally positive outlook on land degradation in Swaziland centers on the condition of communal grazing lands. Data were not available to directly address the nature and extent of soil erosion on grasslands. Most evidence on the condition of communal grazing lands must be inferred from research on cattle production, overgrazing and its presumed effects on land resources, and not from direct measures of soil erosion (Doran et al., 1979; Fowler, 1981; Reij, 1984). The paucity of information on this topic severely limits the evaluation of grassland conditions and development of effective policies to deal with degradation of communal grasslands. This study focuses solely on soil erosion on arable land and does not address grassland conditions.

This chapter has two major analytic thrusts: (1) the development and estimation of several models of soil erosion involving homestead-level demographic and agricultural variables, in conjunction with factors representing the agroclimatic and socioeconomic environment; and (2) the identification and examination of salient agricultural practices thought to be most influential to future conservation efforts in Swaziland. The approach taken to model construction was primarily inductive. Although well-developed theoretical and empirical models of soil erosion are available, these tend to focus largely on the physical processes involved (Wischmeier and Smith, 1978; Hudson, 1981). While physical factors are clearly the proximate determinants of soil erosion and provide a technical explanation of soil loss, they offer little guidance as to what aspects of the social and/or economic system might be changed to slow or reverse the

process. The focus of the latter part of this chapter is on conservation-related agricultural production practices and associated factors that are potentially amenable to policy efforts.

The impacts of these factors were thought to be conditional upon the socioeconomic and agroclimatic environments in which they are found. Consequently, variables representing these factors were included in the models estimated. Figure 2 shows the general analytic scheme underlying the analysis. In this model, land degradation is viewed as primarily a function of agricultural production patterns and, secondarily, of homestead demographic characteristics.

Agroclimatic factors were thought to be important since homesteads farming land located on steeper slopes, with more erodible soils and where the erosivity of rainfall is greatest, obviously have a greater susceptibility to soil erosion than those located in areas lacking these conditions. Other than avoiding cultivation on the steeper slopes, or occasionally altering topography under special circumstances, there is little that SNL farmers can do to change these physical conditions. Fortunately, the more important determinants of soil erosion such as land and crop management practices are often within the control of the homestead (Hudson, 1977).

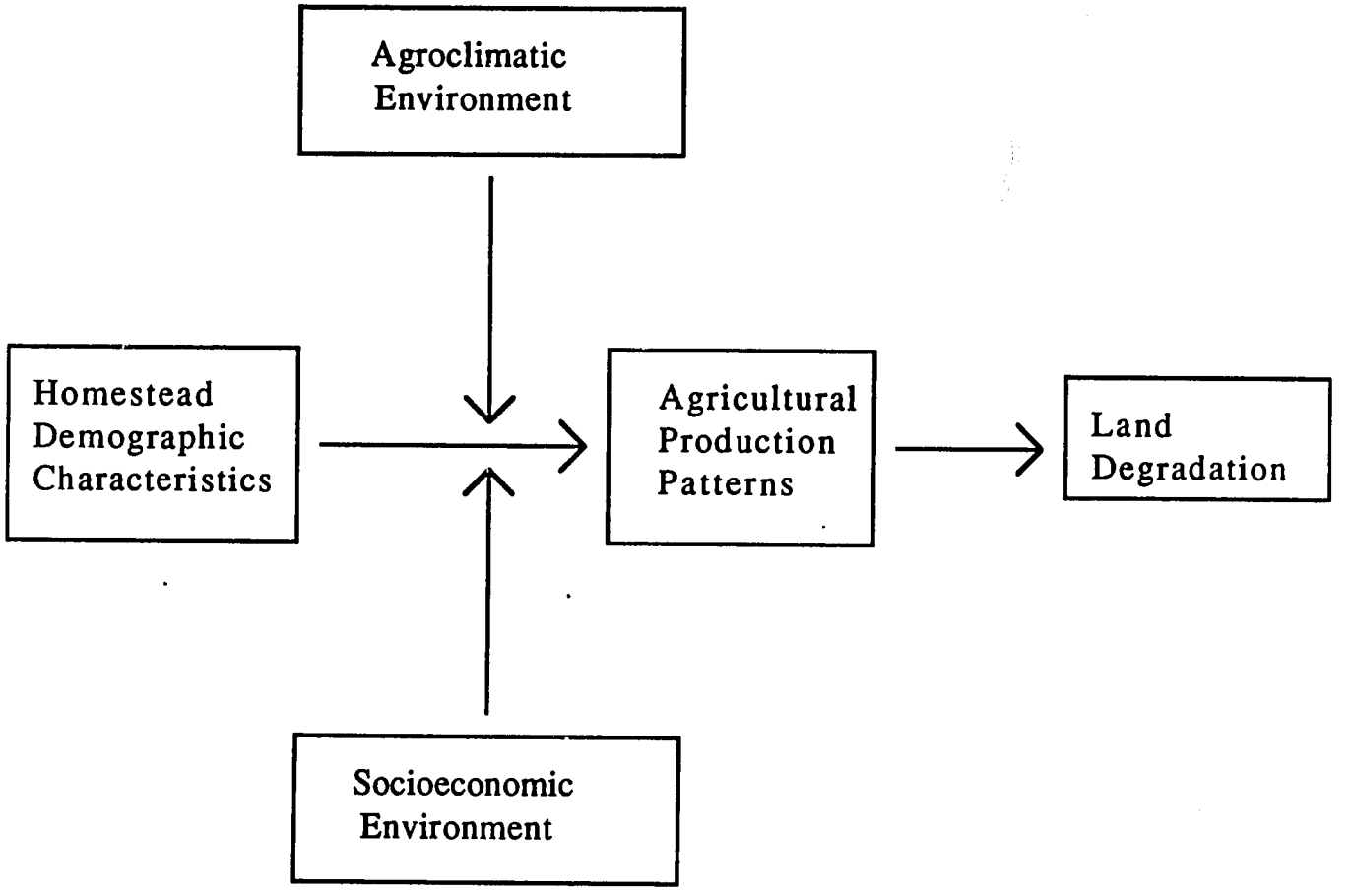

Figure 2. Model of Possible Relationships Among Homestead Demographic Characteristics, Agricultural Production Patterns and Land Degradation, Under Varying Agroclimatic and Socioeconomic Environments.

Unlike the situation with the agroclimatic variables, socioeconomic factors were not thought to directly influence soil erosion. Rather, the location of the homestead in relation to the RDA center where information and access to technology and inputs would be greater, and the presence or absence of employment opportunities were included since both of these factors can alter production patterns and land management practices.

Soil Erosion on Swazi Nation Land Homesteads

Chapter 3 described the range of data available from the Swaziland Cropping Systems Research and Extension Training Project and the supplemental data on land degradation gathered through the special purpose soil survey conducted for this purpose. Given the relatively small number of homesteads available in the sample (N=90), it was necessary to reduce the number of variables in order estimate models of land degradation. Although some reduction was essential, it was important that each major block of variables depicted in Figure 2 be represented. Table 17 lists the reduced set of variables included in the regression analyses of soil erosion and briefly describes their measurement. Distributions on these variables and more complete descriptions were presented in Chapter 3 and are not repeated here. These were selected from the larger set by eliminating those that were either conceptually or statistically redundant, those that were uncorrelated with the primary variables of interest and those lacking strong conceptual justification under one of the four major blocks of variables depicted in Figure 2.

Table 17. Variable List, Descriptions and Measures Used in the Soil Erosion Regressions

Category and Variable	Description and Measurement
Agricultural Practices	
Number of crops	Sum of different crops produced. Ranged from (1) to (7).
Total hours in maize	Sum of all hours expended in maize production.
Percent maize hours by homestead	The percent of total hours in maize production contributed by homestead members.
Use of oxplow	Did the homestead use an oxplow in agricultural production? Coded (1) if yes, (0) if no.
Number of chemicals used	Sum of different types of agricultural chemicals used including: basal fertilizer, topdressing, herbicides and insecticides. Ranged from (0) to (4).
Mean panel width	Average width of panels in meters.
Demographic Characteristics	
Productive units per hectare	Ratio of homestead productive units to hectares where: adult males and females = 1.0 units, children aged 10-14 = .80 units and children aged 5-9 = .25 units.
Agricultural commercialization	Three category variable reflecting the homestead's subsistence needs in relation to expected output. Ranged from (1) non-commercial (subsistence), (2) semi-commercial to (3) commercial. (See Chapter 3)
Households per homestead	Dummy variable coded (1) if the homestead contained >1 household, (0) if only one household.
Number of adult males	Number of males aged 15 years or older counted as members of the homestead. Some may be living and/or working elsewhere.
Number of females employed off-farm	Number of females counted as homestead members who are employed off-farm.

Table 17. (Continued)

Category and Variable	Description and Measurement
Agroclimatic Characteristics	
Erosivity-erodibility index	This variable represents the erosion index which is determined by rainfall erosivity and soil erodibility; this index refers to a standard plot of base soil with a 4.5% slope and 30 meters long. (See Appendix A)
Steepest slope percent	The steepest slope of homestead land being cultivated, in percent.
Socioeconomic Environment	
Employment opportunities	Rank of each RDA from closest to employment opportunities coded (1) to farthest, coded (8).
Distance to RDA center	Distance in kilometers from homestead to RDA center.
Soil Erosion	
Sheet erosion	Coded (1) if A-horizon was partially eroded so that tillage instruments reached underlaying horizon, (0) if A-horizon well-developed.
Rill and gully erosion	Coded (1) if gully of 31 to 100 cm present, (0) if rill of 5-30 cm.

Although multiple categories of sheet erosion were recognized, no homesteads were found in the two more severe sheet erosion categories. Consequently, this variable was dichotomized and treated as a dummy variable coded (1) if sheet erosion was present and (0) if no sheet erosion was found. Similarly, rill and gully erosion was concentrated in only two categories: rills of between 5 and 30 centimeters depth, and shallow gullies between 31 and 100 centimeters in depth. No gullies were found on arable land with depths of more than 100 centimeters. This variable was

also dichotomized by coding those homesteads with gully erosion (1) and those with only rills present as (0).

The two variables representing agroclimatic characteristics were the erosivity-erodibility index and the steepest slope percent. Preliminary analyses also included dummy variables for the Highveld and Middleveld locations of the homesteads. These dummy variables created problems of multicollinearity with several other variables in the regressions, particularly those measuring characteristics of the socioeconomic environment. Consequently, the dummy variables measuring veld location were deleted from the final regression analyses. Because of the demonstrated importance of agroclimatic and topographical variables to soil erosion, the erosivity-erodibility index and steepest slope percent were retained. These two variables measure agroclimatic conditions at the homestead level and thus capture major elements of veld location.

Table 18 presents the zero-order correlations between the two erosion measures and variables representing each of the four major sets of factors depicted in Figure 2. Five of the six variables representing agricultural practices were significantly correlated with sheet erosion. The number of crops grown, the total hours devoted to maize production, the percentage of hours in maize contributed by homestead members, and use of the oxplow were all positively related to sheet erosion. The strongest correlate of sheet erosion was the percent of maize hours contributed by homestead members. Homesteads which relied primarily on their own labor for maize production were more likely to experience sheet erosion.

Table 18. Zero-Order Correlations of Soil Erosion with Agricultural Practices, Demographic Characteristics, Agroclimatic Characteristics and the Socioeconomic Environment

Category and Variable	Type of Soil Erosion	
	Sheet	Rill-Gully
Agricultural Practices		
Number of crops	.36[c]	.01
Total hours in maize	.25[b]	.04
Percent maize hours by homestead	.49[c]	.24[b]
Use of oxplow	.39[c]	.25[b]
Number of chemicals used	-.20[a]	.01
Mean panel width	.12	-.11
Demographic Characteristics		
Productive units per hectare	-.03	-.14
Agricultural commercialization	.12	.01
Households per homestead	-.08	-.14
Number of adult males	.01	-.24[b]
Number of females employed off-farm	-.07	-.23[b]
Agroclimatic Characteristics		
Erosivity-erodibility index	.20[a]	.12
Steepest slope percent	.28[c]	.20[a]
Socioeconomic Environment		
Employment opportunities	-.05	.16
Distance to RDA center	-.08	-.03

[a] $p<.10$
[b] $p<.05$
[c] $p<.01$

The first three variables in Table 18 appear to reflect aspects of agricultural intensification. Those homesteads that produced a greater number of crops, devoted more hours to maize production and utilized largely their own labor resources appear to be farming their land more intensively than other homesteads. These homesteads were more likely to experience sheet erosion.

In contrast, homesteads which used more types of agricultural chemicals on their land were less likely to have sheet erosion. The

negative correlation between use of agricultural chemicals and sheet erosion likely stems not from a direct impact of chemical use on erosion, but from related differences between the orientations to farming among those who use chemicals and those who do not. Those homesteads that apply fertilizers, herbicides and insecticides may be more likely to adopt other modern practices and thus take efforts to protect their landholdings from erosion.

Oxplows tend to be used on land with steeper slopes and its positive correlation with sheet erosion may represent this relationship, rather than a direct negative impact of the oxplow itself. That is, this correlation is not due to use of this technology per se, but to the type of land on which it is used.

Somewhat surprisingly, the average width of panels cultivated by the homestead was not significantly related to sheet erosion at the zero-order level. Although this variable was not significantly correlated at the bivariate level, it was retained in the regression analyses because of its strong theoretical link to erosion and its clear policy relevance.

The demographic variables individually and as a block exhibited weak and nonsignificant correlations with sheet erosion. Since the types of farming practices, agroclimatic conditions and characteristics of the socioeconomic environment were not controlled, it is perhaps not surprising that these factors were not significant at the bivariate level. As Figure 2 suggests, demographic factors are farthest removed from land degradation and thus would not be expected to correlate as highly as more proximate variables.

In contrast to the demographic variables, both indicators of agroclimatic conditions were significantly but modestly related to sheet erosion. The erosivity-erodibility index and the steepest slope percent were positively related, indicating that homesteads with greater rainfall intensity, more erodible soils and landholdings on steeper slopes were more likely to display sheet erosion. The modest size of the coefficients are consistent with the interpretation that current conservation practices are at least partially effective in slowing or avoiding sheet erosion. Finally, neither of the measures of the socioeconomic environment was significantly related to sheet erosion. Since the impact of these variables was thought to be largely through their influence on such factors as homestead labor allocation and cropping patterns, the lack of significant bivariate correlations was perhaps to be expected.

Rill and gully erosion were much more weakly related to agricultural practices than was sheet erosion. Neither the number of crops grown nor the total hours expended in maize production were related to rill and gully erosion. However, similar to sheet erosion, both the use of the oxplow and the percentage of labor spent on maize production were correlated with rill and gully erosion. It appears that homesteads which provide greater amounts of the total labor spent on maize are more likely to have gully erosion. Whether this reflects the types of land being cultivated, the degree of agricultural commercialization, intensity of cultivation or other factors is not clear. Similarly, use of the oxplow was positively related to the presence of shallow gullies. If this is due to their joint association with slope percent, then this relationship should not obtain in

the regression models when slope and other agroclimatic characteristics are controlled.

Unlike the situation with sheet erosion in which none of the homestead demographic variables were significantly correlated, two of the five demographic variables were related to the presence of gully erosion. Both the number of males on the homestead and the number of females employed off-farm were significantly and negatively correlated with gully erosion. Homesteads with a larger number of adult male members were less likely to experience gully erosion. Further, homesteads with females employed off-farm were also less likely to contain gullies. Both of these factors reflect greater labor and capital availability. Homesteads with more adult males and those with one or more females working off-farm, generally have more labor available for farming operations and the employment of women (as well as men) off-farm undoubtedly leads to increased capital for investment in improvements to the homestead's holdings.

Both the erosivity-erodibility index and the steepest slope percent were positively related to the presence of gullies, although only the coefficient for the slope percent was statistically significant. The positive correlations indicate the expected relationship with gully erosion and, at the bivariate level, suggest that slope percent is more closely related. Again, neither of the indicators of the socioeconomic environment was significant.

Regression Models of Sheet Erosion

Table 19 presents five models of sheet erosion.[2] The models were estimated hierarchically in that indicators of agricultural practices were entered first (model 1), then homestead demographic characteristics were added (model 2), followed by agroclimatic characteristics (model 3), and then characteristics of the socioeconomic environment were added (model 4). Finally, a reduced-form equation was estimated (model 5) in which significant variables from the first four equations were retained, while nonsignificant variables were deleted in an attempt to arrive at a more parsimonious model. In addition, the relatively small total sample size (N=90), limited the number of independent variables that could reasonably be included. This inductive procedure and the resulting models delimit the number of variables under consideration and identify the more important factors involved from among the four sets examined. They do not represent rigorously specified models of sheet erosion and should not be interpreted as such.

The first model in Table 19 indicates that the agricultural practices as a block are reasonably sucessful in predicting sheet erosion. The variance explained by this block of variables was 42 percent. Moreover, each of the agricultural practices exhibited a significant coefficient, with the sole exception of chemical use. The sign of each coefficient was consistent with its zero-order correlation. With the exception of chemical use, each of the agricultural variables was positively related to sheet erosion.

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[2]Since the dependent variables (sheet erosion and rill and gully erosion) are both dichotomous, it is possible that OLS regression analysis can create estimation problems. To determine if these problems were present, a logistic regression analysis was also conducted. The results of the logistic analysis were essentially the same as the results of the standard regression analysis. Consequently, for ease of interpretation and exposition, the OLS results are presented.

Table 19. Regression Models of Sheet Erosion on Agricultural Practices, Demographic, Agroclimatic and Socioeconomic Characteristics

Category and Variable	Model 1	2	3	4	5
Agricultural Practices					
Number of crops	.0570[c]	.0557[c]	.0586[c]	.0582[c]	.0648[c]
Total hours in maize	.0001[b]	.0002[c]	.0002[c]	.0002[c]	.0002[c]
Percent maize hrs by homestead	.0065[c]	.0166[c]	.0061[c]	.0055[c]	.0159[c]
Use of oxplow	.1763[c]	.1944[c]	.1753[b]	.1906[b]	.2344[c]
Number of chemicals used	-.0380	-.0472[a]	-.0443	-.0437	
Mean panel width	.0071[c]	.0073[c]	.0074[c]	.0077[c]	.0081[c]
Demographic Characteristics					
Productive units/hectare		.0244	.0288	.0301[a]	.0260[a]
Agricultural commercialization		.0423	.0488	.0274	
Households per homestead		-.1130	-.1033	-.0850	
Number of adult males		-.0047	-.0059	-.0087	
Females employed off-farm		.0474	.0445	.0293	
Agroclimatic Characteristics					
Erosivity-erodibility index			.0007	.0005	
Steepest slope percent			.0052	.0093	
Socioeconomic Environment					
Employment opportunities				-.0045	
Distance to RDA center				-.0373[b]	-.0396[c]
Intercept	-.1316	-.3303	-.3847[a]	-.2378	-.2621[a]
Adjusted R^2	.42	.44	.44	.46	.47
F-ratio	11.85[c]	7.23[c]	6.28[c]	6.10[c]	12.14[c]

[a] $p<.10$
[b] $p<.05$
[c] $p<.01$

Adding the homestead demographic characteristics failed to significantly increase the variance explained in sheet erosion (model 2). Although the total percent of explained variance increased from 42 to 44 percent, the homestead demographic characteristics as a block did not

contribute significantly to the statistical explanation of sheet erosion. None of the demographic characteristics were significant even at the .10 level.

The addition of the agroclimatic characteristics, erosivity-erodibility index and steepest slope percent, similarly failed to increase the explained variation in sheet erosion (model 3). While both factors showed positive coefficients, neither approached statistical significance at conventional levels. The failure of these variables to exert a significant influence on sheet erosion was somewhat surprising given their demonstrated importance in earlier research (Wischmeier and Smith, 1978; Hudson, 1981). One possible reason for this finding may be the efficacy of established conservation practices, although this is only one of several possibilities. The positive and significant coefficients on the mean panel width variable across models is consistent with earlier research on the effects of panel width on soil loss.

The fourth model estimated included each of the previous sets of variables plus the two factors representing the socioeconomic environment. The block of socioeconomic factors did increase the explained variance (adjusted R^2 = .46) significantly in a hierarchical regression analysis (Cohen and Cohen, 1975). The distance to RDA center was negatively related to sheet erosion, indicating that homesteads located farther from the RDA centers were less likely to have sheet erosion. The number of variables in model 4 was relatively large in relation to the number of cases. Consequently, the final model was estimated in order to both trim the model and bring the ratio of variables to cases to a more reasonable level.

The reduced-form fifth model fits the data as well as any of the first four models including the fourth most comprehensive model. Seven variables remain and each is significantly related to sheet erosion. Five of the agricultural practice variables have significant coefficients. Homesteads that produced a greater number of crops, invested more total hours in maize, relied more heavily on the labor of homestead members for maize production and employed the oxplow in cultivating their holdings were more likely to have sheet erosion. The first three variables appear to tap dimensions of agricultural intensification, i.e., those homesteads more involved in utilizing their labor and land to increase yields from agricultural production were more likely to experience sheet erosion. Further, in contrast to its small zero-order correlation with sheet erosion, the average width of panels was positively and significantly related to this form of erosion. As expected, homesteads which farm their land in larger panels were more likely to show evidence of sheet erosion. Since the size of panel farmed is clearly under the control of the homestead, this factor appears to have direct relevance to future conservation efforts.

In addition to the five agricultural practice variables, two additional variables remain in the reduced-form equation. The number of productive units per hectare of land and the distance to the RDA center were both significantly related to sheet erosion. The ratio of labor to landholdings represents both the labor resources of homesteads and their land base. Given the system by which Swazi Nation Land is distributed, the ratio of productive units per hectare was thought to be an important factor to include in the analysis. As with the measures of agricultural

intensification, the positive coefficient suggests that as the ratio of labor to land increases on homesteads, the likelihood of sheet erosion also increases. Finally, the negative impact of distance to RDA center remained. Homesteads located farther from the RDA centers exhibited lower amounts of sheet erosion.

In summary, the reduced-form model revealed that sheet erosion was systematically related to a series of agricultural practices, most of which reflected aspects of agricultural intensification. Those homesteads that expended more labor in maize production by household members, that produced a greater variety of crops and that relied upon animal draft power for plowing were more likely to have sheet erosion. In addition, those homesteads with a higher ratio of labor to land also were more likely to contain sheet erosion, as were homesteads more removed from the RDA center.

Regression Models of Rill and Gully Erosion

The models of rill and gully erosion were estimated in the same fashion as those for sheet erosion. A series of models were estimated adding an additional set of variables to each equation. Although three categories of rill and gully erosion were recognized in the original data collection--rills of between 5 and 30 centimeters depth, shallow gullies between 31 and 100 centimeters depth and deep gullies over 100 centimeters depth--only the first two categories were represented in the sample data. The measure was thus coded (1) if a shallow gully was present and (0) if otherwise. Consequently, the following models contrast those homesteads with shallow gullies with those that contain only rills. These conditions were judged independently of the earlier measures of sheet erosion. Clearly, any given homestead could exhibit sheet erosion in combination

with the others and the distribution of erosion described in Chapter 3 suggests that this is indeed the case.

The first model of gully erosion estimated in Table 20 differs markedly with that of sheet erosion. The agricultural practice variables as a block were relatively successful in predicting the presence of sheet erosion. In contrast, as a block the agricultural practices do not account for a significant portion of the variation in gully erosion. The adjusted R^2 value was 5 percent and the model was not significant at the .10 level. Only one variable, use of the oxplow, was significant at the .05 level. Again, the positive coefficent indicated that homesteads using animal draft power were more likely to contain gullies. The percent of maize hours by the homestead was also positively related at the .10 level.

The addition of the demographic variables as a block (model 2) did not improve the prediction of gully erosion. The adjusted R^2 value increased slightly from 5 percent to 7 percent, but the addition was not significant. The only demographic variable that was statistically significant even at the .10 level was the number of adult males on the homestead. Homesteads with greater numbers of adult male members were less likely to contain gullies.

Model 3 presents the findings from the equation containing the agroclimatic variables, as well as agricultural practices and demographic characteristics. Neither the erosivity-erodibility index nor the steepest slope percent contributed significantly to the explanation of gully erosion. The percent of variance explained was virtually unchanged from model 2. Gully erosion, at least as captured in the present model, appears largely unrelated to agricultural practices, demographic factors or

agroclimatic characteristics. Given the relatively low incidence of shallow gullies on Swazi Nation Land, the failure to find significant impacts for the two agroclimatic characteristics on this dependent variable may, as with sheet erosion, partially reflect the relatively successful efforts of current and past conservation practices.

Table 20. Regression Models of Gully Erosion on Agricultural Practices, Demographic, Agroclimatic and Socioeconomic Characteristics

Category and Variable	Model 1	2	3	4	5
Agricultural Practices					
Number of crops	-.0253	-.0241	-.0371	-.0373	
Total hours in maize	-.0000	.0000	.0000	.0001	
Percent maize hrs by homestead	.0050[a]	.0056[a]	.0055[a]	.0057[a]	.0048[a]
Use of oxplow	.2433[b]	.1545	.0882	.0975	.1901[a]
Number of chemicals used	.0192	.0217	.0124	.0074	
Mean panel width	-.0027	-.0016	-.0013	-.0011	
Demographic Characteristics					
Productive units/hectare		-.0453	-.0524[a]	-.0425	
Agricultural commercialization		-.1014	-.1201	-.1173	
Households per homestead		-.0282	-.0629	.0239	
Number of adult males		-.0427[a]	-.0440[a]	-.0500[b]	-.0424[b]
Females employed off-farm		-.0143	-.0100	-.0069	
Agroclimatic Characteristics					
Erosivity-erodibility index			-.0003	-.0001	
Steepest slope percent			.0198	.0185	
Socioeconomic Environment					
Employment opportunities				.0294	
Distance to RDA center				-.0211	
Intercept	-.2335	.2794	.2859	.1263	-.1537
Adjusted R^2	.05	.07	.08	.07	.11
F-ratio	1.72	1.65	1.56	1.46	4.82[c]

[a] $p<.10$
[b] $p<.05$
[c] $p<.01$

The socioeconomic environment, as represented by the employment opportunities and distance to RDA center variables, similarly failed to exert significant impacts on gully erosion (model 4). Again, the variance explained by the addition of these variables was neither statistically nor substantively significant.

Equation 5 represents the reduced-form model of gully erosion. Only three variables remain in the model: the percentage of maize labor contributed by homestead members, use of the oxplow and the number of adult males on the homestead. These three variables accounted for 11 percent of the variation in gully erosion and the model F-ratio was significant. Homesteads in which most maize labor was contributed by members and those using the oxplow were more likely to have shallow gullies present. Conversely, homesteads with a larger number of adult male members had fewer gullies. The positive relationship between percent maize hours by homestead members and gully erosion was consistent with the findings for sheet erosion. Those homesteads that rely more heavily on their own labor for maize production were more likely to experience both types of erosion.

The models of gully erosion reveal a relatively weak set of relationships between the four major sets of factors--agricultural practices, demographic characteristics, agroclimatic characteristics and the socioeconomic environment--and gully erosion. None of the four sets of variables as a block contributed significantly to the statistical explanation of gully erosion. In addition, few of the individual variables were significant at conventional levels. One demographic factor--number of adult males--and two agricultural practice variables--percent maize hours

by homestead and use of the oxplow--emerged in the reduced-form equation. These relationships represent possibilities for further examination, but the failure to find more systematic patterns between the four sets of factors examined and gully erosion leaves this form of erosion largely unexplained, at least by these sets of factors.

One possible explanation for the weak models found for gully erosion is the impact of the cyclone of 1984 in creating these channels. Several respondents indicated that gullies on their land were created during the cyclone. To the extent to which this was the case and traditional practices were not effective in preventing the formation of gullies, their occurrence is not likely to be explained by the sets of factors examined in this study.

The models of sheet and gully erosion attempted to identify factors which influenced these forms of land degradation. Several of the agricultural practice and demographic variables were found to be related to one or both forms of soil erosion. Similarly, in some instances, variables representing the agroclimatic and socioeconomic environments also exerted significant impacts on soil erosion. Further discussion of these factors and their implications for conservation efforts in Swaziland are reserved for Chapter 5. Before turning to that discussion, a brief analysis of selected agricultural practices thought to be directly relevant to conservation efforts is presented.

Correlates of Conservation-Related Agricultural Practices

Chapter 3 noted that an important issue in future conservation efforts in Swaziland concerned preservation of the grass strips separating cultivated panels. Since much of the arable land in Swaziland is located

on sloping terrain, maintenance of this practice, along with contour plowing, appears to be particularly important. Approximately one-fourth of sample homesteads farmed land with slopes greater than 10 percent, while another one-fifth farmed land with 10 percent slope. Pressures to remove the grass strips can originate from several sources. Increasing population pressure on homesteads, changes in technology and increasing agricultural commercialization can all potentially influence farmers to alter their land management practices. The practice of contour plowing seems firmly established and should not be influenced negatively by these trends. Unfortunately, this is not necessarily the case with the size of panels and the presence of grass strips.

Variation in the widths of panels measured down the slope was described in Table 11. These data revealed wide variation in the size of cultivated panels, suggesting that some homesteads may be removing grass strips in order to farm larger panels. In an attempt to examine some of the factors which might be related to the size of panels, the four size measures described in Table 11 were correlated with measures of agricultural, demographic, agroclimatic and socioeconomic variables. While longitudinal data are clearly necessary to infer changes in panel size or width, a cross-sectional examination of correlates of panel size can provide insight into those practices and homestead characteristics that are associated with differential panel sizes.

The four measures include average panel width, widest panel width, the average maximum width and the number of panels per hectare. All but the second measure, width of the widest panel, were gathered as part of the Swaziland Cropping Systems Research and Extension Training Project. The

width of the widest panel was gathered during the soil survey commissioned for this study (see Appendix A). Since these data were gathered independently by separate researchers at different times, they afford a partial check on the reliability of the size measures. The panels per hectare measure represents a slightly different approach to the size issue and should be correlated in the opposite direction with the four sets of variables examined. An important characteristic of all of these measures is that they are under the control of the homestead and thus can potentially influence the degree of erosion.

The zero-order correlations between these four conservation-related agricultural practices and variables from each of the major sets of factors are presented in Table 21. Three agricultural variables were associated with these conservation-related practices. Those homesteads that used a lower percentage of their own labor on maize, that used tractors and that farmed larger holdings were most likely to cultivate larger panels and farm fewer panels per hectare. These relationships were not surprising given that larger farms and those farms that use tractors usually have larger fields. Larger farms, use of machinery and less dependency on homestead labor also suggest a more commercial orientation to agriculture.

It should be noted that with the exception of the correlation between panels per hectare and percent of maize hours by the homestead, the three size variables were consistently and significantly related to three of the four agricultural practice variables. Moreover, the size of the correlations with percent maize hours, use of tractor and total hectares were of similar magnitude. The consistency of these findings suggests that

the size variables were reliably measured and related in the expected direction with the agricultural practice variables.

Table 21. Zero-Order Correlations of Selected Agricultural Practices, Demographic, Agroclimatic and Socioeconomic Variables with Conservation-Related Agricultural Practices

Variables	Mean Panel Width	Widest Panel Width	Average Maximum Width	Panels Per Hectare
Agricultural Practices				
Percent maize hours by homestead	-.24[b]	-.19[a]	-.21[b]	.10
Use of tractor	.21[b]	.23[b]	.21[b]	-.31[c]
Use of oxplow	-.01	.05	-.01	-.05
Total hectares	.24[b]	.44[c]	.29[c]	-.49[c]
Demographic Characteristics				
Productive units/hectare	-.18[a]	-.28[c]	-.20[a]	.48[c]
Agricultural commercialization	.17[a]	.21[a]	.19[a]	-.31[c]
Total persons in residence	.20[a]	.32[c]	.22[b]	-.27[b]
Agroclimatic Characteristics				
Erosivity-erodibility index	-.00	.04	.03	-.08
Steepest slope percent	-.11	-.06	-.06	.06
Socioeconomic Environment				
Distance to factor market	-.30[c]	-.22[b]	-.27[b]	.34[c]

[a] $p<.10$
[b] $p<.05$
[c] $p<.01$

The fourth agricultural practice variable, use of the oxplow, was unrelated to any measure of panel width or to the number of panels per hectare. This finding suggests that decisions on panel width are largely unrelated to use of the oxplow, contrary to the results observed for use of tractors. Again, the pattern of correlations was quite consistent across the various measures.

Three demographic variables were also systematically correlated with conservation-related practices. Those homesteads that had larger size fields and fewer panels per hectare tended to have fewer productive units per hectare, were more likely to be commercial rather than subsistence producers, and have larger numbers of persons in residence. These findings coupled with the previous agricultural practice findings indicate that larger fields and fewer panels per hectare were characteristic of more commercial type farms. These farms were also closer to factor markets which may facilitate marketing of products and afford easier access to inputs for the farming operation (see bottom row of Table 21).

The two agroclimatic indicators--steepest slope percent and the erosivity-erodibility index--were not correlated with any of the conservation-related agricultural practices. Apparently, larger fields with fewer panels per hectare are not located only on land with relatively little slope, favorable rainfall patterns or erosion-resistant soils. Rather, they are located on land with a wide range of slopes, and with varying potential erosivity and erodibility.

Decisions concerning the size of panels to cultivate are apparently unrelated to the physical characteristics of the soil, topography or rainfall patterns. The limited evidence contained in these correlations suggests that these decisions are more likely to be influenced by demographic and agricultural factors such as the size of the homestead population, whether they are commercially oriented or produce primarily for subsistence needs, the amount of land they control and their use of mechanized power. Implications of these findings and those from the regression models are discussed in Chapter 5.

Chapter 5

Summary and Implications

This study examined the relationships among homestead demographic characteristics, agricultural production practices and land degradation among a sample of Swazi Nation Land farmers. The major objectives of the study were to describe variation in these three factors, relate homestead demographic characteristics to alternative production practices and to estimate the impacts of these factors on land degradation. In addition, characteristics of the socioeconomic and agroclimatic environment thought to influence these relationships were included. This chapter reviews the major findings of the study and discusses their implications for land conservation policies in Swaziland.

Summary of Findings

The examination of homestead demographic characteristics revealed wide variation in the size and composition of Swazi Nation Land homesteads. While the average homestead consisted of a single household, headed by a male and contained between 9 and 10 resident members, there was considerable variation around this norm. The variation in size and composition of homesteads was matched in diversity by the labor utilization patterns of homesteads.

The sample homesteads were heavily involved in both the farm and nonfarm sectors of the economy. In almost one-third of the homesteads the head was employed off-farm, and over 80 percent of all homesteads had one or more workers employed off-farm. Although agriculture was a major source of income for these families, they were clearly involved in both the traditional and nontraditional sectors of the economy. Rural and agricultural policies in Swaziland, including those dealing with

conservation, must be informed by this basic fact. Similarly, recognition of the central role played by women in crop production is important. Women accounted for over half of all labor devoted to maize production. The labor of women and children together accounted for over three-fourths of all the labor expended in maize production.

Given current and past patterns of fertility and population growth, it was not surprising that homesteads contained ample labor supplies. Almost all homesteads had sufficient labor to devote to agricultural production. The same was not true of land resources. The size of holdings varied widely across the homesteads and the size of holdings was positively related to the degree of agricultural commercialization.

Interestingly, commercial homesteads had the smallest total population, the smallest resident population and the fewest number of resident adults. Commercial and non-commercial (subsistence) homesteads had approximately equal numbers of production units, while semi-commercial homesteads had significantly more labor available but employed it in a different fashion. These findings suggest that the decision to become a commercial or non-commercial producer was not determined primarily by the availability of homestead labor.

Although homestead population size was not directly related to agricultural commercialization, the population/land ratios were associated with the degree of commercialization. When the ratio of production or consumption units per hectare of land was examined, commercial homesteads were markedly different from either semi- or non-commercial homesteads. They had twice as much land per consumption unit, but only half the productive units per hectare of subsistence units. Thus, continued rapid

population growth and the accompanying increase in average homestead size is likely to place growing pressure on the available land resources, and may possibly influence the process of agricultural commercialization on Swazi Nation Land by altering the population/land ratios.

A variety of measures of agricultural practices with potential implications for land degradation were examined. Swaziland has an established record of conservation policies designed to promote good land management. Between 1949 and 1960, for example, more than 70,000 miles of contour grass strips were demarcated. These strips separate adjacent panels and were constructed along the contour to impede the downslope transport of soil. In addition, Swazi Nation Land farmers have avoided cultivation of the steeper slopes further preserving the land base.

An important issue in future conservation efforts concerns preservation of these practices in view of increasing pressures to change them. Removal of the grass strips in order to increase the average size of panels cultivated and gradual extension of cultivation to include steeper slopes appear to be possibilities. Although longitudinal data are required to address the extent to which such changes have actually occurred, the current data set provides some baseline information against which future changes may be gauged.

Homesteads varied greatly in the width of panels on the downslope. Some homesteads farmed panels over 100 meters in width, suggesting that contour strips may have been removed. The relationship between average panel width and soil erosion (described below) suggests that increases in panel size will have negative consequences for soil conservation.

Monitoring of trends in the size of panels and the presence or absence of grass strips would appear to be warranted.

Although the size of panels cultivated is central to conservation efforts because it is within the control of homesteads, avoiding cultivation of the steeper slopes is perhaps more important. Research has established that degree of slope is more influential than length of slope in soil loss. One-fifth of homesteads farmed some land with 10 percent slope. Another one-fourth farmed land whose steepest slope was greater than 10 percent. Although these slopes are not excessive in comparison to some nations, they remain a source of concern. If increasing pressure on the land base continues as seems likely, steeper slopes may be brought under cultivation.

Two forms of soil erosion were examined in the study: sheet erosion and rill and gully erosion. Although the overwhelming majority of homesteads were classified as having some sheet erosion in which the A-horizon was eroded sufficiently that tillage implements reached the underlaying horizon, this was not deemed to be a serious problem negatively affecting land quality. The major reasons for the lack of more serious problems appeared to be the practices of grass stripping and contour plowing. None of the sample homesteads fell into the two more severe sheet erosion categories.

Rills were present on almost three-fourths of the homesteads but were not judged to be of such severity to seriously limit land quality. About one-fourth of homestead land contained shallow gullies between 31 and 100 centimeters in depth, most of which were created by the 1984 cyclone which produced conditions in which the usually effective conservation practices

were ineffective. Deep gullies over 100 centimeters in depth were not found on any homesteads surveyed and gully erosion was judged to be a serious problem on less than 10 percent of homesteads.

The findings from rill and gully erosion were similar to those for sheet erosion. Both results suggest that at present soil erosion on arable land is not a serious problem negatively affecting land quality under practiced conservation measures of contour plowing and grass stripping. In the absence of these protective measures, this picture could change relatively quickly. These results provide strong support for continuation of current conservation practices and encourage their wider adoption.

Findings with regard to the erosion susceptibility of Swazi Nation Land indicated that most land was low in susceptibility. Over 80 percent of holdings fell in the low to moderately low susceptibility categories. Undoubtedly, the concentration of arable landholdings on lands of relatively low susceptibility contributed to the rather modest amount of erosion found on homestead land.

These generally positive findings must be qualified by the recognition that they apply only to arable holdings among a relatively small sample of Swazi Nation Land farmers located in the Highveld and Middleveld regions. Extending this research to include the Lowveld and Lubombo regions is needed. However, the largest omission is the absence of information about soil conditions on communal grasslands. While systematic data on the condition of these lands are lacking, they appear to be much more seriously eroded than arable holdings. Future work should examine these lands carefully. At present, their condition is largely inferred indirectly from data on stocking rates, casual observations of grass cover on communal

lands, the low off-take rate of livestock and similar information. Systematic information on this topic is badly needed if policies to deal with the putative problem are to be devised and implemented.

Descriptive findings on homestead size and demographic composition, agricultural practices and the socioeconomic and agroclimatic environments were used to develop regression models of sheet and gully erosion. These models were inductively derived and included factors representative of each of the four major sets of variables examined: demographic characteristics, agricultural practices, and agroclimatic and socioeconomic characteristics.

The various models of sheet erosion revealed that agricultural practices were the most important set of factors influencing sheet erosion. The number of different crops grown, the total number of homestead hours devoted to maize production, the percentage of labor in maize contributed by homestead members (in contrast to exchange, invited or hired labor), use of the oxplow and the average size of panel cultivated were all positively related to sheet erosion. The first three of these factors appear to reflect aspects of agricultural intensification. This suggests that those homesteads most active in utilizing their land and labor to maximize yields from agricultural production were more likely to experience sheet erosion.

Similarly, homesteads which farmed their land in larger panels were also more likely to show evidence of sheet erosion, as were homesteads employing the oxplow. The positive impact of these two factors on sheet erosion appeared to stem from different conditions and agricultural circumstances. More commercial homesteads tended to farm larger panels on which tractors supplement and, to a lesser extent, substitute for animal draft power and manual labor. Oxplows tend to be used on land with steeper

slopes and more rocky soil on which tractors are less useful. Although the results are merely suggestive, they indicate that increasing levels of agricultural commercialization may be associated with increasing panel size.

The demographic variables as a set had little direct impact on sheet erosion. Only one demographic variable had a significant impact on sheet erosion. The ratio of productive units per hectare of land was significantly related to sheet erosion. Homesteads with a high ratio of labor to land were more likely to have sheet erosion. This result was consistent with the findings on the labor utilization patterns suggesting that more intensively farmed land was more likely to be eroded.

Although both indicators of agroclimatic characteristics, the erosivity-erodibility index and the steepest slope percent, were significantly correlated with sheet erosion, neither factor exerted an important impact in the multiple regression analysis. These results suggest that without controlling farming practices such as the width of panels or the intensity of cultivation, physical characteristics such as soil conditions, rainfall patterns and topography are related to sheet erosion in Swaziland. However, once agricultural practices and land use patterns were simultaneously considered, the agroclimatic factors were less important in explaining the actual amounts of sheet erosion on arable land. Such results do not diminish the importance of such factors, rather, they point to the potential of good land management and conservation practices in offsetting their influence.

Characteristics of the socioeconomic environment had little impact on sheet erosion. The proximity of homesteads to off-farm employment

opportunities was initially posited to affect homestead labor allocation and thus indirectly influence sheet erosion. Such was not the case. Distance of the homestead from the RDA center, however, was negatively related to sheet erosion, a finding for which we have no explanation.

The various models of sheet erosion point to the primary importance of agricultural practices in comparison to demographic, agroclimatic or the socioeconomic environment. Five of the six agricultural practices examined in the final models were consistently and significantly related to sheet erosion. Only one demographic variable, the ratio of productive units to hectares of land, and one socioeconomic factor, distance to RDA center, were related to sheet erosion. Perhaps most significant was the finding that agroclimatic characteristics were not influential in explaining sheet erosion once agricultural practices were taken into consideration. This finding is consistent with the interpretation that established conservation practices such as dividing holdings into smaller panels separated by contour grass strips and contour plowing have been effective at limiting soil loss on Swazi Nation Land.

In contrast to the models of sheet erosion, the models of gully erosion were inadequate in explaining this more serious form of land degradation. Only two of the agricultural practices, percent of maize hours by homestead members and use of the oxplow, were significant in any of the models estimated. Both of these factors were positively related to gully erosion, similar to their influence in the sheet erosion models. Further, their impacts varied from model to model indicating instability in estimation of their influence. Similarly, only one demographic factor, the number of adult males on the homestead, was significantly related to gully

erosion. The influence of this factor was consistent in sign and magnitude across the models examined, suggesting gullies were less likely to be found on homesteads with a greater number of adult males.

The contrasting influence of the agricultural practices between the sheet and gully erosion models was not expected. Agricultural practices were consistently related to sheet erosion as hypothesized, but largely unrelated to gully erosion. The 1984 cyclone appears to be largely responsible for the gully erosion observed among this sample, rather than variation in agricultural practices across homesteads. If this interpretation is correct, then neither agricultural practices nor any other set of factors examined in this study were likely to be important factors in explaining gully erosion. The negative influence of the number of adult males on gully erosion suggests that they may be an important labor resource in repairing gullies created by the cyclone or in constructing diversions to avoid such damage. Alternatively, the presence of adult males may also reflect the greater availability of capital to invest in improving the land because of their greater involvement in off-farm employment. These are plausible explanations for this result, but require more information to establish if either is correct.

Homestead demographic characteristics and agricultural practices were both systematically related to conservation-related agricultural practices. The average width of panels on the downslope and the number of panels per hectare were used to indicate conservation-related agricultural practices directly under the control of the homestead and potentially important in preventing soil loss. Both the average width of panels and panels per hectare were significantly associated with homestead size, degree of

agricultural commercialization and the ratio of productive units per hectare of land. Similarly, the homestead's involvement in providing its own labor, the use of tractors and the total size of landholdings were also associated with average panel width and the number of panels per hectare.

These findings revealed that homesteads that used more hired, invited or exchange labor, rather than relying more on homestead labor, that were more commercial in orientation, that used tractors, that had more members and that farmed larger holdings were more likely to farm wider panels and fewer panels per hectare. Interestingly, the agroclimatic characteristics were unrelated to panel width or panels per hectare, suggesting that decisions on the width of panels or number of panels to cultivate are largely unrelated to the erodibility of the soil, rainfall patterns or degree of slope of the land. The implications of these results for future conservation efforts in Swaziland are discussed in the following section.

Discussion and Implications

Perhaps the most encouraging finding from this study was the rather modest amount of soil erosion found on this sample of Swazi Nation Land homesteads. Although most homesteads experienced some sheet and rill erosion, the extent of soil loss was not sufficient to seriously or negatively affect land quality. Shallow gullies stemming primarily from the 1984 cyclone were present on a number of homesteads but these limited land quality on less than ten percent of holdings.

Evidence on the relatively low erosion susceptibility of Swazi Nation Land was similarly encouraging. Since susceptibility incorporates aspects of both the physical environment and management practices (width of panels and percent slope being farmed), the concentration of holdings in the low

susceptibility categories reflects past efforts at conservation, as well as favorable characteristics of the physical environment. While the low susceptibility to erosion of most holdings decreases the probability of erosion, it does not preclude land degradation if the width of panels increase, steeper slopes are brought under cultivation or if the contour grass strips are removed.

Although a cross-sectional study such as this cannot directly address the impact of past conservation practices on soil erosion, the evidence suggests that several practices have had important impacts. The practices of separating cultivated panels on the slope by contour grass strips, plowing along the contour and avoiding cultivation of the steeper slopes have all contributed to the relatively favorable condition of soils.

Whether these same conditions obtain among homesteads located in the Lowveld and Lubombo regions was not examined in this study. More importantly, these findings apply only to arable holdings and do not address the issue of land degradation on communal grasslands. Erosion of these soils is generally held to be more extensive and serious than land cultivated by SNL farmers. We have no systematic data with which to directly address this issue. However, our observations of a limited number of communal pastures is consistent with this interpretation. Given the importance of cattle to the Swazi economic and social system, and the documented over-stocking that occurs, information on this issue is long overdue.

The findings do not point to the primary importance of population growth on land degradation. Demographic factors had relatively minor independent impacts on sheet erosion, particularly in comparison to

agricultural practices. Agricultural practices on the homestead were more important, for example, than total population size, the number of productive units, the number of adult males or off-farm employment patterns of homestead members. Such results do not suggest that demographic factors are irrelevant to land degradation or conservation efforts. At the aggregate level, rapid population growth will undoubtedly result in additional pressure on land resources in Swaziland. And, as available land becomes more scarce, the temptation to bring marginal lands, including those with greater slopes, into cultivation will likely increase. At present, however, the impact of this growth has been mediated by the organization of agriculture on the homestead. Changes in the average size of homestead populations in relation to landholdings should be monitored.

Increased population growth, changes in technology and increased commercialization of agriculture were identified as possible forces influencing homestead agricultural practices which, in turn, affect soil erosion. Several conservation-related practices were associated with homestead population size and the degree of agricultural commercialization. Of particular importance was the width of panels and the number of panels per hectare.

Agricultural commercialization was positively related to the width of panels cultivated and negatively related to the number of panels per hectare. If increasing commercialization results in the removal of grass strips in order to cultivate larger panels, it may also result in greater soil losses unless appropriate counter measures are taken. Conversely, among the non-commercial (subsistence) homesteads and those farming more

marginal lands, the lack of available land may exert pressure to cultivate land with greater slope.

Since the allocation of additional land to existing homesteads, as well as the distribution of land to newly created households, is under the control of local chiefs, future conservation policies and programs should incorporate this group to insure that future policies are effectively implemented. Measures that would avoid cultivation of marginal lands and land on slopes above a given percent could be codified before increased pressure results in their cultivation. Such preventive measures would likely be more effective than ex post programs designed to cope with the rapid degradation possible if marginal lands are brought under cultivation.

The potential impact of increasing commercialization will be more difficult to deal with. Current agricultural development policies are aimed at increasing agricultural productivity and commercialization on Swazi Nation Land homesteads. The policy of self-reliance in maize and the desire to reduce food imports will place increasing pressure on the commercial agriculture sector. If increasing commercialization is associated with increased width of panels and the removal of grass strips, as these data suggest, alternative conservation measures must be developed to prevent future soil losses.

Fortunately, Swaziland has an established tradition of soil conservation with active participation by the government and the Monarchy. Involvement of the government and the authority of the King to issue orders regarding conservation are recognized in Swazi law. For example, under Section 10, Act 79, of the 1950 Swazi Administration Act, the King was empowered to issue orders "preventing soil erosion and for the protection

and construction of anti-soil erosion works (Armstrong, 1986:25)." The importance of soil conservation is recognized by the phrase inscribed on government envelopes: "The soil is our greatest asset--help conserve it."

Swazi Nation Land farmers are also aware of the necessity to protect their soil. In an informal environmental survey conducted among a subset of homesteads included in this sample, the majority of respondents recognized soil losses on their land and took steps to prevent their occurrence. These steps included those discussed earlier such as contour plowing and grass stripping, but also included construction of grassed waterways and trenches to divert runoff.

Although no formal statistical analysis of the environmental survey was undertaken, the magnitude of the perceived problem of soil loss among farmers was consistent with the soil survey undertaken for this study. Given this level of awareness, SNL farmers would likely be receptive to educational efforts aimed at conserving their land. The Ministry of Agriculture and Cooperatives, through the Agricultural Extension Service and other agencies could be utilized to deliver appropriately designed information and educational programs.

The modest amounts of soil erosion on arable land in Swaziland means that effective policies can be implemented before more serious and widespread land degradation occurs. Certain localized areas such as in the southern portions of the nation, already have serious erosion problems. Similarly, although solid evidence is lacking, communal grasslands also appear to be more seriously eroded than do arable lands. Immediate attention to both arable land and communal grazing land can prevent the

widespread deterioration of land resources in Swaziland that is observed elsewhere in sub-Saharan Africa.

Conclusions reached in this study must be tempered with the recognition that these results are based on a relatively small sample of SNL farmers in the Highveld and Middleveld regions of Swaziland. While these results are suggestive and can serve as a baseline against which to measure future changes in land degradation, conservation-related agricultural practices and homestead demographic characteristics, additional work is needed to establish their applicability to other areas of the country and the region. Nonetheless, these findings suggest that population growth, as reflected by homestead size and composition, was not directly related to land degradation.

The degree of agricultural commercialization and the associated differences in agricultural practices appear to mediate the influence of demographic factors on land degradation in Swaziland. Past policies and established conservation practices appear to have been effective in limiting soil erosion on arable landholdings. However, there is a need to examine other areas in southern Africa, and elsewhere, where government policies and conservation practices are not as well established. These areas are therefore likely to have more severe erosion damage.

The models examined in this study could be applied in other settings to determine what differences might exist. For example, the factors that predict erosion might differ considerably in countries where conservation policies are weak and/or where agricultural practices vary markedly from those in Swaziland. Finally, the issue of agricultural commercialization

and its association with the cultivation of larger fields is worthy of additional attention.

At a more general level, the findings of this study strongly support the need to develop models of land degradation which integrate traditional approaches, involving physical and climatological factors, with demographic and agricultural factors. The results argue against simple interpretations of the impacts of these forces on land degradation. Aggregate level statements about the impact of population growth on environmental degradation cannot be made in the absence of knowledge about the organization and type of agriculture being practiced, the size and composition of farm households, and national policies on conservation.

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Appendix A

LAND SUITABILITY FOR TRADITIONAL MAIZE FARMING AND EROSION SUSCEPTIBILITY IN SWAZILAND

by

J. Breyer

Report on a Consultancy undertaken for the
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1. TERMS OF REFERENCE

This research has been carried out as one component of the project "Demographic Pressure, Agricultural Production Systems and Land Degradation in Swaziland" by Professor C. S. Stokes and Professor W. A. Schutjer of the Department of Agricultural Economics and Rural Sociology, The Pennsylvania State University, for USAID, Washington. Their project proposes to examine the effect of increasing population pressure and land degradation in Swaziland. To be investigated are demographic characteristics of traditional farming households, their farming practices and degree of land degradation under diverse socio-economic and environmental conditions.

The required demographic, socio-economic and farm management data for the project are to be extracted from the ongoing "Swaziland Cropping Systems Research/Extension Training Project" (CSRETP) collected by Dr. J. Curry at the Research Station of the Ministry of Agriculture and Cooperatives (MOAC). CSRETP's research is based on a sample of 120 traditional farming households growing maize as the main subsistence crop. These households are located in 10 Rural Development Areas (RDAs) in the four natural regions of the country, i.e. the Highveld, Middleveld, Lowveld, and Lebombo Mountains.

This research was commissioned to provide required environmental data not covered by the CSRETP. The terms of reference are:

1. to assess the suitability of land (i.e. its agroclimatological conditions, relief and soils) for traditional maize farming;

2. to assess the erosion susceptibility (i.e. risks) of arable land under traditional maize farming;

3. and to locate the sample households on the 1:250,000 Map of Swaziland and the 1:50,000 topographic maps as well as to determine the distance of the households from their RDA centers.

Due to substantive and financial considerations it was agreed upon to cut the original CSRETP sample size down to 95 households in 8 RDAs, thus limiting this investigation to the Highveld and Middleveld of the country (figure 1). Within this reduced sample set a further 5 households were eliminated by CSRTEP for reasons such as lack of cooperation, sickness or death of household members (for a list of the sample households refer to table 1).

2. METHODS

2.1 The Land Evaluation Procedure

The international FAO land evaluation procedure (FAO 1983) was used to assess the suitability of land for traditional maize farming which underlying principles are briefly discussed here.

Figure 1

Location of Sample RDAs in Swaziland

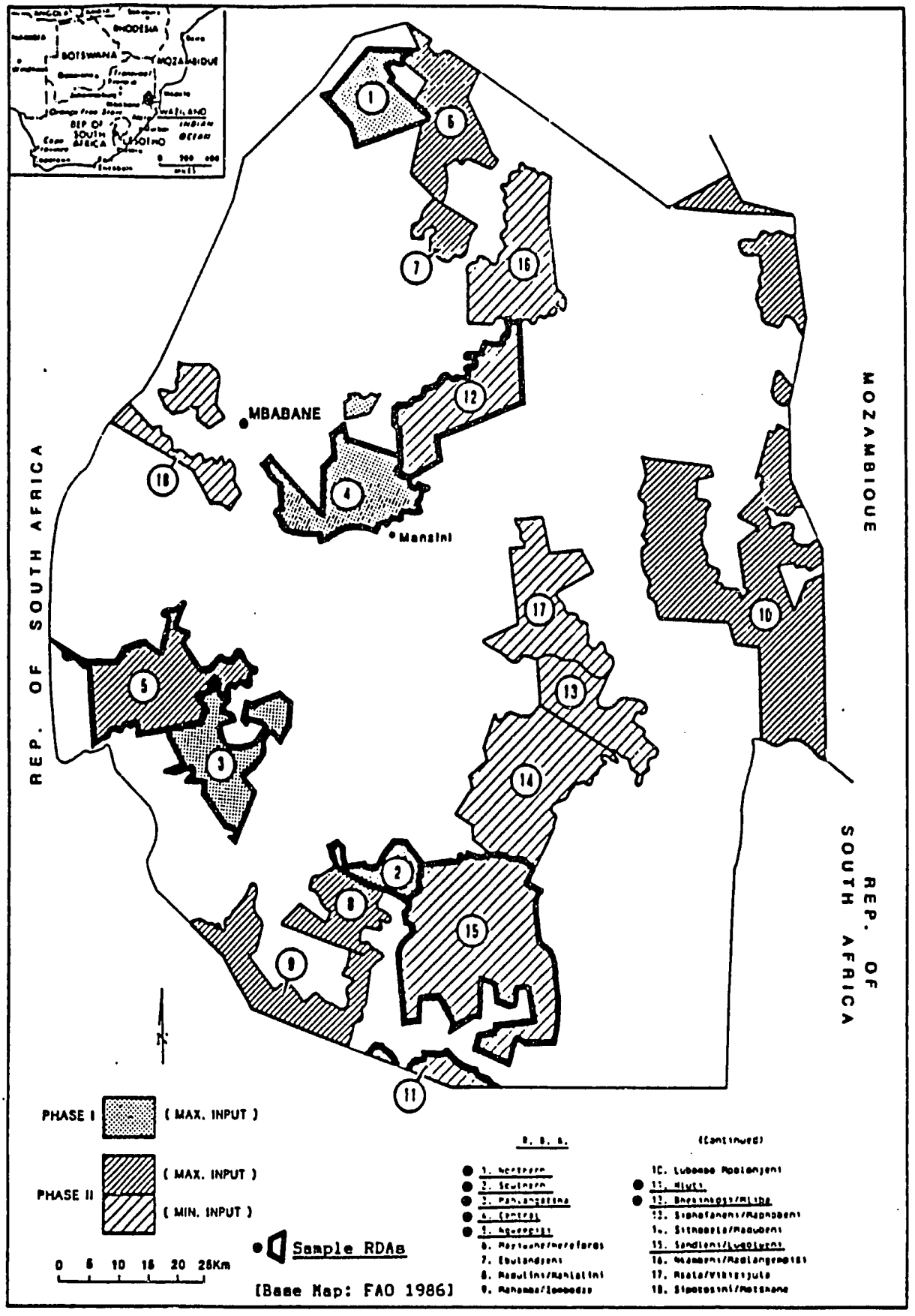

Table 1

Household Sample

	R D A	Household Number
1	Northern RDA	101
2	Northern RDA	102
3	Northern RDA	103
4	Northern RDA	104
5	Northern RDA	105
6	Northern RDA	106
7	Northern RDA	107
8	Northern RDA	108
9	Northern RDA	109
10	Northern RDA	110
11	Northern RDA	111
12	Northern RDA	112
13	Mahlangatsha RDA	201
14	Mahlangatsha RDA	202
15	Mahlangatsha RDA	203
~~16~~	~~Mahlangatsha RDA~~	~~204~~
17	Mahlangatsha RDA	205
18	Mahlangatsha RDA	206
19	Mahlangatsha RDA	207
20	Mahlangatsha RDA	208
21	Mahlangatsha RDA	209
22	Mahlangatsha RDA	210
23	Mahlangatsha RDA	211
120	Mahlangatsha RDA	212
24	Central RDA	303
25	Central RDA	304
26	Central RDA	305
27	Central RDA	306
28	Central RDA	307
29	Central RDA	308
30	Central RDA	313
31	Central RDA	315
32	Central RDA	316
33	Central RDA	318
34	Central RDA	319
35	Central RDA	320
~~36~~	~~Mpolonjeni RDA~~	~~401~~
37	Mpolonjeni RDA	402
38	Mpolonjeni RDA	403
39	Mpolonjeni RDA	405
41	Mpolonjeni RDA	407
42	Mpolonjeni RDA	409
43	Mpolonjeni RDA	411
44	Mpolonjeni RDA	413
45	Mpolonjeni RDA	414
46	Mpolonjeni RDA	415
47	Mpolonjeni RDA	417
48	Mpolonjeni RDA	419
~~40~~	~~Mpolonjeni RDA~~	~~420~~
49	Ngwemphisi RDA	501
50	Ngwemphisi RDA	502
51	Ngwemphisi RDA	503
52	Ngwemphisi RDA	504
53	Ngwemphisi RDA	505
54	Ngwemphisi RDA	506
55	Ngwemphisi RDA	507
56	Ngwemphisi RDA	508
57	Ngwemphisi RDA	509
58	Ngwemphisi RDA	510

RDAs and Households eliminated from original sample. Names of household heads were inlcuded in the original consultancy report but have been deleted to protect the confidentiality of respondents.

Table 1 (Cont.)

	R D A	Household Number
59	Ngwemphisi RDA	511
60	Ngwemphisi RDA	512
61	Bhekinkhosi RDA	601
62	Bhekinkhosi RDA	602
63	Bhekinkhosi RDA	603
64	Bhekinkhosi RDA	604
65	Bhekinkhosi RDA	605
66	Bhekinkhosi RDA	606
67	Bhekinkhosi RDA	607
68	Bhekinkhosi RDA	608
69	Bhekinkhosi RDA	609
70	Bhekinkhosi RDA	610
71	Bhekinkhosi RDA	611
72	Bhekinkhosi RDA	612
73	Southern RDA	701
74	Southern RDA	702
75	Southern RDA	703
76	Southern RDA	704
77	Southern RDA	705
78	Southern RDA	706
79	Southern RDA	707
80	Southern RDA	708
81	Southern RDA	709
82	Southern RDA	710
83	Southern RDA	711
84	Southern RDA	712
85	Tikhuba RDA	801
86	Tikhuba RDA	802
87	Tikhuba RDA	803
88	Tikhuba RDA	804
89	Tikhuba RDA	805
90	Tikhuba RDA	806
91	Tikhuba RDA	807
92	Tikhuba RDA	808
93	Tikhuba RDA	809
94	Tikhuba RDA	810
95	Tikhuba RDA	811
96	Tikhuba RDA	812
97	Hluti RDA	901
98	Hluti RDA	902
99	Hluti RDA	903
100	Hluti RDA	904
101	Hluti RDA	905
102	Hluti RDA	906
103	Hluti RDA	907
104	Hluti RDA	908
105	Sandleni/Luqolweni RDA	1001
106	Sandleni/Luqolweni RDA	1002
107	Sandleni/Luqolweni RDA	1003
108	Sandleni/Luqolweni RDA	1004
109	Sandleni/Luqolweni RDA	1005
110	Sandleni/Luqolweni RDA	1006
111	Sandleni/Luqolweni RDA	1007
112	Sandleni/Luqolweni RDA	1008
113	Sandleni/Luqolweni RDA	1009
114	Sandleni/Luqolweni RDA	1010
115	Sandleni/Luqolweni RDA	1011
116	Sandleni/Luqolweni RDA	1012
117	Sandleni/Luqolweni RDA	1013
118	Sandleni/Luqolweni RDA	1014
119	Sandleni/Luqolweni RDA	1015

Z RDAs and Households eliminated from original sample. Names of household heads were inlcuded in the original consultancy report but have been deleted to protect the confidentiality of respondents.

A. Selection of Land Qualities

First step in the evaluation procedure has been to determine those land qualities which have an essential effect on either maize performance or traditional management practices and conservation measures. Thirteen land qualities have been selected for the evaluation (table 2). These are radiation regime, air temperature regime, moisture regime, flooding hazard, oxygen availability, soil conditions for germination and seedling establishment, rooting conditions, nutrient availability, excess of salts and other soil toxicities which together are crop specific land qualities. Soil workability for animal and tractor drawn farming implements and erosion hazard (1) have been selected as important management and conservation related land qualities.

B. Selection of Diagnostic Land Characteristics

These land qualities have been described by one or more diagnostic land characteristics (table 2) as recommended by FAO (1983). For practical reasons these diagnostic land characteristics have been coded (table 3).

The land quality RADIATION REGIME has been estimated by the diagnostic land characteristic of daylength hours from sunrise to sunset during the stage of floral initiation of maize between November and February depending on its planting date.

The AIR TEMPERATURE REGIME is measured using mean daily air temperatures as well as daily mean maximum temperatures of the hottest month and mean minimum air temperatures of the coldest month during the growing season from October to March.

Due to lack of better diagnostic land characteristics at hand, the MOISTURE REGIME for maize has been primarily assessed by mean rainfall during the growing season. this assumes that rainfall is evenly spaced throughout the season and all moisture becomes available to maize, a situation which is rarely the case due to surface runoff, deep percolation, evaporation etc. Therefore the moisture regime using mean seasonal rainfall data is likely to be considerably overestimated. In addition to mean seasonal rainfall, the drought hazard have been determined which is defined by the number of years, expressed as percentage over the entire record period, when seasonal rainfall between October to March remains below 500 mm, a limit when maize performance is considered to be very severely affected (GOUDIE AND WILLIAMS 1983).

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[1] EROSION HAZARD is defined in this report as the damage done to the land by erosion as evident at present; in contrast EROSION SUSCEPTIBILITY refers here to the risk of erosion likely to take place now and in future under given climatic, landform and soil conditions as well as under traditional farming practices.

Table 2

Land Quality Assessment and Rating for Traditional Maize Farming

Land Quality	Code	Diagnostic Characteristics *	RATINGS s1	s2	s3	n
Radiation Regime	u	daylength during floral initiation of maize	1	2	3	4
Air Temperature Regime	c1	mean daily temperature during growing season, Oct-Mar	4	3,5	2,6	1,7
	c2	mean max daily temperature during hottest month, Oct-Mar	4	3,5	2,6	1,7
	c3	mean min daily temperature during coldest month, Oct-Mar	4	3,5	2,6	1,7
Moisture Regime	m1	total rainfall amount during growing season, Oct-Mar	4	3	2	1
	m2	drought hazard < 500 mm, Oct-Mar	1	2	3	4
Flooding Hazard	f	frequency of damaging floods	1	2	3	4,5
Oxygen Availability	w1	soil drainage	5,7	4	3	1-2
	w2	ponding/low current flooding, Oct-Mar	1	2	3	4-8
Conditions for Germination and Seedling Establishment	g1	soil structure, 3 digit code: 199 massive, 299 loose, otherwise: 1st digit refers to grade, 2nd digit refers to class, 3rd digit refers to type	299 316-7 411-7 511-7 326-7 426-7 526-7	421-5 521-5 336 436 536	311-7 321-5 331-5 431-5 341-5 441-5 199	531-5 541-5 199
	g2	soil consistency	1-2	3	4-5	6-7
	g3	surface cover of gravel	1-2	3	4	5-6
Rooting Conditions	r1	soil effective depth	4	3	2	1
	r2	soil consistency	1-3	4-6	7	-
Nutrient Availability **	n	pH of topsoil	6-8	5 9-10	4 11	1-3 12

Table 2 (Cont.)

Land Quality	Code	Diagnostic Characteristics *	RATINGS s1	s2	s3	n
Excess of	z1	salinity, electrical conduct. mS/cm,sat. extract	1	2	3	4
Salts **	z2	sodicity, indicator pH	1-9	-	10-11	12
Soil	y1	aluminium, indicator pH	>5	-	5	1-4
Toxicity **	y2	manganese, indicator pH	>5	-	-	1-5
Soil	k1	surface cover of gravel	1-2	3	4	5-6
Workability	k2	surface cover of stones and boulders	1	2	3	4-6
(Animal)	k3	soil consistency	1-4	5,6	7	-
Soil	q1	surface cover of gravel	1-2	3	4	5-6
Workability	q2	surface cover of stones and boulders	1	-	2	3-7
(Tractor)	q3	rock outcrop	1	2	3	4
	q4	steepest slope gradient	1-2	3-4	5-6	7-10
	q5	soil consistency	1-5	6	7	-
Erosion	e1	sheet erosion, indicator horizon thickness	1	2	3	4
Hazard	e2	rill/gully erosion 1st digit refers to type, 2nd digit to spacing of rills/gullies	13-14 24	12,23 34	11,22 33	21,31 32

* Land characteristics are coded according to table 3.

** Land qualities are of secondary importance for the land evaluation due to the indicative nature of their diagnostic land characteristics only.

Land Qualities are rated into 4 classes (refer to table 4):
s1 highly suitable
s2 moderately suitable
s3 marginally suitable
n not suitable

Land qualities are rated according to standards for traditional maize farming compiled by Doorenbos and Kassam (1979), FAO (1983), Van der Kevie (1976), Venema (1983) and USDA (1969).

Table 3

Code Sheet of Diagnostic Land Characteristics

u	DAYLENGTH (h)		CODE
	10-12	long	1
	9		2
	8		3
	<8	short	4
c1	MEAN DAILY AIR TEMPERATURE (°C)		CODE
	<15	cold	1
	15-19		2
	20-23		3
	24-30		4
	31-33		5
	34-34		6
	>35	very hot	7
c2	MEAN MAX DAILY AIR TEMPERATURE (°C)		CODE
	<15	cold	1
	15-19		2
	20-23		3
	24-30		4
	31-33		5
	34-34		6
	>35	very hot	7
c3	MEAN MIN DAILY AIR TEMPERATURE (°C)		CODE
	<15	cold	1
	15-19		2
	20-23		3
	24-30		4
	31-33		5
	34-34		6
	>35	very hot	7
m1	RAINFALL mm		CODE
	<500	very low	1
	501-650		2
	551-800		3
	>800	high	4

Table 3 (Cont.)

m2	DROUGHT HAZARD		CODE
	%		
	<20	low	1
	21-30		2
	31-50		3
	>50	very high	4
f	FREQUENCY OF DAMAGING FLOODS		CODE
	1:n-years		
	<20	very rarely	1
	11-20		2
	6-10		3
	3-5		4
	0-2	very frequently	5
w1	SOIL DRAINAGE		CODE
	class		
	Very poorly drained		1
	Poorly drained		2
	Imperfectly drained		3
	Moderately well drained		4
	Well drained		5
	Somewhat excessively drained		6
	Excessively drained		7
w2	PONDING/LOW CURRENT FLOODING		CODE
	days		
	0	none	1
	1-2		2
	3-7		3
	8-14		4
	15-21		5
	22-42		6
	43-140		7
	>140	excessive	8
g1	SOIL STRUCTURE 0-20 cm		CODE
	none		
	massive		199
	single grain		299
	grade		1st digit
	weak		3
	moderate		4
	strong		5

Table 3 (Cont.)

	class	2nd digit
	fine/thin	1
	medium	2
	coarse/thick	3
	very coarse/very thick	4
	type	3rd digit
	platy	1
	prismatic	2
	columnar	3
	angular blocky	4
	subangular blocky	5
	granular	6
	crumb	7
g2	SOIL CONSISTENCY 0-20 cm	CODE
	class	
	loose	1
	very friable, soft	2
	friable, slightly hard	3
	firm, slightly harder	4
	very firm, hard	5
	extremely firm, very hard	6
	extremely hard	7
g3	SURFACE GRAVEL	CODE
	%	
	0 none	1
	1-3	2
	4-15	3
	16-35	4
	36-70	5
	>50 very gravelly	6
r1	SOIL EFFECTIVE DEPTH	CODE
	cm	
	<10 very shallow	1
	10-30	2
	31-50	3
	>50 deep	4

Table 3 (Cont.)

r2	SOIL CONSISTENCY 0-50 cm class		CODE
	loose		1
	very friable, soft		2
	friable, slightly hard		3
	firm, slightly harder		4
	very firm, hard		5
	extremely firm, very hard		6
	extremely hard		7
n	INDICATOR 0-50cm pH		CODE
	<3.6	extremely acid	1
	3.6-4.0		2
	4.1-4.5		3
	4.6-5.0		4
	5.1-5.5		5
	5.6-6.0		6
	6.1-6.5		7
	6.6-7.0	Neutral	8
	7.1-7.5		9
	7.6-8.0		10
	8.1-8.5		11
	>8.5	very alkaline	12
z1	SALINITY 0-50cm mS/cm 25°C		CODE
	<4	none saline	1
	4.1-6		2
	6.1-8		3
	>8	very saline	4
z2	INDICATOR 0-50cm		CODE
y1	pH		
y2	<3.6	extremely acid	1
	3.6-4.0		2
	4.1-4.5		3
	4.6-5.0		4
	5.1-5.5		5
	5.6-6.0		6
	6.1-6.5		7
	6.6-7.0	Neutral	8
	7.1-7.5		9
	7.6-8.0		10
	8.1-8.5		11
	>8.5	very alkaline	12

Table 3 (Cont.)

k1	SURFACE COVERAGE OF GRAVEL		CODE
	area %		
	0	none	1
	1-3		2
	4-15		3
	16-35		4
	36-70		5
	>70	very gravelly	6
k2	SURFACE COVERAGE OF STONES/ BOULDERS		CODE
	area %		
	0-1	few	1
	2-4		2
	5-10		3
	11-25		4
	26-50		5
	51-90		6
	>90	very stony	7
k3	SOIL CONSISTENCY 0-20cm		CODE
	class		
	loose		1
	very friable, soft		2
	friable, slightly hard		3
	firm, slightly harder		4
	very firm, hard		5
	extremely firm, very hard		6
	extremely hard		7
q1	SURFACE COVERAGE OF GRAVEL		CODE
	area %		
	0	none	1
	1-3		2
	4-15		3
	16-35		4
	36-70		5
	>70	very gravelly	6
q2	SURFACE COVERAGE OF STONES/ BOULDERS		CODE
	area %		
	0-1	few	1
	2-4		2
	5-10		3
	11-25		4
	26-50		5
	51-90		6
	>90	very stony	7

Table 3 (Cont.)

q3	ROCK OUTCROP		CODE
	%		
	<1	few	1
	1-2		2
	3-10		3
	>10	very rocky	4
q4	STEEPEST SLOPE GRADIENT		CODE
	%		
	0-2	flat	1
	3-6		2
	7-10		3
	11-14		4
	15-18		5
	19-26		6
	27-32		7
	33-56		8
	57-70		9
	>70	extremely steep	10
q5	SOIL CONSISTENCY 0-20 cm		CODE
	class		
	loose		1
	very friable, soft		2
	friable, slightly hard		3
	firm, slightly harder		4
	very firm, hard		5
	extremely firm, very hard		6
	extremely hard		7
e1	SHEET EROSION		CODE
	class		
	no evidence of erosion, well developed A-horizon		1
	A-horizon partially eroded, tillage implements reach underlaying horizon		2
	A-horizon very thin, underlaying horizon at surface in places		3
	A-horizon eroded, parts of underlaying horizon eroded		4

Table 3 (Cont.)

e2	RILL/GULLY EROSION		CODE
	depth in cm		1st digit
	5-30	rill	1
	31-100	shallow gully	2
	101-300	deep gully	3
	spacing in m		2nd digit
	<20	close	1
	20-50		2
	51-150		3
	>150	wide	4

The FLOODING HAZARD is estimated by the frequency of damaging floods by rivers when crops, land and/or infrastructure is being destroyed.

OXYGEN AVAILABILITY for maize roots has been determined by soil drainage and the duration of ponding and/or low current flooding during the growing season. Ponding refers to the inundation of the soil surface by water due to a temporary rise in the groundwater table, seepage and runoff from adjacent land or by high rainfall on nearly level soils with low permeability (VAN DER KEVIE 1976).

Soil CONDITIONS FOR GERMINATION AND SEEDLING ESTABLISHMENT for maize have been assessed by soil structure and consistency of the plowed surface horizon (0-20 cm) as well as coverage of surface gravel.

ROOTING CONDITIONS for maize are determined by soil effective depth and soil consistency of the topsoil between 0-50 cm depth. The soil effective depth is limited by the presence of bedrock, a stoneline, or a cemented soil horizon.

NUTRIENT AVAILABILITY or the capacity of soil to supply maize with nutrients has been estimated by using soil reaction (ph) of the topsoil between 0-50 cm only due to lack of other soil chemical data.

EXCESS OF SALTS and TOXICITIES by aluminum and manganese have been assessed using electrical conductivity of the soil saturation extract at 25°C or soil reaction as indicators.

SOIL WORKABILITY refers to the ease the soil can be cultivated and plowed either by animal or tractor drawn implements. It has been assessed by incorporating cover of surface gravel (2), stones (3), and boulders (4), rock outcrops as well as slope steepness and soil consistency of the plow layer between 0-20 cm depth.

EROSION HAZARD refers to the damage already done by sheet (5), rill

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[2] GRAVEL: 0.2-7.5 cm in diameter.

[3] STONES: 7.6-25 cm in diameter.

[4] BOULDERS: >25 cm in diameter.

[5] SHEET EROSION refers to the detachment of soil particles through the impact of rain drops and their downslope transport in thin sheets rather than in defined channels.

(6) and gully erosion (7) and has been assessed using surface horizon thickness as an indicator as well as the presence of rills and gullies.

C. Rating of Land Qualities

For each land quality, as estimated by one or more diagnostic land characteristics, four qualitative ratings have been established. Each rating indicates the degree of limitation on crop performance, land management practices and/or conservation measures required (see table 2, 4) and are based on widely accepted qualitative standards compiled by VAN DER KEVIE (1976), DOORENBOS AND KASSAM (1979) and FAO (1983).

The land qualities are rated according to their diagnostic land characteristics. If a land quality is assessed by more than one land characteristic, the land quality rating is determined by either the lowest rating of the diagnostic land characteristic or by that land characteristic considered to be most important which in turn is adjusted by one grade according to the ratings of the secondary characteristics. Thus the air temperature regime is rated primarily by the mean air temperature regime and only downgraded by one if mean maximum and mean minimum air temperature deviate from the mean rated as highly suitable (s1). The moisture regime is primarily rated by mean seasonal rainfall. If its rating deviates from that of the drought hazard by more than one, the rating of the mean seasonal rainfall is adjusted by one grade. For all other land qualities, the lowest rated land characteristics determines the overall land quality rating.

After the selection, assessment and rating of the relevant land qualities, an agroclimatological and soil survey follow which together compile the diagnostic land characteristics for each sample household as required for the land evaluation.

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[6] RILL EROSION refers to the localized small washes in defined channels of equal to or less than 30 cm depth, which are small enough to be eliminated by plowing.

[7] GULLY EROSION refers to the significant removal of soil through large and well established channels of more than 30 cm depth, which usually cannot be crossed by farm implements.

Table 4

Land Quality Ratings*

s1	highly suitable land quality which does not significanlty limit maize performance, land management and/or requires any significant additional conservation measures;
s2	moderately suitable land quality, which moderately limits maize performance and land management and/or requires some additional conservation measures;
s3	marginally suitable land quality, which severely limits maize performance, land management and/or requires considerable additional conservation measures;
n	not suitable land quality, which limits maize performance, land management practices so severely and/or requires so extensive additional conservation measures as to make it impracticle.

* The ratings of individual land qualities are signified by lower case letters to avoid confusion with the final land suitability class, which takes into consideration every land quality rating of a household.

(modified after FAO 1983)

D. Agroclimatological Survey

For each RDA in the sample, representative weather stations have been selected from a relatively dense network of longterm rainfall recording stations, which are closest and at similar altitude of the sample households (see table 5). The rainfall stations have records of 30 years or more, with the exception of Mayiwane for the Northern RDA. Their rainfall records have been analyzed to assess the moisture regime and drought hazard for maize. The drought hazard has not been calculated for the Mayiwane station due to its short record period. Stations with air temperature records are less frequent (see table 5). Thus only one station has been selected to represent all the RDAs located in the Highveld, Upper Middleveld, or Lower Middleveld (8). Their data have been analyzed to establish the air temperature regime of these regions for growing maize.

Daylength does not vary significantly in a small country like Swaziland. Therefore the daylength regime has been determined for one central location of the country only using standard meteorological tables (ILACO 1981) to represent all RDAs in the sample.

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[8] As defined by MURDOCH 1970:9.

Table 5

Representative Weather Stations

RDA	REGION	REPRESENTATIVE STATION FOR Rainfall	Temperature
Northern	Upper Middleveld	Mayiwane (24)	Malkerns
Mahlangatia	Highveld	Mankanyane (74)	Hlatikulu
Central	Upper Middleveld	Matsapa (30)	Malkerns
Ngwempisi	Highveld	Mankanyane (74)	Hlatikulu
Bhekinkosi	Lower Middleveld	Mpsisi (64)	Mpisi
Southern	Upper Middleveld	Kubuta (65)	Malkerns
Hluti	Lower Middleveld	Hluti (67)	Mpisi
Sandleni/ Lugolweni	Lower Middleveld	Hluti (67)	Mpisi

( ) number of record years

E. Soil Survey

The soil survey forms the major component in the assessment of the land suitability for traditional maize farming of the sample households. Logistical support in form of staff and transport was provided by CSRTEP and the Malkerns Research Station. The Research Recorder Ms. P. Malaza joined the soil survey as interpreter, assistant and driver. One laborer at a time was hired privately who did the soil augerings and digging of soil pits.

The soil survey team was joined by the Rural Sociologist, Ms. M. Malaza, who executed environmental perception interviews for the CSRTEP and provided important supplementary data for the soil survey.

All 90 sample households in the 8 RDAs were visited between February and April 1987. The RDAs in proximity to Malkern were visited from the research station. The team established a base at the Southern and later Northern RDA centers to survey the households in the more distant parts of the country.

Prior to the field survey, Ms. P. Malaza and the RDA Research Assistants being most familiar with the areas marked the sample households on aerial photographs, this location was subsequently checked en route to the households on the older 1979 aerial photography in the Hluti RDA, which neither depict major new road alignments, the RDA center nor recently established homesteads as essential ground reference points.

During the soil survey permission was sought from the head of households or their representatives to enter the fields (9). Enquiries were made whether any changes in soils occurred on the farmers land in order to efficiently direct the field traverse. Additional information was recorded from household heads on important changes in soil properties such as texture, color, stoniness, duration and frequency of ponding, or flooding, etc. Frequently the team was accompanied by one household member to show the location of the field, if away from the homestead and to point out where and what kind of changes in soil characteristics occur.

The household's fields (10) have been traversed and slope and soil surface characteristics have been recorded for each panel along the traverse. Usually more than one observation point per field has been selected according to changes in slope and soil surface characteristics for detailed soil descriptions. Soil descriptions have been compiled from augerhole samples and freshly dug soil pits between 50 to 100 cm deep, which have been supplemented by observations from nearby gullies, roadcuts or pits wherever possible. The format of soil description follows international standards (FAO 1977) which to some extent have been modified and expanded to incorporate descriptions of additional diagnostic land characteristics required for the evaluation (for the field record sheet refer to figure 2).

From each soil profile a small soil sample of the top and subsoil has been taken to check or test for additional soil properties such as soil color after air drying, soil texture (11), soil reaction (ph) using Hellige Indicator solution and calcium carbonate content of the soil using 10 percent HCl. Further laboratory analysis has been beyond the means available for this research.

F. Coding and Matching

The diagnostic land characteristics recorded for each household during the agroclimatological and soil survey have been coded (table 3) and then matched with the land quality ratings established in step C. By matching, all thirteen considered land qualities, which determine crop performance, land management practices or conservation measures required have been rated as being highly suitable (s1) to not suitable (n) for traditional maize farming for each sample household (tables 8-23) appendix A,B).

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[9] FIELD is defined here as an entire block of land cultivated by a household. A field is usually subdivided by grass strips perpendicular to the slope. Each of these subdivisions between the grass strips is referred to as a PANEL.

[10] Sketch maps of fields/panels have been available from CSRTEP, which also provided information on panel length and width as well as land use.

[11] By finger test only.

Figure 2

Field Record Sheet

SOIL PROFILE DESCRIPTION
for
Penn State Project, Swaziland

HH #:		DATE:	AUTHOR:
SOIL set:		series:	local:
LOCAT:			GRID REF:
ELEVAT m	SURR RELIEF:		PHYS POS site:
SLOPE at site %:	aspect:		form:
MICRO RELIEF:		VEGET TYPE:	
VEGET	trees: %	dom species:	
COVER	shrubs: %	dom species:	
PCT	grass: %	dom species:	
LAND USE:			
PONDING # days:			
FLOODING # days:		frequency:	
PARENT MATERIAL:			
DRAINAGE class:			
MOIST CONDIT:			
DEPTH TO GROUND WATER (cm):			
SURFACE STONES dom size:			class:
ROCK OUTCROP class:			
EROSION CLASS sheet:	rill:	gully:	wind:
EROSION CONTROL:			
SALT/ ALKALI:			
HUMAN INFLUENCE:			
REMARKS:			

MOAC Info Dept.[3M0287] J Brewer 87

Soil Description cont.

HORIZON:				
DEPTH cm:				
COLOUR m:				
d:				
MOTTLING:				
TEXTURE:				
STRUCTURE:				
CONSISTENCE:				
CUTANS:				
CEMENTATION:				
PORES:				
ROCK/ MIN FRAGMENTS:				
NODULES:				
PANS:				
HCl:				
pH:				
ROOTS:				
BOUNDARY:				
SAMPLE #:				

G. Land Suitability Classification

The individual land quality ratings for each household have been combined into an overall suitability class which is determined by the lowest individual land quality rating of each household with the exception of the land qualities of sodicity or aluminum and manganese toxicities. These land qualities are given only secondary importance for the land evaluation due to the indicative nature of their land characteristics, i.e. soil reaction, which indicates but does not conclusively establish soil limitations such as sodicity or aluminum or manganese toxicities. Analog to the ratings of land qualities, four land suitability classes have been differentiated according to the degree of limitation the land qualities presents for maize performance and land management and/or additional conservation measures required (see table 6 and tables 16-23 in appendix B).

Land suitability subclasses have been identified for each household indicating the nature of the most limiting land qualities. Land suitability subclasses have been given lower-case letters placed after the land suitability class symbol, e.g. S3m, S2e. There are no subclasses to land rated highly suitable (S1) for traditional maize farming.

Table 6

Land Suitability Classes

S1 Highly Suitable	land with no land quality significantly limiting maize performance, land management, and/or requiring any additional conservation measures;
S2 Moderately Suitable	land with one or more land qualities moderately limiting maize performance, land management, and/or requiring some additional conservation measures;
S3 Marginally Suitable	land with one or more land qualities severely limiting maize performance, land management, and/or requiring considerable additional conservation measures;
N Not Suitable	land with one or more land qualities limit maize performance, land management so severely, and/or requiring such extensive additional conservation measures as to make it impracticle.

(modified after FAO 1983)

2.2 Assessing Soil Erosion Susceptibility

Since the 1950s arable lands in Swaziland have been protected by contour plowing and grass strips (REIJ 1984). Strips of grass perpendicular to the slope gradient are left unplowed between panels of cropped land. Surface water runoff moving down slope is intercepted by the grass strips where silt is deposited. Frequently small channels are constructed in the grass strips which collect the storm water flowing off the land and leads it at non eroding velocities into the nearest natural or constructed channel. By this method the slope of the land is divided into a series of short slope segments.

This technique quite satisfactorily controls gully and rill erosion in southern Africa (ELWELL 1978a), but it has become apparent that soil losses from sheet erosion may severely threaten arable land (VAN BAARSEN 1986). For this reasons the investigation here concentrates on the assessment of sheet erosion susceptibility from now on referred to as erosion susceptibility.

The assessment of erosion susceptibility has been based on the Zimbabwean "Soil Loss Estimation for Southern Africa (SLEMSA)" (ELWELL 1978a, b, reviewed and modified by STOCKING 1987). SLEMSA is a method of estimating mean annual soil loss from sheet erosion caused by arable farming and is based on field experiments and laboratory test data. The method has been developed for the Zimbabwean Highveld, but has been used and tested in different countries of southern Africa. To data the SLEMSA methods has been found valid in most of the Highveld and Middleveld of these countries including Swaziland (NKAMBULE, et al. 1987).

The SLEMSA method calculates erosion susceptibility using the formula:

$$\text{Erosion Susceptibility} = Ib \times C \times X$$

Ib represents the erosion index which is determined by rainfall erosivity (E) and soil erodibility (F); this index refers to a standard plot of bare soil with a 4.5 percent slope and 30 m long;

C represents the soil loss ratio which is determined by the density of vegetation cover intercepting rainfall (i);

X represents the soil loss ratio which is determined by slope steepness (s%) and slope length (sm).

In order to assess erosion susceptibility for each household, above diagnostic land characteristics such as rainfall, soil erodibility, vegetation cover and slope properties have been analyzed according to design graphs developed by SLEMSA indicating the relationships between the various land characteristics and erosion susceptibility.

Rainfall influences erosion susceptibility by its erosivity (E), i.e. the potential energy of raindrops to detach particles from the soil surface. Since data for rainfall energy are missing for most rainfall stations, SLEMSA tested the relationship between mean seasonal energy and mean annual rainfall in Zimbabwe (figure 3). Curve 1, which applies to thunderstorm type of rainfall, has been found to best represent Swaziland's Highveld and Middleveld with similar rainfall characteristics (NKAMBULE, et al. 1987). Thus this curve has been used to determine the mean seasonal rainfall energy (E) from mean annual rainfall data for each station representing the sample RDAs.

Soil erodibility (F) expresses the ability of soil to resist erosion which depends on a number of soil physical and chemical properties of the topsoil (0-50 cm). Due to lack of experimental data SLEMSA assigns soil erodibility values according to a simple indexing method taken into consideration soil texture together with a number of other soil properties such as gravel contents, the presence of a lithic phase (12) as well as management practices (table 7). According to this method, a soil erodibility index has been derived for each sample household.

SLEMSA established the relationship between the mean seasonal rainfall energy (E), the soil erodibility index (F) and the erosion susceptibility index (Ib) for a standard plot of bare soil, of 4.5 percent slope and 30 m length (figure 4) which has been established for each sample household modified according to vegetation cover and slope steepness and slope length.

Vegetation cover modifies erosion susceptibility significantly by intercepting raindrops. SLEMSA employs the mean vegetation cover during the growing season to assess the proportion of erosive rainfall that is intercepted by crops in a season (i) and establishes its relationship with the soil loss ratio 'C' (figure 5). For Swaziland the mean seasonal vegetation cover for subsistence maize farming has been estimated to be 30 percent based on remote sensing data combined with field checks (NKAMBULE et al. 1987). This figure has been uniformly applied to all sample households as best data available on a seasonally strongly varying characteristic to arrive at the soil loss ratio C.

The erosion susceptibility index 'Ib' has been further modified by slope properties according to SLEMSA's established relationship between slope steepness, slope length and the soil loss ratio 'X' (figure 6). To determine the soil loss ratio 'X', the steepest and longest slope of a panel have been selected for each household to determine the maximum erosion susceptibility for each sample household possible.

The degree of erosion susceptibility has been calculated for each sample household using the SLEMSA formula incorporating the household data

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[12] LITHIC PHASE refers to continuous, coherent and hard rock within 50 cm from the surface (after FAO 1974).

Figure 3

Relationship between Mean Annual Rainfall (P) and Mean Seasonal Rainfall Energy (E)

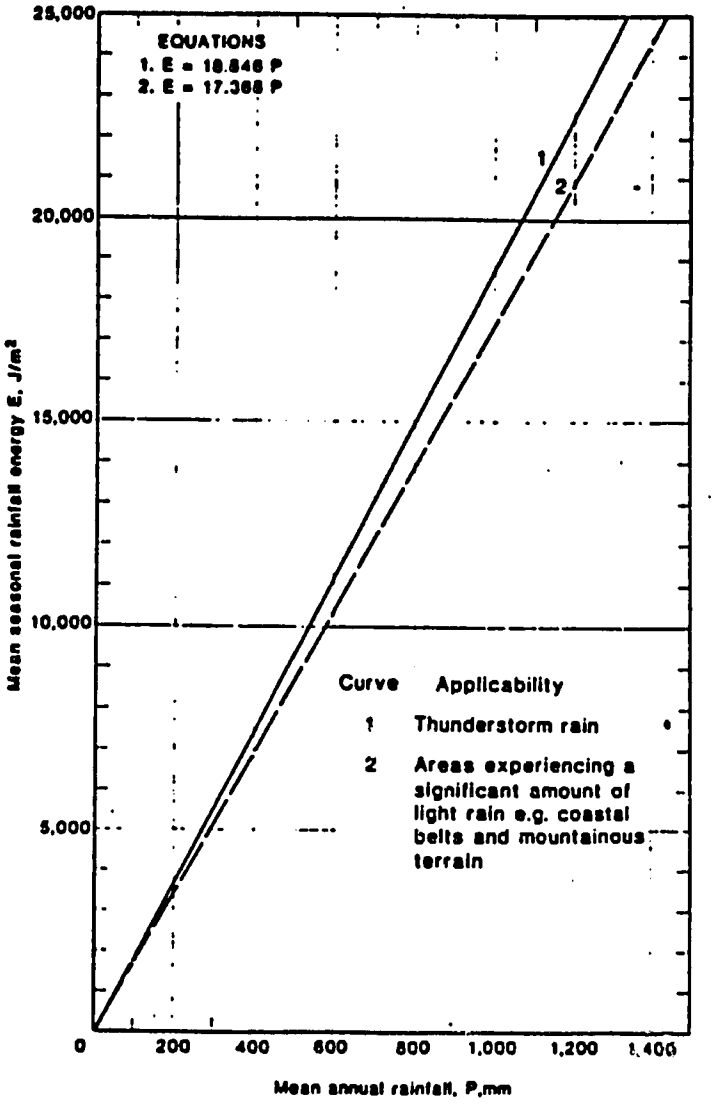
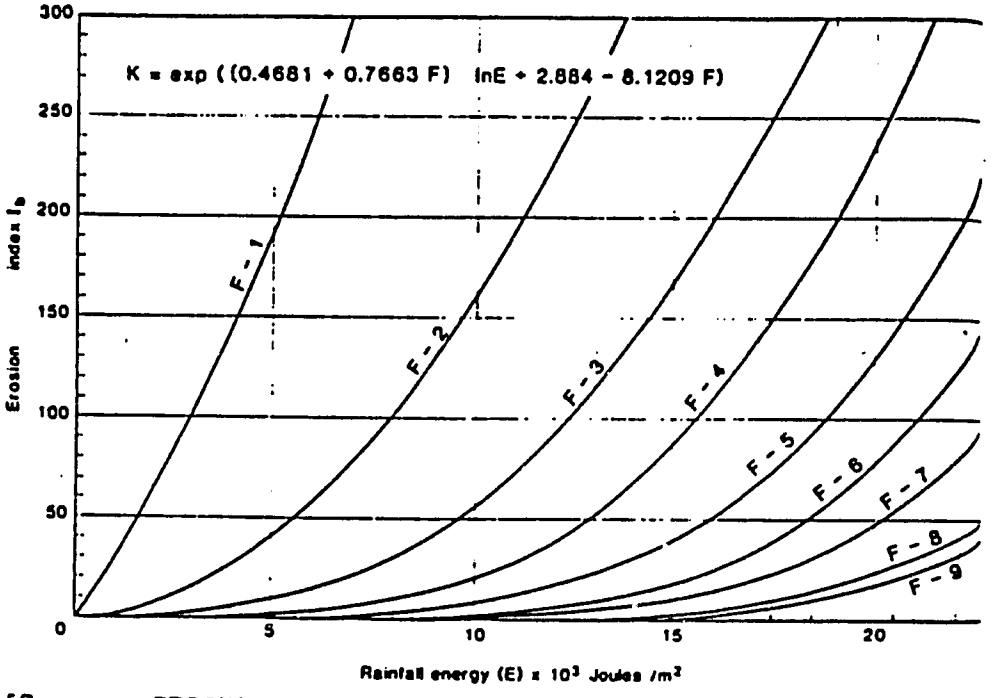


Figure 4

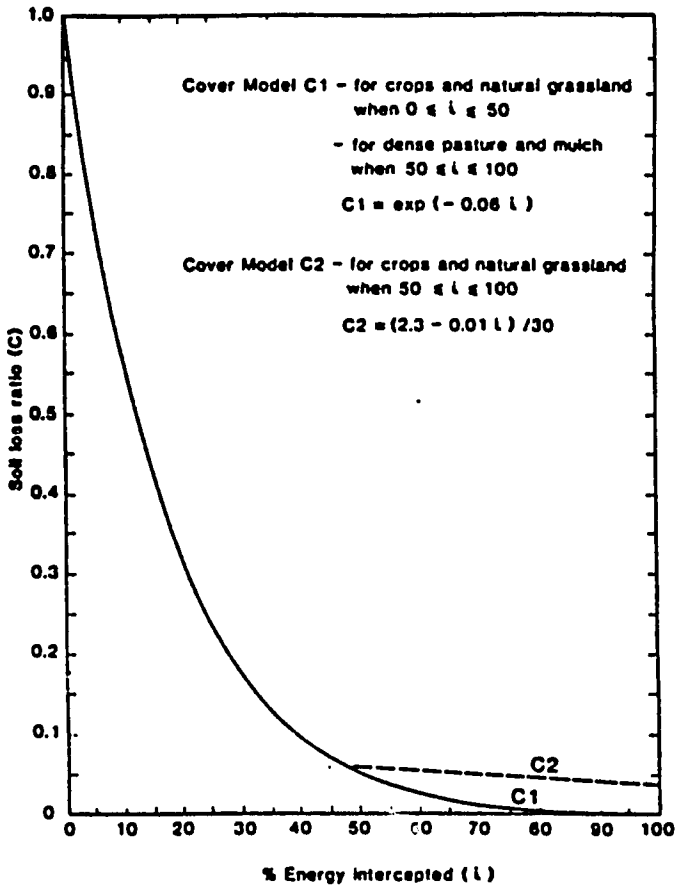
Relationship between Mean Seasonal Energy (E), Soil Erodibility (F), and the Erosion Susceptibility Index (Ib) for Bare Soil at 4.5% Slope and 30 m Long



[Source: STOCKING 1987, refer also to ELWELL 1978 a-c]

Figure 5

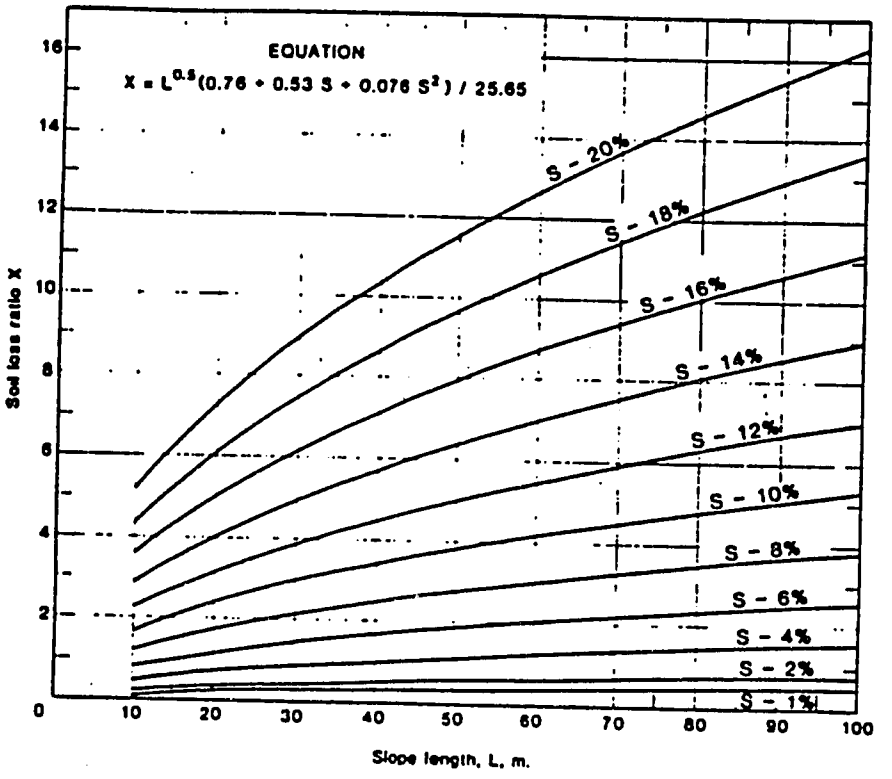
Relationship between Energy Interception (i) and the Soil Loss Ratio (C)



	0	10	20	30	40	50	60	70	80	90	100
C2						0.060	0.057	0.053	0.050	0.047	0.043
C1	1.0	0.55	0.30	0.17	0.09	0.050	0.029	0.015	0.008	0.005	0.002

Figure 6

Relationship between Slope Length (L), Steepness (S) and the Soil Loss Ratio (X)



(Source: STOCKING 1987, refer also to ELWELL 1978 a-c)

of the erosion susceptibility index which is modified according to the soil loss ratio of rainfall energy intercepted by vegetation and soil steepness and slope length. Results of the SLEMSA erosion susceptibility index range from 0 to approximately 1,000. Results of 10 or less indicate low, 11-50 moderately, 51-200 high and above 200 very high erosion susceptibility using Swaziland standards (NKAMBULE et al. 1987).

Table 7

Soil Erodibility Assessment

SOIL	TEXTURE	BASIC INDEX (F)
Coarse	sands loamy sands sandy loams	4
Medium	sandy clay loams clay loams sandy clays	5
Fine	clays	6

Subtract from the basic index:
- 1 for soils with gravels of >15% by volume
- 1 for light textured soils consisting mainly of fine sand and silt;
- 1 for restricted vertical permeability within 1 m of the surface, or for severe soil crusting;
- 1 for plowing up and down the slope;

Add to the basic index:
- 2 for deep (>2 m), well drained, light textured soils;
- 1 for plowing techniques which encourage maximum retention of water on the soil surface, or high infiltration, and maximum water storage in the profile.

(modified after ELWELL 1978a)

3. RESULTS

The diagnostic land characteristics of each sample household required to evaluate the land suitability for traditional maize farming are summarized in tables 8-15 of appendix A.

The diagnostic land characteristics are listed for one or more panels which are representative of the entire field of the sample household. If more than one panel per household is listed the portion of the entire field area it represents is specified.

For practical reasons the diagnostic land characteristics of each sample household are coded according to table 3.

The land quality ratings and land suitability classes for traditional maize farming of each sample household are summarized in tables 16-23 of appendix B. The individual land quality ratings (as defined in table 4) are based on the matching procedure between land quality ratings (compiled in table 2) and the diagnostic land characteristics of each sample household (tables 8-15). The land suitability classes (as defined in table 6) are based on the lowest individual land quality rating with the exception of those land qualities relating to soil toxicities due to the indicative nature of their diagnostic land characteristics employed.

Diagnostic characteristics of soil erosion susceptibility and the soil erosion susceptibility index of the sample households are summarized in tables 24-31. The index, as calculated, refers to the maximum erosion susceptibility on arable land based on the steepest slope and widest panel encountered on the field of a sample household and also takes into consideration the conservation measures of contour plowing and grass stripping as well as crop cover, soil erodibility and rainfall erosivity.

The results presented in these tables of land suitability for traditional maize farming, erosion hazard and soil erosion susceptibility are briefly summarized for each RDA in the following sections for each RDA.

3.1 Northern RDA

The Northern RDA is located in the Middleveld of the Hhohho Region in the northern parts of Swaziland. With a mean annual rainfall of 1056 mm the northern RDA falls into the moister Middleveld. Most rainfall falls during the summer month from October to March. The drought hazard is 17 percent, when less than 500 mm of rainfall are received during the growing season which severely limits maize performance.

The summers are hot with a mean maximum temperature of up to 28°C. The winters are warm during the day and cold at night with occasional frost occurring. The sample households are located along the Ntfonjeni district road and the Piggs-Peak - Matsamo main road on undulating to rolling land between 500-625 m above mean sea level (AMSL).

Parent material of soils for most sample households have been derived from coarse and medium grained granites (Lochiel Granite) and a few from very old schists and gneisses of the Swaziland System.

Their soils are mainly deep, dark reddish brown, sandy clay loams to sandy clays. Others are deep, dark grayish brown loamy sands to sandy loams on gravelly yellowish reddish clay loams. Deep, mottled, wet, gray to black sandy loams occur in a few panels located along channels.

The arable land of most sample households has been rated moderately suitable for traditional maize farming. The most but not severely limiting land quality are the air temperature and moisture regime affecting maize performance somewhat negatively. Arable land of a few households is marginally suitable due to the occurrence of surface stones affecting soil workability by tractor drawn implements. At two households panels close to a channel are unsuitable for maize due to poorly drained conditions limiting severely the oxygen availability in the root zone.

Soil erosion hazard on arable land is not a significantly limiting land quality except in a number of panels at three households where several gullies occur.

Soil erosion susceptibility on arable land is low under given farming practices and conservation measures of contour plowing, grass stripping and water runoff channels with the exception of arable land at a few households. There erosion susceptibility is high due to either the wide spacing of grass strips between panels, relatively steep slopes and/or a high gravel contents of the topsoil.

3.2 Mahlangatia RDA

Most of the Mahlangatia RDA is located in the Highveld of the Manzini Region in the southwestern parts of Swaziland. The climate is moist with a mean annual rainfall 906 mm. The drought hazard is 5 percent.

The summers are considerably cooler than the Middleveld with mean maximum temperatures not exceeding 23°C. The winters are warm during the day, the night are cold and frosts occur frequently during June to August.

The sample households are located between the Mahlangatia Hills and the district road to Ngwempisi on mainly undulating land (4-6%) between 1000-1250 m AMSL.

Parent materials of soils have been derived from microgranites, granophyres and gabbros of the Usushwana Complex as well as felsitic and andesitic lavas of the Insuzi Group. Their soils are mainly deep, dark reddish brown to dark reddish clay loams to clays which are occasionally gravelly in the topsoil. Some are dark reddish brown, very gravelly clay loams to clays with a stoneline at shallow depth.

Arable land of all sample households has been rated marginally suitable for traditional maize farming. The most limiting land quality is the low air temperature regime during the growing season affecting maize performance severely. Other limiting land qualities encountered on arable land at several households are soil conditions for germination, seedling establishment as and rooting due to a hard, compacted or gravelly topsoil.

Soil erosion hazard is low on arable land at the sample households with a few locally restricted exceptions. Similarly, soil erosion

susceptibility of arable land is generally very low due to a combination of low erodibility of the clayey topsoil, gentle slopes and practiced land management and conservation. However, erosion susceptibility increases where soil erodibility is lowered due to the presence of gravels in the topsoil and/or limited soil depth as encountered on arable land at a few households.

3.3 Central RDA

The Central RDA is located in the Middleveld of the Manzini Region in the center of Swaziland. With a mean annual rainfall of 914 mm the RDA falls into the moister parts of the Middleveld. The drought hazard is 8 percent. The summers are hot with mean maximum temperatures of up to 28°C. The winters are warm during the day and cold at night with frosts occurring occasionally during June to August.

The sample households are located on the undulating (3-5%) and rolling (8-18%) parts of the central RDA between 500-750 m AMSL.

Parent material of soils have been derived mainly from coarse and medium granodiorite, diorite and dolerite intrusions of the Usutu Suite. Associated soils are deep, dark reddish brown, sandy clay loams. Other soils are shallow, dark brown to gray, gravelly to very gravelly loamy medium sands to medium sandy loams on hardrock. Soils at one household are deep, dark brown to dark grayish brown medium sandy loams on stratified alluvium close to a channel and deep, yellowish red or brown silty loams on alluvial/colluvial materials.

Arable land of most households has been rated as moderately suitable for traditional maize farming, air temperature and moisture regime being the most but not severely limiting land qualities. The arable land at a few households is marginally or not suitable mainly due to the presence of surface gravel, stones, limited soil depth and slope steepness interfering with the workability of land as well as with germination, seedling establishment and rooting of maize.

Erosion hazard does not present a significantly limiting land quality for the sample households with the exception of a few. Erosion susceptibility is estimated to be moderately low or occasionally low. However, where gravel in the topsoil or hardrock at shallow depth lower the soil erodibility, as encountered in several panels at some households, the soil erosion susceptibility is very high.

3.4 Ngwempisi RDA

The Ngwempisi RDA is located in the Highveld of the Manzini Region south of Mankanyane. The climate is moist with a mean annual rainfall of 906 mm. The drought hazard is 5 percent. The summers are considerably cooler than in the Middleveld not exceeding a mean air temperature of 23°C.

The winters are warm during the days and cold at night with common frosts during June to August.

The sample households are located on undulating to rolling land between 750-1000 m AMSL in Ngwempisi close to the district road while others are located along the main road leading to Mankanyane.

Parent materials of soils are derived from Ngwane and Tsaweta gneisses. Most of their soils are shallow to moderately deep, dark reddish brown, gravelly medium sandy loams with a stoneline which is underlain by deep red clays. Others are deep, dark reddish brown, gravelly sandy clay loams or shallow, gravelly, medium sandy loams to sandy clay loams on hardrock or on a thick stoneline.

Arable land of all sample households has been rated marginally suitable again due to the severely limiting low air temperature regime. Additionally limiting land qualities are frequently soil workability for tractor drawn implements, conditions for seedling establishment and rooting mainly due to the localized occurrence of surface stones, gravels or shallow soils.

Erosion hazard is not a severely limiting land quality except at three sample households where several shallow gullies occur in most panels. Erosion susceptibility is moderately low except at a small number of households due to the high erodibility of a gravelly, shallow topsoils on sloping land.

3.5 Bhekinkosi RDA

The Bhekinkosi RDA is located in the Middleveld of the Manzini region in the center of Swaziland. With a mean annual rainfall of 655 mm the RDA falls into the drier Middleveld. The summers are hot with mean maximum temperatures of up to 30°C. The winters are warm during the day and cold at night with occasional night frosts between June and August.

The sample households are located north of Luve close to the district road and south of Luve along the main road on undulating land with 6-10 percent, occasionally up to 18 percent slopes at an elevation of about 500-750 m AMSL.

Parent material from which soils of most households have developed are coarse and medium grained granodiorite, quartz diorite of the Usutu Intrusive Suite and in some cases tonalitic gneisses (Ngwane Gneiss). Associated soils are deep, dark reddish brown, medium sandy loams to sandy clay loams. Others are shallow, dark brownish red to grayish brown sandy loams overlying decomposed gneiss.

Arable land of all households have been rated marginally suitable for traditional arable farming due to a severely limiting moisture regime for maize. Other limiting land qualities are frequently soil conditions for

germination, seedling establishment and rooting as well as soil workability for animal and tractor drawn farm implements mainly due to a high coverage of surface gravel and shallow soils.

Erosion hazard is not a severely limiting land quality except in a field of one household where several gullies have developed. Similarly the soil erosion susceptibility is low to moderately low, except for four households. There soil susceptibility is high due to a high soil erodibility and long slopes due to the wide spacing of grass strips on sloping land.

3.6 Southern RDA

The Southern RDA covers the Highveld and Middleveld of the Shiselweni Region in the southern parts of Swaziland. The sample households are located in the Middleveld only along the Hlatikulu to Hluti main road on undulating to rolling land (6-12 percent, occasionally up to 22 percent) between 500-875 m AMSL.

With a mean annual rainfall of 784 mm the RDA falls into the drier parts of the Middleveld. The drought hazard is 22 percent. The summers are hot with mean maximum temperatures of up to 28°C. The winters are warm during the days and cold at night with frost occasionally occurring.

Parent material of the soils are quartzites, quartz schists and thin shales of the Mozaan Group all of which are intruded by Post-Karroo dolerites. Associates soils are deep, dark red to reddish brown, locally gravelly clay loams to clays over red clay as well as shallow, dark reddish brown locally gravelly clay loams to clays over red clay on bedrock.

Arable land of all sample households have been rated as marginally suitable for traditional maize farming due to the severely limiting moisture regime for maize. Other, but less frequently occurring limiting land qualities are conditions for germination and seedling establishment as well as workability for animal and tractor drawn farm implements.

Erosion hazard on arable land is not a severely limiting land quality except at three households. There several gullies have developed in most panels. Similarly the soil erosion susceptibility is low or moderately low except in panels of one household where the erosion susceptibility is high due to the presence of gravels in a shallow topsoil.

3.7 Hluti RDA

The Hluti RDA is located in Lowveld and Middleveld of the Shiselweni Region in the southern parts of the country. The sample households are situated in the Middleveld only north of main road in the Lusthof area on undulating (6 to occasionally up to 12 percent slopes) land between 500-750 m AMSL.

With 874 mm mean annual rainfall the RDA falls into the moister parts of the Middleveld. The drought hazard is 16 percent. The summers are hot with mean maximum air temperatures up to 30°C; the winters are warm during the day and cold at night with frost occasionally occurring between June and August.

Parent materials of soils are coarse to medium grained granites with post Karroo dolerite intrusions. Associated soils encountered at the sample households are dark brown to dark grayish brown, locally gravelly, sands to sandy clay loams as well as sands and loamy sands.

Arable land of all sample households have been rated as moderately suitable for traditional maize farming with the exception of one where a shallow topsoil interferes with rooting conditions for maize.

Soil erosion hazard is not a severely limiting land quality except at one household where several gullies have developed in most panels. Similarly the soil erosion susceptibility is low or moderately low for all but one household where erosion susceptibility is high due to a sandy, gravelly and shallow soil.

3.8 Sandleni/Lugolweni RDA

The Sandleni/Logolweni RDA is located in the Middleveld and Lowveld of the Shishelweni Region in the south of Swaziland. The sample households are located in the Middleveld only along the main road north of the Lugolweni Hills on undulating land (6 to occasionally 14 percent slopes) at 625-750 m AMSL. With 874 mm mean annual rainfall the RDA falls into the moister Middleveld. The drought hazard is 16 percent. The summers are hot with mean maximum temperatures of up to 30°C, the winters are warm during the day and cold at night with frosts occurring occasionally.

Parent materials of soils are coarse grained granites (Kwetta and Mtombe Granite) with Post Karroo dolerite intrusions. Associated soils are mostly deep, dark reddish, occasionally dark reddish brown sandy clay loams to sandy clays which are locally gravelly. Other soils are deep, dark reddish brown to dark reddish medium sandy loams and coarse sands on hard reddish sandy clay loams and sandy clays some of which are locally gravelly.

Arable land have been rated as moderately suitable for traditional maize farming with the exception of some arable land which is marginally suitable mainly due to the occurrence of surface stones interfering with the workability of the soil for tractor drawn implements.

The erosion hazard on arable land is not a significantly limiting land quality except at two households where some gullies have developed on several panels. The soil erosion susceptibility is moderately low occasionally low except in a few households with highly erodible soils and steep long slopes between panels.

4. CONCLUSIONS

Three main conclusions can be drawn from this study:

I. THE ARABLE LAND OF MORE THAN HALF OF ALL SAMPLE HOUSEHOLDS IS ONLY MARGINALLY SUITABLE FOR TRADITIONAL MAIZE FARMING

Arable land of all sample households in the Mahlangatia and Ngwempisi RDA, located in the Highveld, are severely limited by a low air temperature regime during the growing season.

Arable land of all sample households in the Bhekinkosi and Southern RDA, located in the drier Middleveld, are severely limited by a low moisture regime during the growing season.

Other, quite frequently and severely limiting land qualities of arable land are conditions for germination, seedling establishment, rooting and workability for animal and tractor drawn farm implements.

Arable land of less than half of the sample households are moderately suitable and an insignificant number of land at 2 households is not suitable for traditional maize farming.

II. EROSION HAZARD ON ARABLE LAND IS NOT A SEVERELY LIMITING LAND QUALITY UNDER PRACTICED CONSERVATION MEASURES OF CONTOUR PLOWING AND GRASS STRIPPING

Arable land of almost all sample households is not or only somewhat limited by erosion hazard, although some signs of some sheet and rill erosion are common at almost all sample households. Gullies, however, are infrequent and of localized occurrence on arable land at most households. They are severely limiting land quality at only six out of 90 sample households.

A number of farmers indicated that the gullies formed during the cyclone 'Domaina' in 1984, thus being the result of a natural disaster beyond the capacity of the otherwise effective traditional soil conservation measures.

III. EROSION SUSCEPTIBILITY ON ARABLE LAND IS LOW TO MODERATELY LOW UNDER PRACTICED CONSERVATION MEASURES OF CONTOUR PLOWING AND GRASS STRIPPING

Erosion susceptibility on arable land is low to moderately low despite high rainfall erosivity and the low vegetation cover of the traditionally grown maize crop. This is mainly due to generally low soil erodibility as a result of clayey soil textures and contour plowing on relatively gentle slopes with grass strips breaking the slope into short segments.

Only at a few households the erosion susceptibility is high on arable land due to a sandy, gravelly and/or shallow topsoil especially where slopes are steeper than 10 percent and grass strips are widely spaced.

It has to be emphasized, however, that this assessment of erosion susceptibility takes into consideration contour plowing and grass stripping which appear to be quite effective conservation measures on arable land. Should these be altered such as by removal or wider spacing of grass stirps, plowing down the slope etc., the erosion susceptibility will be greatly increased especially on the sandy, gravelly and shallow soils very prone to erosion.

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Appendix A

Tables 8-15

Land Qualities of Sample Households

Table 8. Land Qualities of Sample Households in the Northern RDA

RDA	HH/PN	u	c1	c2	c3	m1	m2	f	w1	w2	g1	g2	g3	r1	r2	n	z1	z2	y1	y2	k1	k2	k3	q1	q2	q3	q4	q5	e1	e2	FREQUENCY OF OCCURRENCE
		DIAGNOSTIC LAND CHARACTERISTICS OF LAND QUALITIES																													
N	101-3	1	3	4	5	1	1	1	5	1	436	2	1	4	2	5	1	5	5	5	1	1	2	1	1	1	4	2	2	13(23)	
N	102-5	1	3	4	1	3	1	1	5	1	436	3	1	4	3	5	1	5	5	5	1	1	3	1	1	1	4	3	2	13(22)	
N	103-2	1	3	4	1	3	1	1	5	1	436	2	1	4	3	5	1	5	5	5	1	2	2	1	2	1	3	2	2	13(23)	dominant
N	103-4	1	3	4	1	3	1	1	2	3	299	1	1	4	3	5	1	5	5	5	1	1	1	1	1	1	1	1	2	14	included
N	104-3	1	3	4	1	3	1	1	5	1	436	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	2	2	2	13	
N	105-2	1	3	4	1	3	1	1	5	1	436	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	4	2	2	13(22)	
N	106-4	1	3	4	1	3	1	1	6	1	336	3	2(3)	4	2	5	1	5	5	5	2(3)	2	3	2(3)	2	1	4	3	2	13	
N	107-2	1	3	4	1	3	1	1	5	1	436	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	3	2	2	13	
N	108-2	1	3	4	1	3	1	1	5	1	436	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	2	2	2	14	
N	109-3	1	3	4	1	3	1	1	5	1	436	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	3	2	2	23	dominant
N	109-4	1	3	4	1	3	1	1	2	3	299	1	1	4	3	5	1	5	5	5	1	1	1	1	1	1	1	1	2	14	included
N	110-3	1	3	4	1	3	1	1	5	1	436	2	1	4	2	5	1	5	5	5	1	1	2	1	1	1	3	2	2	13(23)	
N	111-9	1	3	4	1	3	1	1	7	1	299	1	1	4	2	5	1	5	5	5	1	1	1	1	1	1	2	1	2	14	
N	112-3	1	3	4	1	3	1	1	5	1	436	2	1	4	4	5	1	5	5	5	1	1	2	1	1	1	3	2	2	13	

u Daylength
c1 Mean daily air temperature
c2 Mean max daily air temperature
c3 Mean min daily air temperature
m1 Rainfall amount
m2 Drought Hazard
f Frequency of damaging floods
w1 Soil Drainage
w2 Ponding/low current flooding
g1 Soil structure
g2 Soil consistency
g3 Surface gravel
r1 Soil effective depth
r2 Soil consistency
n Indicator pH

z1 Salinity
z2 Indicator pH
y1 Indicator pH
y2 Indicator pH
k1 Surface gravel
k2 Surface stones/boulders
k3 Soil consistency
q1 Surface gravel
q2 Surface stones/boulders
q3 Rock outcrop
q4 Steepest slope gradient
q5 Soil consistency
e1 Sheet erosion
e2 Rill/gully erosion

Land Characteristics are coded according to table 3, () a code in brackets refers to localized occurrence only;

HH/PN #: Sample household number and representative panel number, if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column 'frequency of occurrence' as:

dominant	the panel represents most of the field area
associated	the panel represents at least 20% of the field area
included	the panel represents less than 20% of the field area

RDA Rural Development Area

Table 9. Land Qualities of Sample Households in the Mahlangatia RDA

DIAGNOSTIC LAND CHARACTERISTICS OF LAND QUALITIES

RDA	HH/PN #	u	c1	c2	c3	m1	m2	f	w1	w2	g1	g2	g3	r1	r2	n	z1	z2	y1	y2	k1	k2	k3	q1	q2	q3	q4	q5	e1	e2	FREQUENCY OF OCCURRENCE
Mg	201-5	1	2	3	1	3	1	1	4	1	436	3	1	4	5	5	1	5	5	5	1	1	3	1	1	1	2	3	1	14	
Mg	202-2	1	2	3	1	3	1	1	5	1	436	5	1	4	5	5	1	5	5	5	1	1	5	1	1	1	2.	5	1	14	
Mg	203-1	1	2	3	1	3	1	1	4	1	436	5	1	4	5	5	1	5	5	5	1	1	5	1	1	1	2	5	1	14	
Mg	205-6	1	2	3	1	3	1	1	4	1(2)	436	5	1	4	7	5	1	5	5	5	1	1	5	1	1	1	2	5	1	14(13)	
Mg	206-1	1	2	3	1	3	1	1	4	1	436	5	1	4	5	5	1	5	5	5	1	1	5	1	1	1	2	5	1	14	
Mg	207-5	1	2	3	1	3	1	1	5,6	1	336	2	2,3	4	3	5	1	5	5	5	2,3	1	2	2,3	1	1	2,3	2	1	14	
Mg	208-2	1	2	3	1	3	1	1	5(6)	1(2)	336	3	1(3)	4	5	5	1	5	5	5	1(3)	1	3	1(3)	1	1	2	3	1	13	
Mg	209-6	1	2	3	1	3	1	1	5(6)	1(2)	336	5	1(3)	4	5	5	1	5	5	5	1(3)	1	5	1(3)	1	1	2,3	5	1	14	
Mg	210-4	1	2	3	1	3	1	1	7	1(2)	336	3	1(3)	2	3	5	1	5	5	5	1(3)	1	3	1(3)	1	1	2	3	1	14	dominant
Mg	210-7	1	2	3	1	3	1	1	7	1	299	1	4,2	2	3	5	1	5	5	5	4,2	1,2	1	4,2	1,2	1	2	1	1	14(13)	associated
Mg	211-3	1	2	3	1	3	1	1	4	1	436	5	1	4	5	5	1	5	5	5	1	1	5	1	1	1	2	5	1	14(13)	
Mg	212-3	1	2	3	1	3	1	1	4	1(2)	436	5	1	4	5	5	1	5	5	5	1	1	5	1	1	1	2	5	1	14	

u Daylength
c1 Mean daily air temperature
c2 Mean max daily air temperature
c3 Mean min daily air temperature
m1 Rainfall amount
m2 Drought Hazard
f Frequency of damaging floods
w1 Soil Drainage
w2 Ponding/low current flooding
g1 Soil structure
g2 Soil consistency
g3 Surface gravel
r1 Soil effective depth
r2 Soil consistency
n Indicator pH
z1 Salinity
z2 Indicator pH
y1 Indicator pH
y2 Indicator pH
k1 Surface gravel
k2 Surface stones/boulders
k3 Soil consistency
q1 Surface gravel
q2 Surface stones/boulders
q3 Rock outcrop
q4 Steepest slope gradient
q5 Soil consistency
e1 Sheet erosion
e2 Rill/gully erosion

Land Characteristics are coded according to table 3,
() a code in brackets refers to localized occurrence only;

HH/PN #: Sample household number and representative panel number, if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column 'frequency of occurrence' as:

dominant	the panel represents most of the field area
associated	the panel represents at least 20% of the field area
included	the panel represents less than 20% of the field area

RDA Rural Development Area

Table 10. Land Qualities of Sample Households in the Central RDA

DIAGNOSTIC LAND CHARACTERISTICS OF LAND QUALITIES

RDA	HH/PN #	u	c1	c2	c3	m1	m2	f	w1	w2	g1	g2	g3	r1	r2	n	z1	z2	y1	y2	k1	k2	k3	q1	q2	q3	q4	q5	e1	e2	FREQUENCY OF OCCURRENCE
C	303-2	1	3	4	1	3	1	1	5	1	436	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	4	2	2	13	
C	304-1	1	3	4	1	3	1	1	5	1	436	2	1	4	2	5	1	5	5	5	1	1	2	1	1	1	5	2	2	13	dominant
C	304-3	1	3	4	1	3	1	1	7	1	336	2	2(3)	2	2	5	1	5	5	5	2(4)	1,3	2	2(4)	1,3	1	5	2	2	13	associated
C	304-4	1	3	4	1	3	1	1	7	1	299	1	2(4)	2	2	5	1	5	5	5	2(4)	1	1	2(4)	1	1	5	1	2	13	included
C	305-3	1	3	4	1	3	1	1	5	1	436	2	1	4	2	5	1	5	5	5	1	1	2	1	1	1	2	2	2	14	
C	306-1	1	3	4	1	3	1	1	5	1	436	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	2	2	2	14	dominant
C	306-2	1	3	4	1	3	1	1	7	1	299	1	4,5	2	1	5	1	5	5	5	4,5	3	1	4,5	3	1	2	1	2	14	associated
C	307-4	1	3	4	1	3	1	1	5	1	436	2	1	4	2	5	1	5	5	5	1	1	2	1	1	1	2	2	2	13	
C	308-1	1	3	4	1	3	1	1	5	1	436	3	1	4	5	5	1	5	5	5	1	1	3	1	1	1	3	3	2	23	
C	313-2	1	3	4	1	3	1	1	5	1	436	3	1	4	4	5	1	5	5	5	1	1	3	1	1	1	5	3	2	14	dominant
C	313-5	1	3	4	1	3	1	1	6	1	336	2	1(2)	4	3	5	1	5	5	5	1(2)	1	2	1(2)	1	1	5	2	2	14	associated
C	315-4a	1	3	4	1	3	1	1	3	1	436	3	1	4	3	5	1	5	5	5	1	1	3	1	1	1	1	3	2	14	dominant
C	315-4b	1	3	4	1	3	1	1	6	1	436	3	1	4	3	5	1	5	5	5	1	1	3	1	1	1	2	3	2	14	associated
C	316-1	1	3	4	1	3	1	1	5	1	436	3	1	4	5	5	1	5	5	5	1	1	3	1	1	1	3	3	2	14	
C	318-3	1	3	4	1	3	1	1	6	1	336	2	1(2)	4	3	5	1	5	5	5	1(2)	1	2	1(2)	1	1	1	2	2	14	
C	319-1	1	3	4	1	3	1	1	5	1	436	3	1	4	3	5	1	5	5	5	1	1	3	1	1	1	2	3	2	14	dominant
C	319-3	1	3	4	1	3	1	1	5	1	436	2	1	4	4	5	1	5	5	5	1	1	2	1	1	1	4	2	2	14	associated
C	320-2	1	3	4	1	3	1	1	5	1	436	2	1	4	4	5	1	5	5	5	1	1	2	1	1	1	1	2	2	13	

u Daylength
c1 Mean daily air temperature
c2 Mean max daily air temperature
c3 Mean min daily air temperature
m1 Rainfall amount
m2 Drought Hazard
f Frequency of damaging floods
w1 Soil Drainage
w2 Ponding/low current flooding
g1 Soil structure
g2 Soil consistency
g3 Surface gravel
r1 Soil effective depth
r2 Soil consistency
n Indicator pH

z1 Salinity
z2 Indicator pH
y1 Indicator pH
y2 Indicator pH
k1 Surface gravel
k2 Surface stones/boulders
k3 Soil consistency
q1 Surface gravel
q2 Surface stones/boulders
q3 Rock outcrop
q4 Steepest slope gradient
q5 Soil consistency
e1 Sheet erosion
e2 Rill/gully erosion

Land Characteristics are coded according to table 3, () a code in brackets refers to localized occurrence only;

HH/PN #: Sample household number and representative panel number, if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column 'frequency of occurrence' as:

dominant	the panel represents most of the field area
associated	the panel represents at least 20% of the field area
included	the panel represents less than 20% of the field area

RDA Rural Development Area

Table 11. Land Qualities of Sample Households in the Ngwempisi RDA

DIAGNOSTIC LAND CHARACTERISTICS OF LAND QUALITIES

RDA	HH/PN	u	c1	c2	c3	m1	m2	f	w1	w2	g1	g2	g3	r1	r2	n	z1	z2	y1	y2	k1	k2	k3	q1	q2	q3	q4	q5	e1	e2	FREQUENCY OF OCCURRENCE
Ng	501-3	1	2	3	1	3	1	1	6	1	299	2	3	4	3	5	1	5	5	5	3	2	2	3	1,2	1	2	2	2	23
Ng	502-3	1	2	3	1	3	1	1	6	1	299	2	1	4	4	5	1	5	5	5	1	1	2	1	1	1	3	2	2	22
Ng	503-2	1	2	3	1	3	1	1	6	1	299	2	2	4	3	5	1	5	5	5	2	2	2	2	1,2	1	3	2	2	23
Ng	504-4	1	2	3	1	3	1	1	6	1	336	1	6	4	3	5	1	5	5	5	6	2	1	6	1,2	1	3	1	2	22
Ng	505-2	1	2	3	1	3	1	1	6	1	336	1	2	4	3	5	1	5	5	5	2	2	1	2	1,2	1	2	1	2	13
Ng	506-2	1	2	3	1	3	1	1	7	1	299	1	2	3	1	5	1	5	5	5	2	2	1	2	1,2	1	3	1	2	13
Ng	507-4	1	2	3	1	3	1	1	5	1	336	2	1	4	4	5	1	5	5	5	1	1	2	1	1	1	3	2	2	22
Ng	508-11	1	2	3	1	3	1	1	7	1	336	2	2,3	2	2	5	1	5	5	5	2,3	2	2	2,3	1,2	1	3,4	2	2	13
Ng	509-2	1	2	3	1	3	1	1	6	1	336	2	3,5	4	4	5	1	5	5	5	3,5	1,2	2	3,5	1,2	1	3	2	2	23
Ng	510-3	1	2	3	1	3	1	1	5	1	436	2	1	4	4	5	1	5	5	5	1	1	2	1	1	1	3	2	2	13
Ng	511-4	1	2	3	1	3	1	1	6	1	336	2	2	4	4	5	1	5	5	5	2	2	2	2	1,2	1	3	2	2	14
Ng	512-6	1	2	3	1	3	1	1	7	1	436	3	2	3	5	5	1	5	5	5	2	2	3	2	1,2	1	3	3	2	13

u Daylength
c1 Mean daily air temperature
c2 Mean max daily air temperature
c3 Mean min daily air temperature
m1 Rainfall amount
m2 Drought Hazard
f Frequency of damaging floods
w1 Soil Drainage
w2 Ponding/low current flooding
g1 Soil structure
g2 Soil consistency
g3 Surface gravel
r1 Soil effective depth
r2 Soil consistency
n Indicator pH

z1 Salinity
z2 Indicator pH
y1 Indicator pH
y2 Indicator pH
k1 Surface gravel
k2 Surface stones/boulders
k3 Soil consistency
q1 Surface gravel
q2 Surface stones/boulders
q3 Rock outcrop
q4 Steepest slope gradient
q5 Soil consistency
e1 Sheet erosion
e2 Rill/gully erosion

Land Characteristics are coded according to table 3,
() a code in brackets refers to localized occurrence only;

HH/PN #: Sample household number and representative panel number, if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column 'frequency of occurrence' as:

dominant	the panel represents most of the field area
associated	the panel represents at least 20% of the field area
included	the panel represents less than 20% of the field area

RDA Rural Development Area

Table 12. Land Qualities of Sample Households in the Bhekinkosi RDA

DIAGNOSTIC LAND CHARACTERISTICS OF LAND QUALITIES

RDA	HH/PN #	u	c1	c2	c3	m1	m2	f	w1	w2	g1	g2	g3	r1	r2	n	z1	z2	y1	y2	k1	k2	k3	q1	q2	q3	q4	q5	e1	e2	FREQUENCY OF OCCURRENCE
B	601-2	1	4	4	2	2	0	1	7	1	299	1	3,4	2	1	5	1	5	5	5	3,4	1	1	3,4	1	1	3	1	2	13	dominant
B	601-20	1	4	4	2	2	0	1	7	1	299	1	3	2	1	5	1	5	5	5	3	2	1	3	2	1	3	1	2	22	associated
B	602-4	1	4	4	2	2	0	1	7	1	299	1	3,4	2	1	5	1	5	5	5	3,4	2	1	3,4	2	1	3,4	1	2	13	
B	603-5	1	4	4	2	2	0	1	5	1	336	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	2	2	2	23	
B	604-1	1	4	4	2	2	0	1	5	1	436	2	1	4	5	5	1	5	5	5	1	1	2	1	1	1	1	2	2	12	
B	605-5	1	4	4	2	2	0	1	5(7)	1	336	3	1(3)	4	5	5	1	5	5	5	1(3)	2	3	1(3)	2	1	3,2	3	2	14	
B	606-1	1	4	4	2	2	0	1	4	1	436	3	1	4	5	5	1	5	5	5	1	1	3	1	1	1	2	3	2	14	dominant
B	606-6	1	4	4	2	2	0	1	7	1	299	1	2,4	3	1	5	1	5	5	5	2,4	2,3	1	2,4	2,3	1	3,4	1	2	14	associated
B	607-7	1	4	4	2	2	0	1	6	1	336	3	1	4	5	5	1	5	5	5	1	1	3	1	1	1	3	3	2	14	dominant
B	607-10	1	4	4	2	2	0	1	6	1	336	2	1	4	[illegible]	5	1	5	5	5	1	1	2	1	1	1	3	2	2	23	associated
B	608-12	1	4	4	2	2	0	1	7	1	299	1	2,4	2	1	5	1	5	5	5	2,4	1,2	1	2,4	1,2	1	2,3	1	2	23	
B	609-2	1	4	4	2	2	0	1	6	1	336	2	1	4	5	5	1	5	5	5	1	1	2	1	1	1	5,4	2	2	13	
B	610-5	1	4	4	2	2	0	1	6	1	336	2	1	4	5	5	1	5	5	5	1	1	2	1	1	1	4	2	2	23	
B	611-4	1	4	4	2	2	0	1	7	1	299	1	2	2	1	5	1	5	5	5	2	1	1	2	1	1	3	1	2	13	
B	612-2	1	4	4	2	2	0	1	6	1	336	3	1	4	6	5	1	5	5	5	1	1	3	1	1	1	2	3	2	13	

u Daylength
c1 Mean daily air temperature
c2 Mean max daily air temperature
c3 Mean min daily air temperature
m1 Rainfall amount
m2 Drought Hazard
f Frequency of damaging floods
w1 Soil Drainage
w2 Ponding/low current flooding
g1 Soil structure
g2 Soil consistency
g3 Surface gravel
r1 Soil effective depth
r2 Soil consistency
n Indicator pH
z1 Salinity
z2 Indicator pH
y1 Indicator pH
y2 Indicator pH
k1 Surface gravel
k2 Surface stones/boulders
k3 Soil consistency
q1 Surface gravel
q2 Surface stones/boulders
q3 Rock outcrop
q4 Steepest slope gradient
q5 Soil consistency
e1 Sheet erosion
e2 Rill/gully erosion

Land Characteristics are coded according to table 3, () a code in brackets refers to localized occurrence only;

HH/PN #: Sample household number and representative panel number, if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column 'frequency of occurrence' as:

dominant	the panel represents most of the field area
associated	the panel represents at least 20% of the field area
included	the panel represents less than 20% of the field area

RDA Rural Development Area

Table 13. Land Qualities of Sample Households in the Southern RDA

DIAGNOSTIC LAND CHARACTERISTICS OF LAND QUALITIES

RDA	HH/PN	u	c1	c2	c3	m1	m2	f	w1	w2	g1	g2	g3	r1	r2	n	z1	z2	y1	y2	k1	k2	k3	q1	q2	q3	q4	q5	e1	e2	FREQUENCY OF OCCURRENCE
S	701-1	1	3	4	1	2	2	1	4	1	436	2	1	4	4	5	1	5	5	5	1	1	2	1	1	1	2	2	2	14	
S	702-[illegible]	1	3	4	1	2	2	1	4	1	336	2	3,4	2	4	5	1	5	5	5	3,4	1,3	2	3,4	1,3	1	4	2	2	23	dominant
S	702-4	1	3	4	1	2	2	1	4	1(2)	299	2	3,4	4	2	5	1	5	5	5	3,4	2	2	3,4	2	1	3	2	2	12	associated
S	703-3	1	3	4	1	2	2	1	5	1	436	2	2	4	4	5	1	5	5	5	2	1	2	2	1	1	3	2	2	21	
S	704-3	1	3	4	1	2	2	1	5	1	436	2	1	4	5	5	1	5	5	5	1	1	2	1	1	1	3	2	2	23	
S	705-6	1	3	4	1	2	2	1	4	1	336	2	3,4	2	3	5	1	5	5	5	3,4	2,3	2	3,4	2,3	1	5	2	2	13	associated
S	705-8	1	3	4	1	2	2	1	5	1(2)	436	2	2	4	4	5	1	5	5	5	2	1	2	2	1	1	2	2	2	22	dominant
S	705-10	1	3	4	1	2	2	1	4	1(3)	436	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	2	2	2	22	included
S	706-3	1	3	4	1	2	2	1	4	1	436	3	2,3	2	3	5	1	5	5	5	2,3	1,3	3	2,3	1,3	1	4(6)	3	2	13	associated
S	706-8	1	3	4	1	2	2	1	4	1	436	3	1	4	4	5	1	5	5	5	1	1	3	1	1	1	4	3	2	13	dominant
S	707-1	1	3	4	1	2	2	1	5	1	436	2	3	4	3	5	1	5	5	5	3	1	2	3	1	1	4,5	2	2	23	
S	708-1	1	3	4	1	2	2	1	5	1	436	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	5	2	2	13	
S	709-2	1	3	4	1	2	2	1	5	1	436	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	3	2	2	13	dominant
S	709-6	1	3	4	1	2	2	1	4	1(2)	336	2	1(2)	2	3	5	1	5	5	5	1(2)	1(2)	2	1(2)	1(2)	1	2,3	2	2	13	associated
S	710-1	1	3	4	1	2	2	1	5	1	436	2	1(2)	4	4	5	1	5	5	5	1(2)	1(2)	2	1(2)	1(2)	1	3,2	2	2	13	associated
S	710-2	1	3	4	1	2	2	1	4	1	436	2	1(2)	3	6	5	1	5	5	5	1(2)	1(2)	2	1(2)	1(2)	1	3(1)	2	2	13	dominant
S	711-2	1	3	4	1	2	2	1	4	1	436	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	2	2	2	14	
S	712-2	1	3	4	1	2	2	1	4	1(2)	436	2	1	4	2	5	1	5	5	5	1	1	2	1	1	1	2	2	2	14	

u Daylength
c1 Mean daily air temperature
c2 Mean max daily air temperature
c3 Mean min daily air temperature
m1 Rainfall amount
m2 Drought Hazard
f Frequency of damaging floods
w1 Soil Drainage
w2 Ponding/low current flooding
g1 Soil structure
g2 Soil consistency
g3 Surface gravel
r1 Soil effective depth
r2 Soil consistency
n Indicator pH
z1 Salinity
z2 Indicator pH
y1 Indicator pH
y2 Indicator pH
k1 Surface gravel
k2 Surface stones/boulders
k3 Soil consistency
q1 Surface gravel
q2 Surface stones/boulders
q3 Rock outcrop
q4 Steepest slope gradient
q5 Soil consistency
e1 Sheet erosion
e2 Rill/gully erosion

Land Characteristics are coded according to table 3, () a code in brackets refers to localized occurrence only;

HH/PN #: Sample household number and representative panel number, if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column 'frequency of occurrence' as:

dominant	the panel represents most of the field area
associated	the panel represents at least 20% of the field area
included	the panel represents less than 20% of the field area

RDA Rural Development Area

Table 14. Land Qualities of Sample Households in the Hluti RDA

DIAGNOSTIC LAND CHARACTERISTICS OF LAND QUALITIES

RDA	HH/PN #	u	c1	c2	c3	m1	m2	f	w1	w2	g1	g2	g3	r1	r2	n	z1	z2	y1	y2	k1	k2	k3	q1	q2	q3	q4	q5	e1	e2	FREQUENCY OF OCCURRENCE
H	901-3	1	4	4	2	3	1	1	5	1	436	2	1	4	4	5	1	5	5	5	1	1	2	1	1	1	2	2	2	13	
H	902-3	1	4	4	2	3	1	1	5	1	436	2	1,3	4	4	5	1	5	5	5	1,3	1	2	1,3	1	1	2,3	2	2	14	
H	903-3	1	4	4	2	3	1	1	5	1	436	2	1	4	2	5	1	5	5	5	1	1	2	1	1	1	2	2	2	14(23)	
H	905-2	1	4	4	2	3	1	1	7	1	299	2	1	4	2	5	1	5	5	5	1	1	2	1	1	1	2	2	2	13(12)	
H	906-4	1	4	4	2	3	1	1	7	1	336	2	1,3	2	2	5	1	5	5	5	1,3	1	2	1,3	1	1	4	2	2	22	
H	908-4	1	4	4	2	3	1	1	6	1	436	2	1	2	2	5	1	5	5	5	1	1	2	1	1	1	4	2	2	14(23)	

u Daylength
c1 Mean daily air temperature
c2 Mean max daily air temperature
c3 Mean min daily air temperature
m1 Rainfall amount
m2 Drought Hazard
f Frequency of damaging floods
w1 Soil Drainage
w2 Ponding/low current flooding
g1 Soil structure
g2 Soil consistency
g3 Surface gravel
r1 Soil effective depth
r2 Soil consistency
n Indicator pH

z1 Salinity
z2 Indicator pH
y1 Indicator pH
y2 Indicator pH
k1 Surface gravel
k2 Surface stones/boulders
k3 Soil consistency
q1 Surface gravel
q2 Surface stones/boulders
q3 Rock outcrop
q4 Steepest slope gradient
q5 Soil consistency
e1 Sheet erosion
e2 Rill/gully erosion

Land Characteristics are coded according to table 3, () a code in brackets refers to localized occurrence only;

HH/PN #: Sample household number and representative panel number, if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column 'frequency of occurrence' as:

dominant	the panel represents most of the field area
associated	the panel represents at least 20% of the field area
included	the panel represents less than 20% of the field area

RDA Rural Development Area

Table 15. Land Qualities of Sample Households in the Sandleni/Lugolweni RDA

DIAGNOSTIC LAND CHARACTERISTICS OF LAND QUALITIES

RDA HH/PN #	u	c1	c2	c3	m1	m2	f	w1	w2	g1	g2	g3	r1	r2	n	z1	z2	y1	y2	k1	k2	k3	q1	q2	q3	q4	q5	e1	e2	FREQUENCY OF OCCURRENCE
S/L 1001-6	1	4	4	2	3	1	1	5	1	336	2	1(3)	4	2	5	1	5	5	5	1(3)	1	2	1(3)	1	1	3,4	2	2	23	
S/L 1002-3	1	4	4	2	3	1	1	5	1	436	2	1(3)	4	3	5	1	5	5	5	1(3)	1	2	1(3)	1	1	3	2	2	22(21)	
S/L 1003-5	1	4	4	2	3	1	1	4	1	436	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	3	2	2	14	
S/L 1004-3	1	4	4	2	3	1	1	5	1	436	3	1	4	4	5	1	5	5	5	1	1	3	1	1	1	3,4	3	2	12	dominant
S/L 1004-6	1	4	4	2	3	1	1	5	1	336	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	3	2	2	12	associated
S/L 1005-3X	1	4	4	2	3	1	1	6	1	436	2	1(2)	4	2	5	1	5	5	5	1(2)	1	2	1(2)	1	1	4	2	2	23	dominant
S/L 1005-3A	1	4	4	2	3	1	1	6	1	336	2	1(2)	3	2	5	1	5	5	5	1(2)	1(2)	2	1(2)	1(2)	1	4	2	2	22	associated
S/L 1007-5	1	4	4	2	3	1	1	5	1	299	1	1	4	2	5	1	5	5	5	1	1(2)	1	1	1(2)	1	4,3	1	2	23	
S/L 1008-2	1	4	4	2	3	1	1	5	1	436	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	3	2	2	12	dominant
S/L 1008-5	1	4	4	2	3	1	1	4	1	436	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	2	2	2	13	associated
S/L 1010-3	1	4	4	2	3	1	1	7	1	299	1	1(2)	4	2	5	1	5	5	5	1(2)	1	1	1(2)	1	1	4,5	1	2	23	
S/L 1011-3	1	4	4	2	3	1	1	5	1	436	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	3	2	2	23	
S/L 1012-4	1	4	4	2	3	1	1	5	1	436	2	1	4	3	5	1	5	5	5	1	1(2)	2	1	1(2)	1	3	2	2	23	
S/L 1013-3	1	4	4	2	3	1	1	5	1	436	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	3	2	2	12	
S/L 1014-4	1	4	4	2	3	1	1	5	1	436	2	1	4	2	5	1	5	5	5	1	1	2	1	1	1	4	2	2	13	
S/L 1015-13	1	4	4	2	3	1	1	5	1	436	2	1	4	4	5	1	5	5	5	1	1	2	1	1	1	4	2	2	14	dominant
S/L 1015-21	1	4	4	2	3	1	1	5	1	436	2	1	4	3	5	1	5	5	5	1	1	2	1	1	1	3	2	2	13	associated

u Daylength
c1 Mean daily air temperature
c2 Mean max daily air temperature
c3 Mean min daily air temperature
m1 Rainfall amount
m2 Drought Hazard
f Frequency of damaging floods
w1 Soil Drainage
w2 Ponding/low current flooding
g1 Soil structure
g2 Soil consistency
g3 Surface gravel
r1 Soil effective depth
r2 Soil consistency
n Indicator pH

z1 Salinity
z2 Indicator pH
y1 Indicator pH
y2 Indicator pH
k1 Surface gravel
k2 Surface stones/boulders
k3 Soil consistency
q1 Surface gravel
q2 Surface stones/boulders
q3 Rock outcrop
q4 Steepest slope gradient
q5 Soil consistency
e1 Sheet erosion
e2 Rill/gully erosion

Land Characteristics are coded according to table 3, () a code in brackets refers to localized occurrence only;

HH/PN #: Sample household number and representative panel number, if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column 'frequency of occurrence' as:

dominant	the panel represents most of the field area
associated	the panel represents at least 20% of the field area
included	the panel represents less than 20% of the field area

RDA Rural Development Area

Appendix B

Tables 16-23

Land Suitability of Sample Households

Table 16. Land Suitability of Sample Households in the Northern RDA

RDA	HH/PN #	u	c1	c2	c3	m1	m2	f	w1	w2	g1	g2	g3	r1	r2	n	z1	z2	y1	y2	k1	k2	k3	q1	q2	q3	q4	q5	e1	e2	SUITABILITY CLASS
		DIAGNOSTIC LAND CHARACTERISTICS OF LAND QUALITIES																													
N	101-3	s1	s2		s2		s1	s1		s2	s1	s1		s1	s1	s2	s1	s1	s3	n	s1		s1	s1		s1	s2	s1	s2	s1(2)	S2
N	102-5	s1	s2		s2		s1	s1		s2	s2	s1		s1	s1	s2	s1	s1	s3	n	s1		s1	s1		s1	s2	s1	s2	s1(3)	S2[S3e]
N	103-2	s1	s2		s2		s1	s1		s2	s1	s1		s1	s1	s2	s1	s1	s3	n	s1		s2	s1	s1	s3	s1	s2	s1	s2	s1(2)	S3
N	103-4	s1	s2		s2		s1	n		s1	s1	s1		s1	s1	s2	s1	s1	s3	n	s1		s1	s1	s1	s1	s1	s1	s2	s1	[Nw]
N	104-3	s1	s2		s2		s1	s1		s2	s1	s1		s1	s1	s2	s1	s1	s3	n	s1		s1	s1	s1	s1	s1	s1	s2	s1	S2
N	105-2	s1	s2		s2		s1	s1		s2	s1	s1		s1	s1	s2	s1	s1	s3	n	s1		s1	s1	s1	s1	s2	s1	s2	s1(3)	S2[S3e]
N	106-4	s1	s2		s2		s1	s1		s2	s2	s1(2)		s1	s1	s2	s1	s1	s3	n	s1(2)		s2	s1	s1(2)	s3	s1	s2	s1	s2	s1	S3
N	107-2	s1	s2		s2		s1	s1		s2	s1	s1		s1	s1	s2	s1	s1	s3	n	s1		s1	s1	s1	s1	s1	s2	s1	s2	s1	S2
N	108-2	s1	s2		s2		s1	s1		s2	s1	s1		s1	s1	s2	s1	s1	s3	n	s1		s1	s1	s1	s1	s1	s1	s2	s1	S2
N	109-3	s1	s2		s2		s1	s1		s2	s1	s1		s1	s1	s2	s1	s1	s3	n	s1		s1	s1	s1	s1	s2	s1	s2	s2	[NW]
N	109-4	s1	s2		s2		s1	n		s1	s1	s1		s1	s1	s2	s1	s1	s3	n	s1		s1	s1	s1	s1	s1	s1	s2	s2	S2*
N	110-3	s1	s2		s2		s1	s1		s2	s1	s1		s1	s1	s2	s1	s1	s3	n	s1		s1	s1	s1	s1	s2	s1	s2	s1(2)	S2
N	111-9	s1	s2		s2		s1	s1		s1	s1	s1		s1	s1	s2	s1	s1	s3	n	s1		s1	s1	s1	s1	s1	s1	s2	s1	S2
N	112-3	s1	s2		s2		s1	s1		s2	s1	s1		s1	s2	s2	s1	s1	s3	n	s1		s1	s1	s1	s1	s2	s1	s2	s1	S2

DIAGNOSTIC LAND CHARACTERISTCS

u	Daylength	z1	Salinity
c1	Mean daily air temperature	z2	Indicator pH
c2	Mean max daily air temperature	y1	Indicator pH
c3	Mean min daily air temperature	y2	Indicator pH
m1	Rainfall amount	k1	Surface gravel
m2	Drought Hazard	k2	Surface stones/boulders
f	Frequency of damaging floods	k3	Soil consistency
w1	Soil Drainage	q1	Surface gravel
w2	Ponding/low current flooding	q2	Surface stones/boulders
g1	Soil structure	q3	Rock outcrop
g2	Soil consistency	q4	Steepest slope gradient
g3	Surface gravel	q5	Soil consistency
r1	Soil effective depth	e1	Sheet erosion
r2	Soil consistency	e2	Rill/gully erosion
n	Indicator pH		

Land quality ratings in brackets ( ) refer to diagnostic land characteristics of localized occurrence only;

HH/PN #: Sample household number and representative panel number; if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column 'suitability class' as:

dominant	the panel represents most of the field area,
associated	the panel represents at least 20% of the field area, indicated by an '*'
included	the panel represents less than 20% of the field area, indicated by [].

RDA Rural Development Area

LAND QUALITY RATINGS

s1 highly suitable land quality, which does not significantly limit maize performance, land management and/or requires significant conservation measures;

s2 moderately suitable land quality, which somewhat limits maize performance, land management and/or requires some conservation measures;

s3 marginally suitable land quality, which severely limits maize performance, land management and/or requires considerable conservation measures;

n not suitable land quality, which limits maize performance and land management so severely and/or requires such extensive conservation measures as to make it impractical.

LAND SUITABILITY CLASSES

S1 Highly Suitable Land with no land quality significantly limiting maize performance, management practices and/or requiring and conservation measures;

S2 Moderately Suitable Land with one or more land qualities significantly limiting maize performance, management practices and/or requiring some conservation measures;

S3 Marginally Suitable Land with one or more land qualities severely limiting maize performance, management practices and/or requiring considerable conservation measures;

N Not Suitable Land with one or more land qualities limiting maize performance and land management so severely and/or requiring such extensive conservation measures as to make it impractical.

S3e Land suitability classes carry one or more letter suffixes indicating its most limiting land quality/qualities.

Table 17. Land Suitability of Sample Households in the Mahlangatia RDA

RDA	HH/PN #	u	c1	c2	c3	m1	m2	f	w1	w2	g1	g2	g3	r1	r2	n	z1	z2	y1	y2	k1	k2	k3	q1	q2	q3	q4	q5	e1	e2	SUITABILITY CLASS
		DIAGNOSTIC LAND CHARACTERISTICS OF LAND QUALITIES																													
Mg	201-5	s1	s3				s2		s1	s2	s2	s2	s1	s1	s2	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s1	s1	s1	s1	S3c
Mg	202-2	s1	s3				s2		s1	s1	s2	s3	s1	s1	s2	s2	s1	s1	s3	n	s1	s1	s2	s1	s1	s1	s1	s2	s1	s1	S3c,g
Mg	203-1	s1	s3				s2		s1	s2	s2	s3	s1	s1	s2	s2	s1	s1	s3	n	s1	s1	s2	s1	s1	s1	s1	s2	s1	s1	S2c,g
Mg	205-6	s1	s3				s2		s1	s2	s2	s3	s1	s1	s3	s2	s1	s1	s3	n	s1	s1	s2	s1	s1	s1	s1	s2	s1	s1	S3c,g,r
Mg	206-1	s1	s3				s2		s1	s2	s2	s3	s1	s1	s2	s2	s1	s1	s3	n	s1	s1	s2	s1	s1	s1	s1	s2	s1	s1	S3c,g
Mg	207-5	s1	s3				s2		s1	s1	s2	s1	s1,2	s1	s1	s2	s1	s1	s3	n	s1,2	s1	s1	s1,2	s1	s1	s1,2	s1	s1	s1	S3c
Mg	208-2	s1	s3				s2		s1	s1	s2	s2	s1(2)	s1	s2	s2	s1	s1	s3	n	s1(2)	s1	s1	s1(2)	s1	s1	s1	s1	s1	s1	S3c
Mg	209-6	s1	s3				s2		s1	s1	s2	s3	s1(2)	s1	s2	s2	s1	s1	s3	n	s1(2)	s1	s2	s1(2)	s1	s1	s1,2	s2	s1	s1	S3c,g
Mg	210-4	s1	s3				s2		s1	s1	s2	s2	s1(2)	s3	s2	s2	s1	s1	s3	n	s1(2)	s1	s1	s1(2)	s1	s1	s1	s1	s1	s1	S3c
Mg	210-7	s1	s3				s2		s1	s1	s1	s1	s3,1	s3	s1	s2	s1	s1	s3		S3,1	s1	s1	s3,1	s1,3	s1	s1	s1	s1	s1	S3c
Mg	211-3	s1	s3				s2		s1	s2	s2	s3	s1	s1	s2	s2	s1	s1	s3	n	s1	s1	s2	s1	s1	s1	s1	s2	s1	s1	S3c,g
Mg	212-3	s1	s3				s2		s1	s2	s2	s3	s1	s1	s2	s2	s1	s1	s3	n	s1	s1	s2	s1	s1	s1	s1	s2	s1	s1	S3c,g

DIAGNOSTIC LAND CHARACTERISTCS

u	Daylength	z1	Salinity
c1	Mean daily air temperature	z2	Indicator pH
c2	Mean max daily air temperature	y1	Indicator pH
c3	Mean min daily air temperature	y2	Indicator pH
m1	Rainfall amount	k1	Surface gravel
m2	Drought Hazard	k2	Surface stones/boulders
f	Frequency of damaging floods	k3	Soil consistency
w1	Soil Drainage	q1	Surface gravel
w2	Ponding/low current flooding	q2	Surface stones/boulders
g1	Soil structure	q3	Rock outcrop
g2	Soil consistency	q4	Steepest slope gradient
g3	Surface gravel	q5	Soil consistency
r1	Soil effective depth	e1	Sheet erosion
r2	Soil consistency	e2	Rill/gully erosion
n	Indicator pH		

Land quality ratings in brackets ( ) refer to diagnostic land characteristics of localized occurrence only;

HH/PN #: Sample household number and representative panel number; if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column 'suitability class' as:

dominant	the panel represents most of the field area,
associated	the panel represents at least 20% of the field area, indicated by an '*'
included	the panel represents less than 20% of the field area, indicated by [].

RDA Rural Development Area

LAND QUALITY RATINGS

s1 highly suitable land quality, which does not significantly limit maize performance, land management and/or requires significant conservation measures;

s2 moderately suitable land quality, which somewhat limits maize performance, land management and/or requires some conservation measures;

s3 marginally suitable land quality, which severely limits maize performance, land management and/or requires considerable conservation measures;

n not suitable land quality, which limits maize performance and land management so severely and/or requires such extensive conservation measures as to make it impractical.

LAND SUITABILITY CLASSES

S1 Highly Suitable Land with no land quality significantly limiting maize performance, management practices and/or requiring and conservation meansures;

S2 Moderately Suitable Land with one or more land qualities significantly limiting maize performance, management practices and/or requiring some conservation measures;

S3 Marginally Suitable Land with one or more land qualities severely limiting maize performance, management practices and/or requiring considerable conservation meansures;

N Not Suitable Land with one or more land qualities limiting maize performance and land management so severely and/or requiring such extensive conservation measures as to make it impractical.

S3e Land suitability classes carry one or more letter suffixes indicating its most limiting land quality/qualities.

Table 18. Land Suitability of Sample Households in the Central RDA

DIAGNOSTIC LAND CHARACTERISTICS OF LAND QUALITIES

RDA	HH/PN #	u	c1	c2	c3	m1	m2	f	w1	w2	g1	g2	g3	r1	r2	n	z1	z2	y1	y2	k1	k2	k3	q1	q2	q3	q4	q5	e1	e2	SUITABILITY CLASS
C	303-2	s1	s2			s2		s1	s1		s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s2	s1	s2	s1	S2
C	304-1	s1	s2			s2		s1	s1		s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s3	s1	s2	s1	S3q
C	304-3	s1	s2			s2		s1	s1		s2	s1	s1(2)	s3	s1	s2	s1	s1	S2	n	s1(3)	s1,3	s1	s1(23	s1,n	s1	s3	s1	s2	s1	Ng*
C	304-4	s1	s2			s2		s1	s1		s1	s1	s1(3)	s3	s1	s2	s1	s1	s3	n	s1(3)	s1	s1	s1(3)	s1	s1	s3	s1	s2	s1	[S3g,r,k,q]
C	305-3	s1	s2			s2		s1	s1		s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s1	s1	s2	s1	S2
C	306-1	s1	s2			s2		s1	s1		s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s1	s1	s2	s1	S2
C	306-2	s1	s2			s2		s1	s1		s1	s1	s3,n	s3	s1	s2	s1	s1	s3	n	S3,n	s3	s1	s3,n	s3,n	s1	s1	s1	s2	s1	Nq*
C	307-4	s1	s2			s2		s1	s1		s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s1	s1	s2	s1	S2
C	308-1	s1	s2			s2		s1	s1		s2	s2	s1	s1	s2	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s2	s1	s2	s2	S2
C	313-2	s1	s2			s2		s1	s1		s2	s2	s1	s1	s2	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s3	s1	s2	s1	S3q
C	313-5	s1	s2			s2		s1	s1		s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s3	s1	s2	s1	S3q*
C	315-4a	s1	s2			s2		s1	s3		s2	s2	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s1	s1	s2	s1	S3w
C	315-4b	s1	s2			s2		s1	s1		s2	s2	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s1	s1	s2	s1	S2*
C	316-1	s1	s2			s2		s1	s1		s2	s2	s1	s1	s2	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s2	s1	s2	s1	S2
C	318-3	s1	s2			s2		s1	s1		s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s1	s1	s2	s1	S2
C	319-1	s1	s2			s2		s1	s1		s2	s2	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s1	s1	s2	s1	S2
C	319-3	s1	s2			s2		s1	s1		s2	s1	s1	s1	s2	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s2	s1	s2	s1	S2*
C	320-2	s1	s2			s2		s1	s1		s2	s1	s1	s1	s2	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s1	s1	s2	s1	S2

DIAGNOSTIC LAND CHARACTERISTCS

u	Daylength	z1	Salinity
c1	Mean daily air temperature	z2	Indicator pH
c2	Mean max daily air temperature	y1	Indicator pH
c3	Mean min daily air temperature	y2	Indicator pH
m1	Rainfall amount	k1	Surface gravel
m2	Drought Hazard	k2	Surface stones/boulders
f	Frequency of damaging floods	k3	Soil consistency
w1	Soil Drainage	q1	Surface gravel
w2	Ponding/low current flooding	q2	Surface stones/boulders
g1	Soil structure	q3	Rock outcrop
g2	Soil consistency	q4	Steepest slope gradient
g3	Surface gravel	q5	Soil consistency
r1	Soil effective depth	e1	Sheet erosion
r2	Soil consistency	e2	Rill/gully erosion
n	Indicator pH		

Land quality ratings in brackets ( ) refer to diagnostic land characteristics of localized occurrence only;

HH/PN #: Sample household number and representative panel number; if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column 'suitability class' as:

dominant	the panel represents most of the field area,
associated	the panel represents at least 20% of the field area, indicated by an '*'
included	the panel represents less than 20% of the field area, indicated by [].

RDA Rural Development Area

LAND QUALITY RATINGS

s1 highly suitable land quality, which does not significantly limit maize performance, land management and/or requires significant conservation measures;

s2 moderately suitable land quality, which somewhat limits maize performance, land management and/or requires some conservation measures;

s3 marginally suitable land quality, which severely limits maize performance, land management and/or requires considerable conservation measures;

n not suitable land quality, which limits maize performance and land management so severely and/or requires such extensive conservation measures as to make it impractical.

LAND SUITABILITY CLASSES

S1 Highly Suitable Land with no land quality significantly limiting maize performance, management practices and/or requiring and conservation meansures;

S2 Moderately Suitable Land with one or more land qualities significantly limiting maize performance, management practices and/or requiring some conservation measures;

S3 Marginally Suitable Land with one or more land qualities severely limiting maize performance, management practices and/or requiring considerable conservation meansures;

N Not Suitable Land with one or more land qualities limiting maize performance and land management so severely and/or requiring such extensive conservation measures as to make it impractical.

S3e Land suitability classes carry one or more letter suffixes indicating its most limiting land quality/qualities.

Table 19. Land Suitability of Sample Households in the Ngwempisi RDA

RDA	HH/PN #	u	c1	c2	c3	m1	m2	f	w1	w2	g1	g2	g3	r1	r2	n	z1	z2	y1	y2	k1	k2	k3	q1	q2	q3	q4	q5	e1	e2	SUITABILITY CLASS
		DIAGNOSTIC LAND CHARACTERISTICS OF LAND QUALITIES																													
Ng	501-3	s1	s3			s2			s1	s1			s1	s1	s2		s1	s1	s2	s1	s1	s3	n	s2		s2		s1	s2		s1,3	s1	s1	s1	s2	s2	S3c,q
Ng	502-3	s1	s3			s2			s1	s1			s1	s1	s1		s1	s2	s2	s1	s1	s3	n	s1		s1		s1	s1		s1		s1	s2	s1	s2	s3	S3c,e
Ng	503-2	s1	s3			s2			s1	s1			s1	s1	s1		s1	s1	s2	s1	s1	s3	n	s1		s2		s1	s1		s1,3	s1	s2	s1	s2	s2	S3c,q
Ng	504-4	s1	s3			s2			s1	s1			s2	s1	n		s1	s1	s2	s1	s1	s3	n	n		s2		s1	n		s1,3	s1	s2	s1	s2	s3	Nc,k,g
Ng	505-2	s1	s3			s2			s1	s1			s2	s1	s1		s1	s1	s2	s1	s1	s3	n	s1		s2		s1	s1		s1,3	s1	s1	s1	s2	s1	S3c,q
Ng	506-2	s1	s3			s2			s1	s1			s1	s1	s1		s2	s2	s2	s1	s1	s3	n	s1		s2		s1	s1		s1,3	s1	s2	s1	s2	s1	S3c,q
Ng	507-4	s1	s3			s2			s1	s1			s2	s1	s1		s1	s2	s2	s1	s1	s3	n	s1		s1		s1	s1		s1		s1	s2	s1	s2	s3	S3c,e
Ng	508-11	s1	s3			s2			s1	s1			s2	s1	s1,2		s3	s2	s2	s1	s1	s3	n	s1,2		s2		s1	s1,2		s1,3	s1	s2	s1	s2	s1	S3c,r,q
Ng	509-2	s1	s3			s2			s1	s1			s2	s1	s2,n		s1	s2	s2	s1	s1	s3	n	s2,n		s1,2		s1	s2,n		s1,3	s1	s2	s1	s2	s2	S3c,q&Nc,g,k,q
Ng	510-3	s1	s3			s2			s1	s1			s2	s1	s1		s1	s2	s2	s1	s1	s3	n	s1		s1		s1	s1		s1		s1	s2	s1	s2	s1	S3c
Ng	511-4	s1	s3			s2			s1	s1			s2	s1	s1		s1	s2	s2	s1	s1	s3	n	s1		s2		s1	s1		s1,3	s1	s2	s1	s2	s1	S3c,q
Ng	512-6	s1	s3			s2			s1	s1			s2	s2	s1		s2	s2	s2	s1	s1	s3	n	s1		s2		s1	s1		s1,3	s1	s2	s2	s2	s1	S3c,q

DIAGNOSTIC LAND CHARACTERISTCS

u	Daylength	z1	Salinity
c1	Mean daily air temperature	z2	Indicator pH
c2	Mean max daily air temperature	y1	Indicator pH
c3	Mean min daily air temperature	y2	Indicator pH
m1	Rainfall amount	k1	Surface gravel
m2	Drought Hazard	k2	Surface stones/boulders
f	Frequency of damaging floods	k3	Soil consistency
w1	Soil Drainage	q1	Surface gravel
w2	Ponding/low current flooding	q2	Surface stones/boulders
g1	Soil structure	q3	Rock outcrop
g2	Soil consistency	q4	Steepest slope gradient
g3	Surface gravel	q5	Soil consistency
r1	Soil effective depth	e1	Sheet erosion
r2	Soil consistency	e2	Rill/gully erosion
n	Indicator pH		

Land quality ratings in brackets ( ) refer to diagnostic land characteristics of localized occurrence only;

HH/PN #: Sample household number and representative panel number; if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column 'suitability class' as:

dominant	the panel represents most of the field area,
associated	the panel represents at least 20% of the field area, indicated by an '*'
included	the panel represents less than 20% of the field area, indicated by [].

RDA Rural Development Area

LAND QUALITY RATINGS

s1 highly suitable land quality, which does not significantly limit maize performance, land management and/or requires significant conservation measures;

s2 moderately suitable land quality, which somewhat limits maize performance, land management and/or requires some conservation measures;

s3 marginally suitable land quality, which severely limits maize performance, land management and/or requires considerable conservation measures;

n not suitable land quality, which limits maize performance and land management so severely and/or requires such extensive conservation measures as to make it impractical.

LAND SUITABILITY CLASSES

S1 Highly Suitable Land with no land quality significantly limiting maize performance, management practices and/or requiring and conservation meansures;

S2 Moderately Suitable Land with one or more land qualities significantly limiting maize performance, management practices and/or requiring some conservation measures;

S3 Marginally Suitable Land with one or more land qualities severely limiting maize performance, management practices and/or requiring considerable conservation meansures;

N Not Suitable Land with one or more land qualities limiting maize performance and land management so severely and/or requiring such extensive conservation measures as to make it impractical.

S3e Land suitability classes carry one or more letter suffixes indicating its most limiting land quality/qualities.

Table 20. Land Suitability of Sample Households in the Bhekinkosi RDA

RDA	HH/PN #	DIAGNOSTIC LAND CHARACTERISTICS OF LAND QUALITIES																													SUITABILITY CLASS
		u	c1	c2	c3	m1	m2	f	w1	w2	g1	g2	g3	r1	r2	n	z1	z2	y1	y2	k1	k2	k3	q1	q2	q3	q4	q5	e1	e2	
B	601-2	s1	s1			s3			s1	s1		s1	s1	s2,3	s3	s1	s2	s1	s1	s3	n	s2,3	s1		s1	s2,3	s1		s1	s2		s1	s2	s1	S3m,g,k,q
B	601-20	s1	s1			s3			s1	s1		s1	s1	s2	s3	s1	s2	s1	s1	s3	n	s2	s2		s1	s2	s3		s1	s2		s1	s2	s3	S3m,r,q,e*
B	602-4	s1	s1			s3			s1	s1		s1	s1	s2,3	s3	s1	s2	s1	s1	s3	n	s2,3	s2		s1	s2,3	n		s1	s2		s1	s2	s1	S3m
B	603-5	s1	s1			s3			s1	s1		s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1		s1	s1	s1		s1	s1		s1	s2	s2	S3m
B	604-1	s1	s1			s3			s1	s1		s2	s1	s1	s1	s2	s2	s1	s1	s3	n	s1	s1		s1	s1	s1		s1	s1		s1	s2	s2	S3m
B	605-5	s1	s1			s3			s1	s1		s2	s2	s1(2)	s1	s2	s2	s1	s1	s3	n	s1(2)	s2		s1	s1(2)	s3		s1	s2,1		s1	s2	s1	S3m,q
B	606-1	s1	s1			s3			s1	s2		s2	s2	s1	s1	s2	s2	s1	s1	s3	n	s1	s1		s1	s1	s1		s1	s1		s1	s2	s1	S3m
B	606-6	s1	s1			s3			s1	s1		s1	s1	s1,3	s2	s1	s2	s1	s1	s3	n	s1,3	s2(3)		s1	s1,3	s3,n		s1	s2		s1	s2	s1	S3m,g,k,q&Nq*
B	607-7	s1	s1			s3			s1	s1		s2	s2	s1	s1	s2	s2	s1	s1	s3	n	s1	s1		s1	s1	s1		s1	s2		s1	s2	s1	S3m
B	607-10	s1	s1			s3			s1	s1		s2	s1	s1	s1	s2	s2	s1	s1	s3	n	s1	s1		s1	s1	s1		s1	s2		s1	s2	s2	S3m*
B	608-12	s1	s1			s3			s1	s1		s1	s1	s1,3	s3	s1	s2	s1	s1	s3	n	s1,3	s1,2		s1	s1,3	s1,3		s1	s1,2		s1	s2	s2	S3m,g,r,k,q
B	609-2	s1	s1			s3			s1	s1		s2	s1	s1	s1	s2	s2	s1	s1	s3	n	s1	s1		s1	s1	s1		s1	s3,2		s1	s2	s1	S3m,q
B	610-5	s1	s1			s3			s1	s1		s2	s1	s1	s1	s2	s2	s1	s1	s3	n	s1	s1		s1	s1	s1		s1	s2		s1	s2	s2	S3m
B	611-4	s1	s1			s3			s1	s1		s1	s1	s1	s3	s1	s2	s1	s1	s3	n	s1	s1		s1	s1	s1		s1	s2		s1	s2	s1	S3m,r
B	612-2	s1	s1			s3			s1	s1		s2	s2	s1	s1	s2	s2	s1	s1	s3	n	s1	s1		s1	s1	s1		s1	s1		s1	s2	s1	S3m

DIAGNOSTIC LAND CHARACTERISTCS

u	Daylength	z1	Salinity
c1	Mean daily air temperature	z2	Indicator pH
c2	Mean max daily air temperature	y1	Indicator pH
c3	Mean min daily air temperature	y2	Indicator pH
m1	Rainfall amount	k1	Surface gravel
m2	Drought Hazard	k2	Surface stones/boulders
f	Frequency of damaging floods	k3	Soil consistency
w1	Soil Drainage	q1	Surface gravel
w2	Ponding/low current flooding	q2	Surface stones/boulders
g1	Soil structure	q3	Rock outcrop
g2	Soil consistency	q4	Steepest slope gradient
g3	Surface gravel	q5	Soil consistency
r1	Soil effective depth	e1	Sheet erosion
r2	Soil consistency	e2	Rill/gully erosion
n	Indicator pH		

Land quality ratings in brackets ( ) refer to diagnostic land characteristics of localized occurrence only;

HH/PN #: Sample household number and representative panel number; if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column 'suitability class' as:

dominant	the panel represents most of the field area,
associated	the panel represents at least 20% of the field area, indicated by an '*'
included	the panel represents less than 20% of the field area, indicated by [].

RDA Rural Development Area

LAND QUALITY RATINGS

s1 highly suitable land quality, which does not significantly limit maize performance, land management and/or requires significant conservation measures;

s2 moderately suitable land quality, which somewhat limits maize performance, land management and/or requires some conservation measures;

s3 marginally suitable land quality, which severely limits maize performance, land management and/or requires considerable conservation measures;

n not suitable land quality, which limits maize performance and land management so severely and/or requires such extensive conservation measures as to make it impractical.

LAND SUITABILITY CLASSES

S1 Highly Suitable Land with no land quality significantly limiting maize performance, management practices and/or requiring and conservation meansures;

S2 Moderately Suitable Land with one or more land qualities significantly limiting maize performance, management practices and/or requiring some conservation measures;

S3 Marginally Suitable Land with one or more land qualities severely limiting maize performance, management practices and/or requiring considerable conservation meansures;

N Not Suitable Land with one or more land qualities limiting maize performance and land management so severely and/or requiring such extensive conservation measures as to make it impractical.

S3e Land suitability classes carry one or more letter suffixes indicating its most limiting land quality/qualities.

Table 21. Land Suitability of Sample Households in the Southern RDA

RDA	HH/PN #	u	c1	c2	c3	m1	m2	f	w1	w2	g1	g2	g3	r1	r2	n	z1	z2	y1	y2	k1	k2	k3	q1	q2	q3	q4	q5	e1	e2	SUITABILITY CLASS
		DIAGNOSTIC LAND CHARACTERISTICS OF LAND QUALITIES																													
S	701-1	s1	s2			s3		s1	s2		s2	s1	s1	s1	s2	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s1	s1	s2	s1	S3m
S	702-1	s1	s2			s3		s1	s2		s2	s1	s2,3	s3	s2	s2	s1	s1	s3	n	s2,3	s1,3	s1	s2,3	s1,n	s1	s2	s1	s2	s2	S3m,g,r,k,q
S	702-4	s1	s2			s3		s1	s2		s1	s1	s2,3	s1	s1	s2	s1	s1	s3	n	s2,3	s2	s1	s2,3	s3	s1	s2	s1	s2	s2	S3m,g,k,q*
S	703-3	s1	s2			s3		s1	s1		s2	s1	s1	s1	s2	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s2	s1	s2	n	Ne
S	704-3	s1	s2			s3		s1	s1		s2	s1	s1	s1	s2	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s2	s1	s2	s2	S3m
S	705-6	s1	s2			s3		s1	s2		s2	s1	s2,3	s3	s1	s2	s1	s1	s3	n	s2,3	s2,3	s1	s2,3	s3,n	s1	s3	s1	s2	s1	S3m,g,r,k,q&Nq
S	705-8	s1	s2			s3		s1	s1		s2	s1	s1	s1	s2	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s1	s1	s2	s3	S3m,e
S	705-10	s1	s2			s3		s1	s2		s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s1	s1	s2	s3	[S3m,e]
S	706-3	s1	s2			s3		s1	s2		s2	s2	s1,2	s3	s1	s2	s1	s1	s3	n	s1,2	s1,3	s2	s2,3	s1,n	s1	s2(3)	s2	s2	s1	S3m,r,k,q&Nq*
S	706-8	s1	s2			s3		s1	s2		s2	s2	s1	s1	s2	s2	s1	s1	s3	n	s1	s1	s2	s1	s1	s1	s2	s2	s2	s1	S3m
S	707-1	s1	s2			s3		s1	s1		s2	s1	s2	s1	s1	s2	s1	s1	s3	n	s2	s1	s1	s2	s1	s1	s2,3	s1	s2	s2	S3m,q
S	708-1	s1	s2			s3		s1	s1		s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s3	s1	s2	s1	S3m,q
S	709-2	s1	s2			s3		s1	s1		s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s2	s1	s2	s1	S3m
S	709-6	s1	s2			s3		s1	s2		s2	s1	s1	s3	s1	s2	s1	s1	s3	n	s1	s1(2)	s1	s1	s1(3)	s1	s1,2	s1	s2	s1	S3m,r,q*
S	710-1	s1	s2			s3		s1	s1		s2	s1	s1	s1	s2	s2	s1	s1	s3	n	s1	s1(2)	s1	s1	s1(3)	s1	s2,1	s1	s2	s1	S3m,q*
S	710-2	s1	s2			s3		s1	s2		s2	s1	s1	s2	s2	s2	s1	s1	s3	n	s1	s1(2)	s1	s1	s1(3)	s1	s2(1)	s1	s2	s1	S3m,q
S	711-2	s1	s2			s3		s1	s2		s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s1	s1	s2	s1	S3m
S	712-2	s1	s2			s3		s1	s2		s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s1	s1	s2	s1	S3m

DIAGNOSTIC LAND CHARACTERISTCS

u	Daylength	z1	Salinity
c1	Mean daily air temperature	z2	Indicator pH
c2	Mean max daily air temperature	y1	Indicator pH
c3	Mean min daily air temperature	y2	Indicator pH
m1	Rainfall amount	k1	Surface gravel
m2	Drought Hazard	k2	Surface stones/boulders
f	Frequency of damaging floods	k3	Soil consistency
w1	Soil Drainage	q1	Surface gravel
w2	Ponding/low current flooding	q2	Surface stones/boulders
g1	Soil structure	q3	Rock outcrop
g2	Soil consistency	q4	Steepest slope gradient
g3	Surface gravel	q5	Soil consistency
r1	Soil effective depth	e1	Sheet erosion
r2	Soil consistency	e2	Rill/gully erosion
n	Indicator pH		

Land quality ratings in brackets ( ) refer to diagnostic land characteristics of localized occurrence only;

HH/PN #: Sample household number and representative panel number; if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column 'suitability class' as:

dominant	the panel represents most of the field area,
associated	the panel represents at least 20% of the field area, indicated by an '*'
included	the panel represents less than 20% of the field area, indicated by [].

RDA Rural Development Area

LAND QUALITY RATINGS

- s1 highly suitable land quality, which does not significantly limit maize performance, land management and/or requires significant conservation measures;
- s2 moderately suitable land quality, which somewhat limits maize performance, land management and/or requires some conservation measures;
- s3 marginally suitable land quality, which severely limits maize performance, land management and/or requires considerable conservation measures;
- n not suitable land quality, which limits maize performance and land management so severely and/or requires such extensive conservation measures as to make it impractical.

LAND SUITABILITY CLASSES

- S1 Highly Suitable Land with no land quality significantly limiting maize performance, management practices and/or requiring and conservation meansures;
- S2 Moderately Suitable Land with one or more land qualities significantly limiting maize performance, management practices and/or requiring some conservation measures;
- S3 Marginally Suitable Land with one or more land qualities severely limiting maize performance, management practices and/or requiring considerable conservation meansures;
- N Not Suitable Land with one or more land qualities limiting maize performance and land management so severely and/or requiring such extensive conservation measures as to make it impractical.

S3e Land suitability classes carry one or more letter suffixes indicating its most limiting land quality/qualities.

Table 22. Land Suitability of Sample Households in the Hluti RDA

RDA	HH/PN #	u	c1	c2	c3	m1	m2	f	w1	w2	g1	g2	g3	r1	r2	n	z1	z2	y1	y2	k1	k2	k3	q1	q2	q3	q4	q5	e1	e2	SUITABILITY CLASS
		DIAGNOSTIC LAND CHARACTERISTICS OF LAND QUALITIES																													
H	901-3	s1	s1		s2		s1	s1		s2	s1	s1		s1	s2	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s1	s2	s1		S2
H	902-3	s1	s1		s2		s1	s1		s2	s1	s1,2	s1	s2	s2	s1	s1	s3	n	s1,2	s1	s1	s1,2	s1	s1	s1,2	s1	s2	s1		S2
H	903-3	s1	s1		s2		s1	s1		s2	s1	s1		s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s1	s2	s1(2)		S2
H	905-2	s1	s1		s2		s1	s1		s1	s1	s1		s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s1	s2	s1(2)		S2
H	906-4	s1	s1		s2		s1	s1		s2	s1	s1,2	s3	s1	s2	s1	s1	s3	n	s1,2	s1	s1	s1,2	s1	s1	s2	s1	s2	s3		S3r,e
H	908-4	s1	s1		s2		s1	s1		s2	s1	s1		s3	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s2	s1	s2	s1(2)		S3r

DIAGNOSTIC LAND CHARACTERISTCS

u	Daylength	z1	Salinity
c1	Mean daily air temperature	z2	Indicator pH
c2	Mean max daily air temperature	y1	Indicator pH
c3	Mean min daily air temperature	y2	Indicator pH
m1	Rainfall amount	k1	Surface gravel
m2	Drought Hazard	k2	Surface stones/boulders
f	Frequency of damaging floods	k3	Soil consistency
w1	Soil Drainage	q1	Surface gravel
w2	Ponding/low current flooding	q2	Surface stones/boulders
g1	Soil structure	q3	Rock outcrop
g2	Soil consistency	q4	Steepest slope gradient
g3	Surface gravel	q5	Soil consistency
r1	Soil effective depth	e1	Sheet erosion
r2	Soil consistency	e2	Rill/gully erosion
n	Indicator pH		

Land quality ratings in brackets ( ) refer to diagnostic land characteristics of localized occurrence only;

HH/PN #: Sample household number and representative panel number; if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column 'suitability class' as:

dominant	the panel represents most of the field area,
associated	the panel represents at least 20% of the field area, indicated by an '*'
included	the panel represents less than 20% of the field area, indicated by [].

RDA Rural Development Area

LAND QUALITY RATINGS

s1 highly suitable land quality, which does not significantly limit maize performance, land management and/or requires significant conservation measures;

s2 moderately suitable land quality, which somewhat limits maize performance, land management and/or requires some conservation measures;

s3 marginally suitable land quality, which severely limits maize performance, land management and/or requires considerable conservation measures;

n not suitable land quality, which limits maize performance and land management so severely and/or requires such extensive conservation measures as to make it impractical.

LAND SUITABILITY CLASSES

S1 Highly Suitable Land with no land quality significantly limiting maize performance, management practices and/or requiring and conservation meansures;

S2 Moderately Suitable Land with one or more land qualities significantly limiting maize performance, management practices and/or requiring some conservation measures;

S3 Marginally Suitable Land with one or more land qualities severely limiting maize performance, management practices and/or requiring considerable conservation meansures;

N Not Suitable Land with one or more land qualities limiting maize performance and land management so severely and/or requiring such extensive conservation measures as to make it impractical.

S3e Land suitability classes carry one or more letter suffixes indicating its most limiting land quality/qualities.

Table 23. Land Suitability of Sample Households in the Sandleni/Lugolweni RDA

RDA HH/PN #	DIAGNOSTIC LAND CHARACTERISTICS OF LAND QUALITIES u	c1	c2	c3	m1	m2	f	w1	w2	g1	g2	g3	r1	r2	n	z1	z2	y1	y2	k1	k2	k3	q1	q2	q3	q4	q5	e1	e2	SUITABILITY CLASS
S/L 1001-6	s1	s1			s2			s1	s1	s2	s1	s1(2)	s1	s1	s2	s1	s1	s3	n	s1(2)	s1	s1	s1(2)	s1	s1	s2	s1	s2	s2	S2
S/L 1002-3	s1	s1			s2			s1	s1	s2	s1	s1(2)	s1	s1	s2	s1	s1	s3	n	s1(2)	s1	s1	s1(2)	s1	s1	s2	s1	s2	s3(n)	S3e&Ne
S/L 1003-5	s1	s1			s2			s1	s2	s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s2	s1	s2	s1	S2
S/L 1004-3	s1	s1			s2			s1	s1	s2	s2	s1	s1	s2	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s2	s1	s2	s2	S2
S/L 1004-6	s1	s1			s2			s1	s1	s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s2	s1	s2	s2	S2*
S/L 1005-3X	s1	s1			s2			s1	s1	s2	s1	s1(2)	s1	s1	s2	s1	s1	s3	n	s1(2)	s1	s1	s1(2)	s1	s1	s2	s1	s2	s2	S2
S/L 1005-3A	s1	s1			s2			s1	s1	s2	s1	s1(2)	s2	s1	s2	s1	s1	s3	n	s1(2)	s1(2)	s1	s1(2)	s1(3)	s1	s2	s1	s2	s3	S3e,q*
S/L 1007-5	s1	s1			s2			s1	s1	s1	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1(2)	s1	s1	s1(3)	s1	s2	s1	s2	s2	S2,S3q
S/L 1008-2	s1	s1			s2			s1	s1	s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s2	s1	s2	s2	S2
S/L 1008-5	s1	s1			s2			s1	s2	s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s1	s1	s2	s1	S2*
S/L 1010-3	s1	s1			s2			s1	s1	s1	s1	s1(2)	s1	s1	s2	s1	s1	s3	n	s1(2)	s1	s1	s1(2)	s1	s1	s2,3	s1	s2	s2	S2,S3q*
S/L 1011-3	s1	s1			s2			s1	s1	s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s2	s1	s2	s2	S2
S/L 1012-4	s1	s1			s2			s1	s1	s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1(2)	s1	s1	s1(3)	s1	s2	s1	s2	s2	S2,S3q
S/L 1013-3	s1	s1			s2			s1	s1	s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s2	s1	s2	s2	S2
S/L 1014-4	s1	s1			s2			s1	s1	s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s2	s1	s2	s1	S2
S/L 1015-13	s1	s1			s2			s1	s1	s2	s1	s1	s1	s2	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s2	s1	s2	s1	S2
S/L 1015-21	s1	s1			s2			s1	s1	s2	s1	s1	s1	s1	s2	s1	s1	s3	n	s1	s1	s1	s1	s1	s1	s2	s1	s2	s1	S2*

DIAGNOSTIC LAND CHARACTERISTCS

u	Daylength	z1	Salinity
c1	Mean daily air temperature	z2	Indicator pH
c2	Mean max daily air temperature	y1	Indicator pH
c3	Mean min daily air temperature	y2	Indicator pH
m1	Rainfall amount	k1	Surface gravel
m2	Drought Hazard	k2	Surface stones/boulders
f	Frequency of damaging floods	k3	Soil consistency
w1	Soil Drainage	q1	Surface gravel
w2	Ponding/low current flooding	q2	Surface stones/boulders
g1	Soil structure	q3	Rock outcrop
g2	Soil consistency	q4	Steepest slope gradient
g3	Surface gravel	q5	Soil consistency
r1	Soil effective depth	e1	Sheet erosion
r2	Soil consistency	e2	Rill/gully erosion
n	Indicator pH		

Land quality ratings in brackets ( ) refer to diagnostic land characteristics of localized occurrence only;

HH/PN #: Sample household number and representative panel number; if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column 'suitability class' as:

dominant	the panel represents most of the field area,
associated	the panel represents at least 20% of the field area, indicated by an '*'
included	the panel represents less than 20% of the field area, indicated by [].

RDA Rural Development Area

LAND QUALITY RATINGS

s1 highly suitable land quality, which does not significantly limit maize performance, land management and/or requires significant conservation measures;

s2 moderately suitable land quality, which somewhat limits maize performance, land management and/or requires some conservation measures;

s3 marginally suitable land quality, which severely limits maize performance, land management and/or requires considerable conservation measures;

n not suitable land quality, which limits maize performance and land management so severely and/or requires such extensive conservation measures as to make it impractical.

LAND SUITABILITY CLASSES

S1 Highly Suitable Land with no land quality significantly limiting maize performance, management practices and/or requiring and conservation meansures;

S2 Moderately Suitable Land with one or more land qualities significantly limiting maize performance, management practices and/or requiring some conservation measures;

S3 Marginally Suitable Land with one or more land qualities severely limiting maize performance, management practices and/or requiring considerable conservation meansures;

N Not Suitable Land with one or more land qualities limiting maize performance and land management so severely and/or requiring such extensive conservation measures as to make it impractical.

S3e Land suitability classes carry one or more letter suffixes indicating its most limiting land quality/qualities.

Appendix C

Tables 24-31

Erosion Susceptibility of Sample Households

Table 24. Erosion Susceptibility of Sample Households in the Northern RDA

RDA	HH/PN #	DIAGNOSTIC CHARACTERISTICS OF EROSION SUSCEPTIBILITY P	E	t	g	LP	F	Ib	C	s	sm	X	ES CLASS
N	101-3	1056	19500	C	0	0	7	40	0.18	12	43	4.5	32
N	102-5	1056	19500	sC	0	0	6	70	0.18	12	36	4.0	50
N	103-2	1056	19500	scL,sC	0	0	6	70	0.18	7	86	3.0	38
N	103-4	1056	19500	sL	0	0	5	120	0.18	2	20	0.5	[11]
N	104-3	1056	19500	scL	0	0	6	70	0.18	4	85	1.5	19
N	105-2	1056	19500	scL,sC	0	0	6	70	0.18	12	80	6.0	76
N	106-4	1056	19500	scL,sC	+	0	5	120	0.18	12	27	3.5	76
N	107-2	1056	19500	scL,sC	0	0	6	70	0.18	8	26	2.0	25
N	108-2	1056	19500	scL,sC	0	0	6	70	0.18	6	51	2.0	25
N	109-3	1056	19500	sC	0	0	6	70	0.18	8	39	2.0	25
N	109-4	1056	19500	sL	0	0	5	120	0.18	2	30	0.5	[11]
N	110-3	1056	19500	sC	0	0	6	70	0.18	8	90	3.5	44
N	111-9	1056	19500	lmeS	0	0	5	120	0.18	6	110	2.5	54
N	112-3	1056	19500	scL	0	0	6	70	0.18	10	36	3.0	38

DIAGNOSTIC CHARACTERISTICS OF EROSION SUSCEPTIBILITY

P mean annual rainfall
E mean seasonal rainfall energy
t texture of topsoil
g gravel content of topsoil >15% Vol
0 not present, + present
lp lithic phase,
0 not present, + present

Fb soil erodibility index
Ib erosion susceptibility index
C soil loss ratio C
s percentage of steepest slope
sm longest panel slope in meters
X soil loss ratio X

ES EROSION SUSCEPTIBILITY CLASS calculated according to:

Erosion Susceptibility = Ib x C x X

Interpretation of Erosion Susceptibility Class Values:

0 - 10	low soil erosion susceptibility
11 - 50	moderately low soil erosion susceptibility
51 - 200	high soil erosion susceptibility
> 200	very high soil erosion susceptibility

HH/PN #: Sample household number and representative panel number; if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column EROSION SUSCEPTIBILITY CLASS as:

dominant	the panel represents most of the field area,
associated	the panel represents at least 20% of the field area, indicated indicated by an '*',
included	the panel represents less than 20% of the field area, indicated by [].

Table 25. Erosion Susceptibility of Sample Households in the Mahlangatia RDA

RDA	HH/PN #	DIAGNOSTIC CHARACTERISTICS OF EROSION SUSCEPTIBILITY P	E	t	g	LP	F	Ib	C	s	sm	X	ES CLASS
Mg	201-5	906	16900	cL,C	0	0	6	30	0.18	5	26	1.0	5
Mg	202-2	906	16900	cL	0	0	6	30	0.18	4	32	1.0	5
Mg	203-1	906	16900	C	0	0	7	15	0.18	4	28	1.0	3
Mg	205-6	906	16900	cL,C	0	0	6	30	0.18	5	14	0.5	3
Mg	206-1	906	16900	C	0	0	7	15	0.18	5	33	1.0	1
Mg	207-5	906	16900	cL,C	+	0	5	60	0.18	10	26	2.5	27
Mg	208-2	906	16900	C	(+)	0	7(6)	15(30)	0.18	6	21	1.0	3(5)
Mg	209-6	906	16900	C	(+)	0	7(6)	15(30)	0.18	10	35	3.0	8(16)
Mg	210-4	906	16900	C	(+)	+	6(5)	30(60)	0.18	5	38	1.0	5(11)
Mg	210-7	906	16900	C	+	+	5	60	0.18	6	38	1.5	16*
Mg	211-3	906	16900	C	0	0	7	15	0.18	5	28	1.0	3
Mg	212-3	906	16900	C	0	0	7	15	0.18	6	48	2.0	5

DIAGNOSTIC CHARACTERISTICS OF EROSION SUSCEPTIBILITY

P mean annual rainfall
E mean seasonal rainfall energy
t texture of topsoil
g gravel content of topsoil >15% Vol
0 not present, + present
lp lithic phase,
0 not present, + present

Fb soil erodibility index
Ib erosion susceptibility index
C soil loss ratio C
s percentage of steepest slope
sm longest panel slope in meters
X soil loss ratio X

ES EROSION SUSCEPTIBILITY CLASS calculated according to:

Erosion Susceptibility = Ib x C x X

Interpretation of Erosion Susceptibility Class Values:

0 - 10	low soil erosion susceptibility
11 - 50	moderately low soil erosion susceptibility
51 - 200	high soil erosion susceptibility
> 200	very high soil erosion susceptibility

HH/PN #: Sample household number and representative panel number; if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column EROSION SUSCEPTIBILITY CLASS as:

dominant	the panel represents most of the field area,
associated	the panel represents at least 20% of the field area, indicated indicated by an '*',
included	the panel represents less than 20% of the field area, indicated by [].

Table 26. Erosion Susceptibility of Sample Households in the Central RDA

RDA	HH/PN #	P	E	t	g	LP	F	Ib	C	s	sm	X	ES CLASS
		DIAGNOSTIC CHARACTERISTICS OF EROSION SUSCEPTIBILITY											
C	303-2	914	17000	scL	0	0	6	30	0.18	14	17	3.5	19
C	304-1	914	17000	scL	0	0	6	30	0.18	17	34	7.0	38
C	304-3	914	17000	mesL	+	+	3	230	0.18	17	34	7.0	290*
C	304-4	914	17000	mesL	+	+	3	230	0.18	17	34	7.0	[290]
C	305-3	914	17000	scL,sc	0	0	6	30	0.18	4	26	1.0	5
C	306-1	914	17000	scL	0	0	6	30	0.18	4	77	1.5	8
C	306-2	914	17000	scL	+	+	4	130	0.18	3	77	1.5	35*
C	307-4	914	17000	scL	0	0	6	30	0.18	5	23	1.0	5
C	308-1	914	17000	scL	0	0	6	30	0.18	10	50	4.0	22
C	313-2	914	17000	scL	0	0	6	30	0.18	18	20	6.0	32
C	313-5	914	17000	scL	0	0	6	30	0.18	18	20	6.0	32*
C	315-4a	914	17000	siL,scL	0	0	5	60	0.18	1	60	0.5	5
C	315-4b	914	17000	mesL,scL	0	0	5	60	0.18	5	60	1.5	16*
C	316-1	914	17000	scL	0	0	6	30	0.18	10	54	4.0	22
C	318-3	914	17000	scL	+	0	5	60	0.18	1	30	0.2	2
C	319-1	914	17000	scL	0	0	6	30	0.18	4	27	1.0	5
C	319-3	914	17000	scL	0	0	6	30	0.18	12	27	3.5	19*
C	320-2	914	17000	scL	0	0	6	30	0.18	2	53	0.5	3

DIAGNOSTIC CHARACTERISTICS OF EROSION SUSCEPTIBILITY

P mean annual rainfall
E mean seasonal rainfall energy
t texture of topsoil
g gravel content of topsoil >15% Vol
  0 not present, + present
lp lithic phase,
  0 not present, + present

Fb soil erodibility index
Ib erosion susceptibility index
C soil loss ratio C
s percentage of steepest slope
sm longest panel slope in meters
X soil loss ratio X

ES EROSION SUSCEPTIBILITY CLASS calculated according to:

Erosion Susceptibility = Ib x C x X

Interpretation of Erosion Susceptibility Class Values:

0 - 10	low soil erosion susceptibility
11 - 50	moderately low soil erosion susceptibility
51 - 200	high soil erosion susceptibility
> 200	very high soil erosion susceptibility

HH/PN #: Sample household number and representative panel number; if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column EROSION SUSCEPTIBILITY CLASS as:

dominant	the panel represents most of the field area,
associated	the panel represents at least 20% of the field area, indicated indicated by an '*',
included	the panel represents less than 20% of the field area, indicated by [].

Table 27. Erosion Susceptibility of Sample Households in the Ngwempisi RDA

RDA	HH/PN #	P	E	t	g	LP	F	Ib	C	s	sm	X	ES CLASS
		DIAGNOSTIC CHARACTERISTICS OF EROSION SUSCEPTIBILITY											
Ng	501-3	906	16900	scL,sc	+	0	5	60	0.18	6	58	2.0	22
Ng	502-3	906	16900	mesL,scL	+	0	4	130	0.18	10	22	2.5	59
Ng	503-2	906	16900	mesL,scL	+	0	4	130	0.18	8	31	2.0	47
Ng	504-4	906	16900	mesL	+	0	4	130	0.18	10	23	2.5	59
Ng	505-2	906	16900	mesL	+	0	4	130	0.18	6	30	1.5	35
Ng	506-2	906	16900	mesL	+	+	3	230	0.18	10	25	2.5	104
Ng	507-4	906	16900	mesL,scL	0	0	5	60	0.18	10	24	2.5	27
Ng	508-11	906	16900	scL	+	+	4	130	0.18	14	25	4.5	105
Ng	509-2	906	16900	scL	+	0	5	60	0.18	8	20	2.0	22
Ng	510-3	906	16900	scL	0	0	6	30	0.18	8	20	2.0	11
Ng	511-4	906	16900	scL	+	0	5	60	0.18	10	21	2.5	27
Ng	512-6	906	16900	scL	+	+	4	130	0.18	10	24	2.5	59

DIAGNOSTIC CHARACTERISTICS OF EROSION SUSCEPTIBILITY

P mean annual rainfall
E mean seasonal rainfall energy
t texture of topsoil
g gravel content of topsoil >15% Vol
  0 not present, + present
lp lithic phase,
  0 not present, + present

Fb soil erodibility index
Ib erosion susceptibility index
C soil loss ratio C
s percentage of steepest slope
sm longest panel slope in meters
X soil loss ratio X

ES EROSION SUSCEPTIBILITY CLASS calculated according to:

Erosion Susceptibility = Ib x C x X

Interpretation of Erosion Susceptibility Class Values:

0 - 10	low soil erosion susceptibility
11 - 50	moderately low soil erosion susceptibility
51 - 200	high soil erosion susceptibility
> 200	very high soil erosion susceptibility

HH/PN #: Sample household number and representative panel number; if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column EROSION SUSCEPTIBILITY CLASS as:

dominant	the panel represents most of the field area,
associated	the panel represents at least 20% of the field area, indicated indicated by an '*',
included	the panel represents less than 20% of the field area, indicated by [].

Table 28. Erosion Susceptibility of Sample Households in the Bhekinkosi RDA

RDA	HH/PN #	DIAGNOSTIC CHARACTERISTICS OF EROSION SUSCEPTIBILITY P	E	t	g	LP	F	Ib	C	s	sm	X	ES CLASS
B	601-2	655	12000	mesL	+	+	3	90	0.18	9	57	3.5	57
B	601-20	655	12000	mesL	+	+	3	90	0.18	10	57	4.0	65*
B	602-4	655	12000	mesL	+	+	3	90	0.18	13	10	2.5	32
B	603-5	655	12000	lmeS,C	0	0	5	10	0.18	6	30	1.5	3
B	604-1	655	12000	scL	0	0	6	5	0.18	2	34	0.5	0.5
B	605-5	655	12000	mesL,C	(+)	0	5(4)	10(35)	0.18	8	35	2.0	4(13)
B	606-1	655	12000	C	0	0	7	5	0.16	6	14	1.0	1
B	606-6	655	12000	mesL	+	+	3	90	0.18	13	14	3.0	49*
B	607-7	655	12000	mesL	0	0	5	10	0.18	7	40	2.0	4
B	607-10	655	12000	mesL,coS	0	0	5	10	0.18	7	40	2.0	4*
B	608-12	655	12000	mesL	+	+	3	90	0.18	10	41	3.5	57
B	609-2	655	12000	mesL	0	0	5	10	0.18	18	22	6.0	11
B	610-5	655	12000	mesL	0	0	5	10	0.18	12	20	3.0	5
B	611-4	655	12000	mesL	+	+	3	90	0.18	10	41	3.5	57
B	612-2	655	12000	mesL	0	0	5	10	0.18	4	14	0.5	1*

DIAGNOSTIC CHARACTERISTICS OF EROSION SUSCEPTIBILITY

P mean annual rainfall
E mean seasonal rainfall energy
t texture of topsoil
g gravel content of topsoil >15% Vol
0 not present, + present
lp lithic phase,
0 not present, + present

Fb soil erodibility index
Ib erosion susceptibility index
C soil loss ratio C
s percentage of steepest slope
sm longest panel slope in meters
X soil loss ratio X

ES EROSION SUSCEPTIBILITY CLASS calculated according to:

Erosion Susceptibility = Ib x C x X

Interpretation of Erosion Susceptibility Class Values:

0 - 10	low soil erosion susceptibility
11 - 50	moderately low soil erosion susceptibility
51 - 200	high soil erosion susceptibility
> 200	very high soil erosion susceptibility

HH/PN #: Sample household number and representative panel number; if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column EROSION SUSCEPTIBILITY CLASS as:

dominant	the panel represents most of the field area,
associated	the panel represents at least 20% of the field area, indicated indicated by an '*',
included	the panel represents less than 20% of the field area, indicated by [].

Table 29. Erosion Susceptibility of Sample Households in the Southern RDA

RDA	HH/PN #	P	E	t	g	LP	F	Ib	C	s	sm	X	ES CLASS
		DIAGNOSTIC CHARACTERISTICS OF EROSION SUSCEPTIBILITY											
S	701-1	782	14500	cL,C	0	0	6	10	0.18	4	41	1.0	2
S	702-1	782	14500	cL,C	+	+	4	75	0.18	12	29	4.0	54
S	702-4	782	14500	cL,C	+	0	5	30	0.18	12	29	4.0	22*
S	703-3	782	14500	cL	(+)	0	6(5)	10(30)	0.18	8	36	2.0	4.5(14)
S	704-3	782	14500	cL,C	0	0	6	10	0.18	8	36	2.0	4
S	705-6	782	14500	C	+	+	5	30	0.18	18	27	7.0	38*
S	705-8	782	14500	cL,C	(+)	0	6(5)	10(30)	0.18	5	27	1.0	2(5)
S	705-10	782	14500	C	0	0	7	5	0.18	5	27	1.0	[1]
S	706-3	782	14500	C	(+)	+	6(5)	10(30)	0.18	22	17	7.0	13(38)*
S	706-8	782	14500	C	0	0	7	5	0.18	13	17	3.0	1
S	707-1	782	14500	cL	(+)	0	6(5)	10(30)	0.18	17	40	8.0	14(43)
S	708-1	782	14500	C	0	0	7	5	0.18	15	92	9.5	9
S	709-2	782	14500	cL,C	0	0	6	10	0.18	10	86	5.0	9
S	709-6	782	14500	C	+	+	5	30	0.18	10	86	5.0	27*
S	710-1	782	14500	C	(+)	0	7(6)	5(10)	0.18	8	53	3.0	3(5)*
S	710-2	782	14500	cL,C	(+)	+	5(4)	30(75)	0.18	8	53	3.0	16(41)
S	711-2	782	14500	C	0	0	7	5	0.18	6	44	2.0	2
S	712-2	782	14500	C	0	0	7	5	0.18	6	43	2.0	2

DIAGNOSTIC CHARACTERISTICS OF EROSION SUSCEPTIBILITY

P mean annual rainfall
E mean seasonal rainfall energy
t texture of topsoil
g gravel content of topsoil >15% Vol
  0 not present, + present
lp lithic phase,
  0 not present, + present

Fb soil erodibility index
Ib erosion susceptibility index
C soil loss ratio C
s percentage of steepest slope
sm longest panel slope in meters
X soil loss ratio X

ES EROSION SUSCEPTIBILITY CLASS calculated according to:

Erosion Susceptibility = Ib x C x X

Interpretation of Erosion Susceptibility Class Values:

0 - 10	low soil erosion susceptibility
11 - 50	moderately low soil erosion susceptibility
51 - 200	high soil erosion susceptibility
> 200	very high soil erosion susceptibility

HH/PN #: Sample household number and representative panel number; if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column EROSION SUSCEPTIBILITY CLASS as:

dominant	the panel represents most of the field area,
associated	the panel represents at least 20% of the field area, indicated indicated by an '*',
included	the panel represents less than 20% of the field area, indicated by [].

Table 30. Erosion Susceptibility of Sample Households in the Hluti RDA

RDA	HH/PN #	DIAGNOSTIC CHARACTERISTICS OF EROSION SUSCEPTIBILITY P	E	t	g	LP	F	Ib	C	s	sm	X	ES CLASS
H	901-3	874	16000	scL,sC	0	0	6	20	0.18	6	24	1.5	5
H	902-3	874	16000	scL,sC	(+)	0	6(5)	20(50)	0.18	10	64	4.0	14(36)
H	903-3	874	16000	scL,sC	0	0	6	20	0.18	4	25	1.0	4
H	905-2	874	16000	coS	0	0	5	50	0.18	6	24	1.5	14
H	906-4	874	16000	lmeS	(+)	+	4(3)	110(200)	0.18	11	29	3.0	59(108)
H	908-4	874	16000	scL	0	+	5	50	0.18	12	38	4.5	41

DIAGNOSTIC CHARACTERISTICS OF EROSION SUSCEPTIBILITY

P mean annual rainfall
E mean seasonal rainfall energy
t texture of topsoil
g gravel content of topsoil >15% Vol
  0 not present, + present
lp lithic phase,
  0 not present, + present

Fb soil erodibility index
Ib erosion susceptibility index
C soil loss ratio C
s percentage of steepest slope
sm longest panel slope in meters
X soil loss ratio X

ES EROSION SUSCEPTIBILITY CLASS calculated according to:

Erosion Susceptibility = Ib x C x X

Interpretation of Erosion Susceptibility Class Values:

0 - 10	low soil erosion susceptibility
11 - 50	moderately low soil erosion susceptibility
51 - 200	high soil erosion susceptibility
> 200	very high soil erosion susceptibility

HH/PN #: Sample household number and representative panel number; if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column EROSION SUSCEPTIBILITY CLASS as:

dominant	the panel represents most of the field area,
associated	the panel represents at least 20% of the field area, indicated indicated by an '*',
included	the panel represents less than 20% of the field area, indicated by [].

Table 31. Erosion Susceptibility of Sample Households in the Sandleni/Lugolweni RDA

RDA	HH/PN #	P	E	t	g	LP	F	Ib	C	s	sm	X	ES CLASS
		DIAGNOSTIC CHARACTERISTICS OF EROSION SUSCEPTIBILITY											
S/L	1001-6	874	16000	mesL,scL	(+)	0	5(4)	50(110)	0.18	14	31	5.0	45(99)
S/L	1002-3	874	16000	scL,sC	(+)	0	6(5)	20(50)	0.18	8	30	2.0	7(18)
S/L	1003-5	874	16000	cL,C	0	0	6	20	0.18	10	84	5.0	18
S/L	1004-3	874	16000	scL,sC	0	0	6	20	0.18	14	35	5.0	20
S/L	1004-6	874	16000	lmeS,sC	0	0	5	50	0.18	11	35	3.5	32
S/L	1005-3X	874	16000	scL	+	0	5	50	0.18	14	49	6.0	59
S/L	1005-3A	874	16000	scL	+	+	4	110	0.18	14	49	6.0	129
S/L	1007-5	874	16000	lfiS	0	0	5	50	0.18	11	32	3.5	32
S/L	1008-2	874	16000	scL	0	0	6	20	0.18	10	17	2.0	7
S/L	1008-5	874	16000	C	0	0	7	10	0.18	6	17	1.0	2
S/L	1010-3	874	16000	lvycoS	+	0	4	110	0.18	15	34	6.0	119
S/L	1011-3	874	16000	scL,sC	0	0	6	20	0.18	10	16	2.0	7
S/L	1012-4	874	16000	scL	0	0	6	20	0.18	10	25	2.5	9
S/L	1013-3	874	16000	scL,sC	0	0	6	20	0.18	10	12	2.0	7
S/L	1014-4	874	16000	scL,scL	0	0	6	20	0.18	15	18	4.0	16
S/L	1015-13	874	16000	scL,sC	0	0	6	20	0.18	11	17	2.5	9
S/L	1015-21	874	16000	scL,sC	0	0	6	20	0.18	10	17	2.0	36

DIAGNOSTIC CHARACTERISTICS OF EROSION SUSCEPTIBILITY

P mean annual rainfall
E mean seasonal rainfall energy
t texture of topsoil
g gravel content of topsoil >15% Vol
  0 not present, + present
lp lithic phase,
  0 not present, + present

Fb soil erodibility index
Ib erosion susceptibility index
C soil loss ratio C
s percentage of steepest slope
sm longest panel slope in meters
X soil loss ratio X

ES EROSION SUSCEPTIBILITY CLASS calculated according to:

Erosion Susceptibility = Ib x C x X

Interpretation of Erosion Susceptibility Class Values:

0 - 10	low soil erosion susceptibility
11 - 50	moderately low soil erosion susceptibility
51 - 200	high soil erosion susceptibility
> 200	very high soil erosion susceptibility

HH/PN #: Sample household number and representative panel number; if more than 1 panel is listed per household, the portion of the entire field area it represents is listed under the column EROSION SUSCEPTIBILITY CLASS as:

dominant	the panel represents most of the field area,
associated	the panel represents at least 20% of the field area, indicated indicated by an '*',
included	the panel represents less than 20% of the field area, indicated by [].

Appendix D

Table 32

Distance of Sample Households from the RDA Centres

Table 32

Distance of Sample Households from RDA Centre

Household	RDA	Distance from RDA Centre km	Remarks #
101	N	3.0	Topographic Map
102	N	2.3	2531CD
103	N	3.0	2531CB
104	N	3.2	(2)
105	N	2.9	
106	N	4.2	
107	N	1.3	
108	N	0.3	
109	N	0.5	
110	N	1.1	
111	N	1.8	
112	N	1.9	
201	Mh	5.6 (4.7)	Topographic Map
202	Mh	5.0	2631CC
203	Mh	5.0	(23)
205	Mh	4.8	
206	Mh	3.6	
207	Mh	1.4	
208	Mh	1.1	
209	Mh	1.5 (0.9)	
210	Mh	1.3 (0.9)	
211	Mh	1.7 (0.5)	
212	Mh	1.1 (0.2)	
303	C	3.5	Topographic Map
304	C	5.4	2631AD
305	C	1.0	(12)
306	C	1.4	
307	C	4.4	
308	C	8.6	
313	C	12.8	
315	C	1.8	
316	C	1.9	
318	C	0.5	
319	C	0.8	
320	C	1.2	
501	Ng	0.5	Topographic Map
502	Ng	1.2	2631CA
503	Ng	1.1	(17)
504	Ng	1.4	
505	Ng	1.5	
506	Ng	1.4	

Table 32 (Cont.)

Household	RDA	Distance from RDA Centre km	Remarks #
507	Ng	1.0	
508	Ng	9.1	
509	Ng	12.9	
510	Ng	12.9	
511	Ng	10.5	
512	Ng	9.6	
601	B	1.3	Topographic Map
602	B	3.2	2631AD
603	B	0.7	(12)
604	B	0.3 (0.6)	
605	B	4.1	
606	B	3.5	
607	B	4.2	
608	B	3.4	
609	B	3.6	
610	B	4.1	
611	B	4.7	
612	B	3.5	
701	S	5.3	Topographic Map
702	S	2.2	2631CD
703	S	2.3	(24)
704	S	4.4	2731BA
705	S	5.7	(12)
706	S	4.0	
707	S	5.0	
708	S	3.8	
709		4.8 (3.8)	
710	S	1.0	
711	S	0.8	
712	S	1.3	
901	H	0.6	Topographic Map
902	H	0.9	2731BA
903	H	0.8	(30)
905	H	0.5	
906	H	0.6	
908	H	1.0	

Table 32 (Cont.)

Household	RDA	Distance from RDA Centre km	Remarks #
1001	S/L	1.0	Topographic Map
1002	S/L	1.1	2731AB
1003	S/L	2.0	(30)
1004	S/L	1.7	2731BA
1005	S/L	2.8	(29)
1007	S/L	1.4	
1008	S/L	1.4 (0.9)	
1010	S/L	1.4	
1011	S/L	2.2	
1012	S/L	1.8	
1013	S/L	0.6	
1014	S/L	0.7	
1015	S/L	0.1	

The distance between RDA centre and household/field has been measured as a straight line. If the household and the field are at two different locations, the distance between the field and the RDA centre is given in brackets.

Abbreviations of Soil Texture

coS	coarse sand
meS	medium sand
fiS	fine sand
lcoS	loamy coarse sand
lmeS	loamy medium sand
lfiS	loamy fine sand
cosL	coarse sandy loam
mesL	medium sandy loam
fisL	fine sandy loam
L	loam
siL	silt loam
Si	silt
sicL	silty clay loam
cL	clay loam
scL	sandy clay loam
sC	sandy clay
siC	silty clay
C	clay

Length

millimeter 1mm = 0.25 in.

centimeter 1cm = 2.54 in.

meter 1m = 3.25 ft.

kilometer 1km = 1.61 mi.

Slope Steepness

%	-	°
2	-	1
6	-	3
10	-	6
14	-	8
18	-	10
26	-	15
32	-	18
56	-	29
70	-	35
100	-	45

Energy

Joule J

Temperature

°C = 0.555 (°F-32)

Electrical Conductivity

millisiemens/centimeter ms/cm

Area

square meter $1m^2$ = 10.76 $ft.^2$

hectare 1ha = 2.47 acre