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ABSTRACT

CHANGES IN DROUGHT-COPING STRATEGIES IN THE SEGU REGION OF MALI

By

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The choice of drought-coping strategies during the droughts of 1973 and 1984 in a Sudano-Sahelian area in Mali, West Africa, were examined in relation to location, ethnic group, and economic status. The results indicate that response to drought is a complex phenomenon that is influenced by all three variables. The adoption of drought-coping strategies involves a diverse 'toolkit' of strategies that changes over time as circumstances warrant. Drought-responses were diverse and creative in both 1973 and 1984. While 1973 may be described in general as a period of mutual aid, divestment of a variety of assets including livestock, and wage labor, 1984 was characterized by agricultural innovation to address food security issues and the need for cash, the divestment of livestock, and wage labor. The use of drought-coping strategies that were stigmatized by the general population (begging, pledging assets or a family member, and eating certain wild foods), although never used by a majority of respondents, declined from 1973 to 1984. Most non-agricultural strategies declined in general importance, with the exception of labor migration of family

members other than the head of household. Assets from seasonal migration were used to purchase livestock and agricultural equipment for the family.

In many marginal areas of Africa where the range of existing and potential drought-coping strategies is small, drought has been the cause of great human suffering. However, the results of the present study suggest that in some cases drought can act as a stimulus to technological change which ultimately mitigates the impact of drought. The findings also suggest that in the study area an agricultural transformation influenced by drought is taking place. The technological changes associated with this transformation are significant because they have changed the terms of the human-environment relation from 1973 to 1984. This change implies a reduction in the vulnerability of people to drought.

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CHAPTER ONE: INTRODUCTION

Drought has played an important role in human-environment relations throughout history. It has devastated agricultural and pastoral production systems (Carpenter 1966, Wigley et al. 1981), exacerbated social processes of economic marginalization (Hewitt 1983, Meillassoux 1974), and stimulated the development of new impact-minimizing responses (Bramner 1987, Skinner 1978). In some cases drought has precipitated the downfall of governments, for example, Niger and Ethiopia in the early 1970s (Higgott and Fuglestad 1975). Greater understanding at the local, national, and international levels of the impacts of drought upon human systems is essential in the search for suitable land use and land use policy in areas of great rainfall variability.

This study examines the patterns of drought-coping strategies used by Sudano-Sahelian farmers, agropastoralists, and fishers during the droughts of 1973 and 1984 in relation to spatial, social, and economic variables with particular reference to location, ethnicity, and wealth. The differences in choice of drought-coping strategy between three ethnic groups, three ecozones, and three wealth classes in 1973 and 1984 are examined. Two wider theoretical approaches to the interpretation of the impact of drought and change in drought response are

identified and discussed in this study: the approach of Ester Boserup/Paul Richards and the moral economy approach. This wider framework enables discussion of the implications of change in drought-coping strategies over time as well as over social and economic space. Generalizations are drawn from this examination about the contribution of each theory to the explanation of behavior and behavior change over time and space that may contribute to further theory formation.

What is Drought?

There is no continent on earth that is drought-free and few regions are free from occasional drought. The greatest impacts of drought are in areas bordering deserts where annual deviation of precipitation is highest (Cole 1989a). These semi-arid areas are transition zones from aridity to more humid conditions. Historically, their moisture regimes have fluctuated widely (Maley 1977, Petit-Maire et al. 1985). Defining what consititues drought has been a matter for debate. The onset of drought is generally slow and drought impacts are scattered across time, space, and social classes. There are problems of boundary definition; it is difficult, for example, to separate meteorological drought from agricultural drought (Glantz 1987).

> A meteorological drought could arbitrarily be defined as that time period when the amount of precipitation is less than some designated percentage of the long-term mean. An agricultural drought, on the other hand, could be defined in terms of seasonal vegetation

> development. If the precipitation is not available to crops such as cereal grains at crucial periods in crop development, the seedlings or, at some later state of crop development, the plant will wither and die (Katz and Glantz 1977, 83).

A farmer who cultivates a crop with a high moisture requirement, for example, rice, and a farmer who cultivates drought-tolerant sorghum or millet may have different drought experiences as well; less stress will be felt by the sorghum farmer than the rice farmer. Somewhere between these two extremes, to complicate this simplified picture, is the farmer who plants maize, more drought-tolerant than rice but considerably less drought-tolerant than sorghum or millet. In reality, most farmers do not conform to simple models of their behavior: most farmers plant as many crops as possible (and undertake a myriad of economic activities): they plant rice, sorghum and millet, maize, and more if at all possible in order to spread the impacts of possible drought. Risk-spreading in agriculture is accomplished by cultivating many different crops and crop varieties that have different site and moisture requirements. For most years, this method of risk-spreading ensures a harvest. For families in poverty, however, drought years can be especially stressful. The differential distribution of the impacts of drought on people further obscures the process of defining what is drought. Katz and Glantz (1977, 82)

believe that "because perceptions about what constitutes a drought vary, there is no widely accepted definition." After a very bad drought year poor people may become destitute and face high malnutrition rates (less than 80% weight for height) often as high as 45% of children aged less than 5 years (Cole 1989a). In addition, poor people are the most seriously affected by economic circumstances that may be only tangentially related to drought, such as, inflation trends in cereals prices.

Although these caveats exist concerning the difficulty of defining drought, an attempt at a definition will be made. Drought, most simply defined, is a deficit in moisture that has impacts on the biotic and abiotic elements of the environment. Strahler and Strahler (1979, 535) define drought as the "occurrence of substantially lower-than-average precipitation in a season that normally has ample precipitation for the support of food producing plants." Meteorological drought has been defined as a 25% decline in long-term mean annual precipitation for an area (Glantz 1987). Hydrologic drought occurs when river or stream flow falls below a predetermined level (Dracup, Lee, and Paulson 1980 in Glantz 1987).

Most definitions of drought refer to a measurable decrease in precipitation that have measurable impacts on the environment (Palutikof 1977). The World Bank (1985; 5) in a less rigorous manner defined drought as "... a quantity of rainfall clearly inferior to the mean in one year or in a

succession of years." Sen (1981; 115) defined drought as simply "... a short-fall in rain." There is something to be said for Sen's apparently loose definition; there is, for example, some debate on the usefulness of the long-term annual rainfall average as an indicator of drought (Katz and Glantz 1977, World Bank 1985). This debate centers on two issues:

1. The long term mean may conceal wide interannual deviations. Several years of good rainfall may inflate the overall mean and present a more optimistic view of an area than that indicated by the general deviation of rainfall from the mean.
2. Rainfall only partially determines productivity of the measurable environment. The fertility and structure of the soil and the distribution of rainfall in time and space play a crucial role in determining productivity (World Bank 1985) perhaps more than total rainfall. A rainy season of lower than average rainfall, for example, may be more productive than a rainy season of above average rainfall if the rainfall is well-distributed spatially and/or temporally. The 1985-1986 rainy season in central Mali was a

> good example of good harvests and lower than average but well-distributed yearly rainfall.

Kates et al. (1981; 235), characterized drought as:

> the most poorly assessed hazard of the leading geophysical hazards. Unlike earthquakes, floods, and tropical cyclones, its onset is often slow and cumulative, extending over years rather than moments or days.

Intra-annual, or seasonal drought may be of short or of long duration within one year. If a drought is short and occurs at the wrong time in the agricultural season, crop damage can be just as serious as if the drought had lasted the entire season. For example, if a drought of one week occurs when crops are flowering, much of the potential harvest will be lost. Measurable environmental impacts that are associated with intra-annual droughts involve soil desiccation, the evaporation of surface water, the death of annual vegetation, and the defoliation of many perennials. Other measures of intra-annual drought are perennial vegetation vigor, standing dry biomass, and seed production (Cissé and Hiernaux 1984).

Environmental impacts associated with inter-annual decreases in precipitation include soil removal, sedimentation, loss of organic matter, the formation of crusts, duststorms, salinization, alkalization, and biomass reduction (Advisory Group on the Sahel 1984, Berry and Ford 1977, Reining 1978). Inter-annual impacts of precipitation

variation are generally measured in terms of rainfall deviation from a long-term average (as with intra-annual drought), soil moisture and ground water levels, evapotranspiration, and albedo. Although the terms "land degradation" and "desertification" appear to best characterize the impacts of inter-annual drought, creating operational definitions of land degradation is difficult. The principal problem is one of distinguishing between the impacts of human land use and the impacts of drought. See Haywood (1980), Cole (1989a), and De Wispelaere (1980) for attempts at defining land degradation. The impacts of rainfall variation on vegetation, for example, are often exacerbated by human land use systems that simplify ecological diversity through overgrazing, overfarming, or other abusive land use practices (Benoit 1984, Cole 1989b, Katz and Glantz 1977, Jakêl 1977, MacLeod 1976, Maley 1982). Each plant species, for example, possesses its own responses to variations in moisture. Many species in association possess many different response patterns and the formation of associated species is stronger than its constituents (for example, the dynamic and mobile relation of species in brousse tigrée, tiger bush). Simplifying ecological diversity can culminate in a denuded and eroded landscape which may erroneously be associated with the effects of drought.

Drought and Adaptation

The impacts of drought may be negligible or they may disrupt the established patterns of human socio-economic behavior. Behavior change associated with drought is termed adaptation (Alland 1975). Adaptation to variation in precipitation is part of response to a complex of interrelated variables in the political, economic, and social dimensions. Drought is a single variable of many that cause people to change their behavior.

Intra-annual variations in precipitation may affect only a minority of individuals, for example, the poor or the socially marginalized (landless, low caste, servile, or otherwise deprived and/or stigmatized population) (Chambers 1982, Cole 1989a, Jodha 1978, Miracle 1961, Ogbu 1973, Richards 1986) while long-term inter-annual deviations may make established patterns of production untenable (Brett-Smith 1984, Cutler 1986, De Grunne 1985). The social impacts of drought are distributed unequally among people (Watts 1983a) just as rainfall is distributed unequally in time and space (Cole 1989a).

The impacts of drought which have a social dimension are made manifest first in the primary activities of agriculture and pastoralism in Africa today and last in secondary and tertiary activities such as manufacturing and political administration. In the rural areas where primary activities take place, the most important social impacts of drought, particularly where the majority of people are

involved in agriculture or pastoralism, are the decline in yield or the complete failure of cash and food crops, loss of employment, bankruptcy, the decline or failure of rainfed biomass production, and moderate to high livestock mortality.

The impacts of drought are conditioned by the ability of an individual or group to respond within a political, economic, environmental, and social context; this means that the ability to respond to drought is influenced by events that may be unrelated to the drought itself. In human terms, drought is more difficult to define than geophysical drought as the question of a differential vulnerability must be addressed. Kolawale in a study in northern Nigeria (1987: 59) found that vulnerability to drought:

> ...is a function of the relationship between the natural environment and socio-economic and political forces. Response mechanisms are affected by state interventions which may ameliorate or exacerbate ... vulnerability.

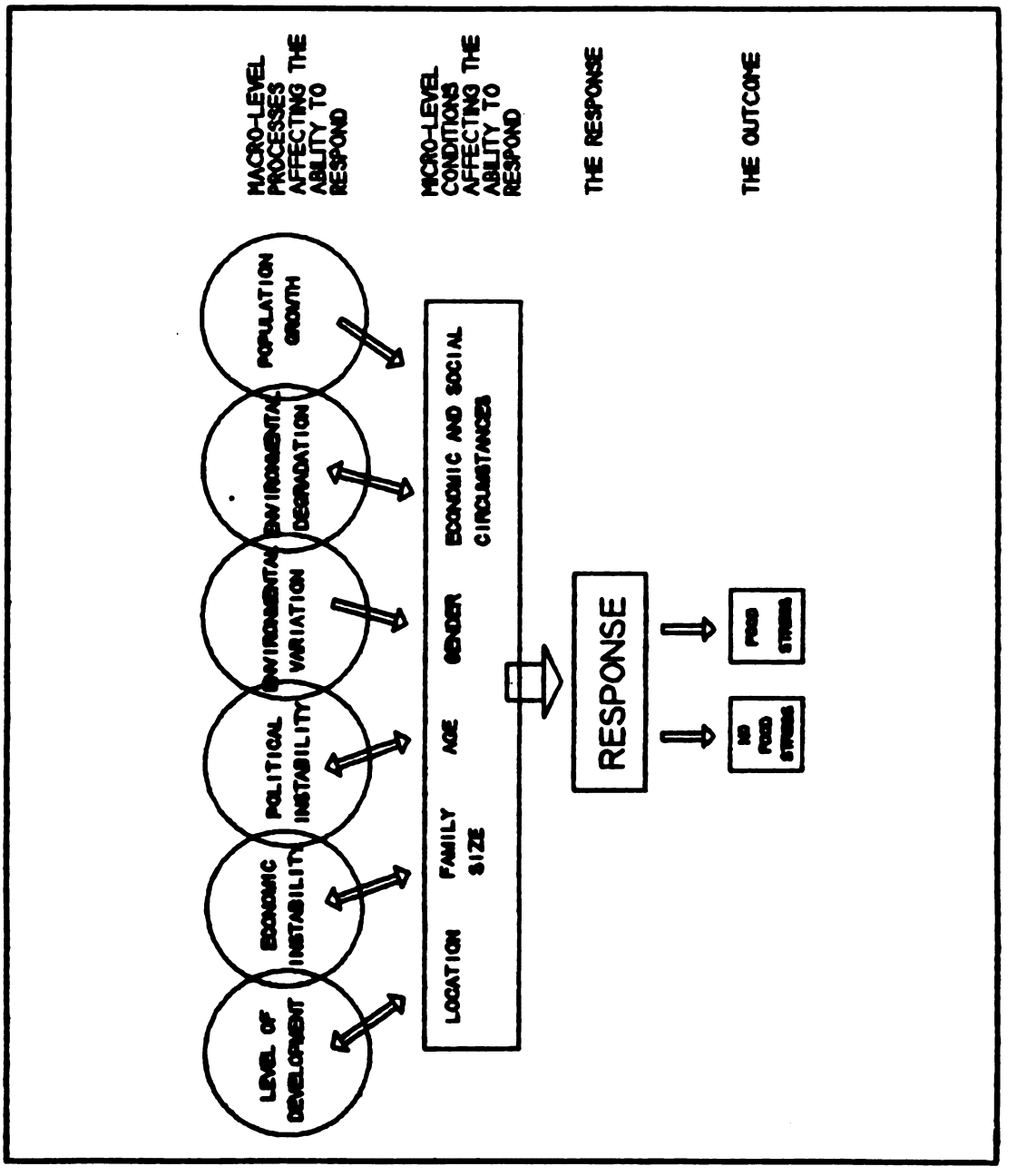
In Ethiopia, Mesfin Wolde Mariam (1984) found local-level social factors in conjunction with the natural environment decisive in transforming drought into famine. He states that the orientation of production exclusively towards subsistence was the major factor responsible for the "propagation of famine." It is the production for subsistence:

> ... with its incapacitating disincentives of oppression and exploitation, which keeps peasants and their families permanently at barely subsistence level without any means of averting or of coping with the consequences of crop failure, [that] creates famine in time of peace (1984: 177).

Figure 1.3 below (Cole 1989a) illustrates the range of factors which helps to determine which drought impacts will be felt by an individual or family and which also influences drought response.

For the purposes of the present study drought, or rainfall variation, is defined as a rainfall deficit that precipitates a subsistence crisis (or widens one that exists for other reasons) and is generally recognized as preventing, inhibiting, or changing in some compensatory fashion the practice of customary economic activities and land use. It may lead to increased human or livestock mortality. Response to drought includes, for example, divestment of assets, labor migration, use of wild foods, and agricultural change. In some extreme cases, a family may sell or pawn its own members to obtain subsistence.

Figure 1.3. Environmental, political, social and economic factors that influence drought impacts and influence the choice of coping strategies.



Destitute individuals and families will often migrate to the urban periphery to seek informal sector employment or to agricultural schemes where seasonal employment is available. In extreme droughts, herders will migrate hundreds of miles with their animals away from traditional pastures. Droughts where behavior changes are generally named and remembered by those who have endured them. In the definition adopted for the present study, drought is treated as an environmental phenomenon with economic and social implications.

Importance of the Study

Drought has been a periodic problem throughout semi-arid Africa. Responding to these periodic crises has been the principal responsibility of policymakers of national governments and the international community. Until recently, not much was understood about the ways in which people adapt to drought. The present study contributes to current knowledge on drought and drought response in Mali and should assist policymakers in making informed decisions regarding assistance to and investment in drought-prone areas. Increased understanding of drought-coping strategies and how they change over time is essential if national governments, non-governmental organizations, and the international community are to effectively respond to the drought-related human tragedy in Africa today.

The present study contributes to our understanding of the effects of drought on human social systems in semiarid

Africa in three ways. First, drought-coping strategies are empirically examined during two time periods. Diachronic studies of changes in drought-coping responses are rare (Torry 1979a) although there have been a small number of studies of drought response of different cultures in different ecological zones and wealth and social classes. The precolonial period is examined from the historical record and a panorama of social, political, and economic processes are examined in relation to environmental variation.

The second contribution of this study is the examination of the impact of Islam and the 19th century jihaad[1] on the political and economic lives of people in the Ségu region. Islam is an urban, monotheistic religion with claims to universal application. Traditional Bamana religion is personal and is attached closely to the environment and agriculture. Islamic cosmology is antithetical to Bamana cosmology and much in Islam is offensive to traditional Bamana values.

Perhaps the most important contribution of the present study, and one which combines the first and second contributions, is a questioning of current received wisdom about drought, the market, and vulnerability to drought in the present compared to the precolonial period. The moral economy approach (held by many modern Marxists and liberal

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[1] See Appendix J for a note on orthographic conventions used for foreign words.

leftists) to interpreting the impacts of drought on society holds that in the precolonial period a moral, or "natural", economy existed in which people were less vulnerable to drought than today. The moral economy hypothesis faults the market economy as the principal agent behind the increase in vulnerability. Results from the present study indicate that because of the political and economic turmoil that occurred during the precolonial period in the region in which the study area is located it would be impossible to characterize the precolonial period as one in which people were less vulnerable to drought. On the contrary, the market has contributed to decreasing the vulnerability of people to drought in the study area since the precolonial period. This is because of the opportunity offered to engage in a diverse range of activities that spread risk - away from farm-related activities.

Outline of the Dissertation

The dissertation is organized into six chapters. Chapter One is the introduction. Chapter Two presents a review of recent literature on drought-coping strategies: twentieth-century interpretations of drought and social change in Africa and behavioral models of drought-coping strategies. Chapter Three discusses recent drought in the study area, the environmental landscape in which drought response takes place, some characteristics of the population of the study area, and a detailed examination of location,

culture, and wealth in the study area to show the importance of the hypothesized relationship between these variables and drought-coping behavior. The physical characteristics of the study area are presented first and the ecozones that exist within the study area are defined. Chapter Three includes a historical examination of agriculture, human organization and the social, political, institutional, technical, and environmental bases necessary to accomplish agriculture in the often harsh environmental conditions in the study area. The notion of expanding and contracting opportunities to cope with drought is introduced in a discussion of the impacts of precolonial political instability upon the ability of people to respond to rainfall variation. Finally, the impacts of the French conquest in the study area and particularly on the ability of people to respond to drought are discussed.

The methods used in the present study are discussed in Chapter Four. The results and discussion of the quantitative analysis of drought-coping strategies in 1973 and 1984 are presented in Chapter Five. The conclusions and implications for policy are presented in Chapter Six.

CHAPTER TWO: LITERATURE REVIEW

In this chapter, interpretations of drought in Africa in the twentieth century, drought impacts, and response to drought are presented and discussed first. After this presentation, models of drought response are presented and discussed.

Interpretations of Drought, Drought Response, and Adaptation

The Legacy of Environmental Determinism

The interpretation of the impact and the significance of drought in Africa has changed greatly in the twentieth century. In general, early interpreters sought to explain the human-environment interface in determinist terms while later views stressed social and political factors. For the major part of this century, causal attribution of social disaster and biophysical degradation to drought and climate was not disputed. The human drama associated with drought, land degradation, and desertification was viewed as inextricably linked to physical processes. Research efforts in Africa were made during the first half of this century to ascertain the existence of secular climatic trends within which particular droughts were exemplifications of a downward trend toward general desiccation and the expansion of deserts (Chudeau 1921, Hubert 1920, Jones 1938, Renner 1926, Stebbing 1935). This focus on climate was the theoretical and methodological legacy of the environmental

determinists who were interested in examining what they perceived as the rigid relationships between climatic change, environment, and human culture (Pepper 1984). Determinists viewed climate as the determinant factor in human behavior and environmental change as strictly linked to climate change outside the purview of human agency (see Pepper 1984).

French and British research during the late 1940s and early 1950s indicated that the measurement of the effects of secular climatic trends was largely obscured by the increasingly damaging influence of human activities upon the landscape (Aubréville 1949, Bousquet 1952, Chevalier 1950a 1950b 1950c 1950d, Dresch 1959, Grove 1951, Pelissier 1951, Pitôt 1952; Tondeur 1949). In 1949, an international conference was held to pool knowledge on the subject so that appropriate policy could be formulated to address the problem of environmental degradation in Africa (Bulletin Agricole du Congo Belge 1949). This group of researchers attributed land degradation to abusive African land use systems, human and animal population growth, the introduction of the plow, and the breakdown of precolonial social, economic, and spatial organization (Guillaume 1949, Grove 1949, Leakey 1949, Portiéres 1949, Renard 1949, Thornton 1949, Viguier 1949a 1949b).

These scholars found that aside from the negative ecological impacts of human population growth, African farmers, herders, and fishers were actively destroying the

balance between environment and resources. This imbalance was a problem which they felt an economically rational, modernization-oriented policy could address. Although some aspects of modernization were being criticized[2], it was widely held that the wider use of more economically rational, modern and comprehensive sets of inputs, techniques, and management (technological "packages") would ameliorate environmental degradation.

The interest of British East Africa scholars in drought focussed on the radical spatial reorganization and colonization the British colonial government effected in East Africa (Kitching 1982, Mehretu 1989) and the population pressure and land degradation associated with them. The human-environment relationship in East Africa was exacerbated for the local populations by a colonial policy which promoted the resettlement of African producers in reserves located in marginal areas (Prescott 1961, Silberfein 1984, Tondeur 1949). This was generally not the case in West Africa where de facto internal colonization after the breakdown of slavery, not a government policy of native reserves, pushed groups of farmers and herders to the agricultural and pastoral margins (Dresch 1959, Fuglestad 1983).

Some researchers were anecdotally concerned with the general impacts of drought- or locust-induced food shortages

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[2] Criticism was centered on the adoption of partial, "unbalanced" technological packages.

on individual behavior. Later studies were more quantitative and systematic in their estimations of impacts (Corkill 1949, Ortoli 1939). There was much scholarly activity devoted to the cataloging of foods used during scarcities (Aubréville 1950, Irvine 1954, 1948, Tayeau et al. 1955). This work has continued (Berhaut 1975, Bernus 1980, Bhandari 1974, Cole 1987, Gast 1972).

Research in the 1960s and early 1970s into human-environment relations was characterized by a neomalthusian view of human-environment relations. As population grew from the 1950s to the 1970s so did the importance attributed to the role of the human agent in environmental degradation (Giri 1983, Glantz 1977). The neomalthusians hold that the severe consequences of exceeding the carrying capacity of the environment according to the Malthusian view may be mitigated by migration (Boserup 1965).

Recent Mainstream Interpretations of Drought and Drought Response

In the middle 1970s and 1980s the issues of drought, adaptation, population and population growth, distress migration, and land degradation were taken up anew (Faulkingham and Thorbahn 1975, Gallais 1977a 1977b, Morris 1974, Newman 1977, O'Leary 1983, 1980, Pitte 1975, Turton 1977, Turton and Turton 1984, Vermeer 1981, Wata 1979, White 1974). The contribution of this group of researchers put

into perspective, much as the earlier neomalthusian French and British research had done, the relationship between growing population, limited resources, and rainfall variation in fragile semi-arid environments. This group of researchers was interested in the impacts of environmental change on population flows, resource degradation, and carrying capacity (see Brown 1981 and Brush 1975).

Another group of researchers was interested in behavior change in relation to natural hazards. Neoclassical economics, with its emphasis upon maximization behavior, and later individual optimization behavior (Kunreuther and Slovic 1986, Lipton 1968, Slovic, Kunreuther, and White 1974), provided a much used framework (see also Berg 1976, Popkin 1980) in these studies. These researchers developed models of individual behavior that revolved around previous experience as the key element in behavior change after a natural hazard (Burton, Kates, White 1978, Kates 1971).

Debate concerning the role of population in agricultural change arose around the thesis of Ester Boserup (1981, 1965) who postulated that population pressure is a key element in the process of technological change rather than the inverse (see Gleave and White (1969) who arrived independently at the same conclusions as Boserup). She suggested that a society experiencing population pressure undergoes a series of agricultural transformations that increase the ability of the system to support its growing population. Geertz (1963) found similar results in

Indonesia in farm activities that could absorb great labor inputs such as paddy rice cultivation. In Boserup's view, population-induced agricultural intensification manifested itself as a series of stages on a continuum beginning with shortened fallows and ending in permanent cultivation. Furthermore, she states that food stress may serve to accelerate the adoption of technology that permits higher levels of production.

> The relationship between food scarcity and development is much more complicated than is assumed by Malthus and neo-Malthusian theories. These theories focus on the negative effects an increasing man-land ratio on food supply, but they have overlooked or underestimated the positive effects which increasing population may have on infrastructural investment and technological levels. (1983: 208)

Neomalthusians, in contrast, hold that population increase leads to the degradation and destruction of the land (rather than the destruction of surplus human population, the malthusian predicted outcome). To avoid starvation people must migrate to new land and begin a new cycle of land degradation (see Clanet 1982). Boserup holds that the neomalthusians ignore key issues related to the intensification of land use caused by population growth.

> Furthermore the neomalthusians neglect the evidence we have of growing populations which managed to change their methods of production in such a way as to preserve and improve the

fertility of their land (Boserup 1965; 21).

Boserup's research is of interest to researchers investigating drought and food stress because drought provides a context in which the relationship between population and resources is dramatically altered. The implications of her research are thought-provoking when such stressful situations are examined in light of her intensification hypothesis. Other research addressing this issue has traditionally been from the disciplines of geography (Brookfield 1972, Bowden et al. 1981, Denevan 1983, Grigg 1980, Hankins 1974, High, Oguntoyinbo, and Richards 1973) and anthropology (Alland 1975, Calhoun 1972, Colson 1979, Dahl and Hjort 1980, Dirks 1980, Fleuret 1985, Geertz 1963, Hogg 1985 1980, Holy 1980, Laughlin 1974, McNetting 1968, Torry 1987, 1979a 1979b) as well as other disciplines (Bramner 1987, Corbett 1988). Recently, Richards (1985; 53) presented a "compendium of skills" view to replace the Boserupian stage and systems approach which he criticized as teleological. He stated that this approach avoids the "...difficult notion of what constitutes 'progress.'" Richards presents a continuum of possible ecological adjustments that are based upon a farmer's rich ecological knowledge and diverse technical knowledge and skills (see Oguntoyinbo and Richards 1978). In contrast to Boserup and consonant with Brookfield (1972), Richards holds that producers may adopt less intensive activities and even

abandon intensive for extensive activities if conditions warrant.

Richards' approach to the study of drought coping strategies is workable and analytically flexible. He views West African farmers as possessing " ... a rich 'tool' kit of land management procedures in which the value of different items in the 'kit' varies according to the nature of the job in hand...which...has equipped many West African farmers with a subtle sense of ecological dynamics" (see also Ag Arias and Bernus (1977), Johnson (1972) for a discussion on technological change and experimentation in traditional farming systems).

The contributions made by Boserup and Richards provided researchers with a framework to reinterpret the gloomy malthusian dictum that technological change causes population to increase by increasing agricultural output. They also gave African producers a rationality and purposiveness that had not been attributed to them previously. Despite these contributions, there were certain other issues related to the impacts of drought that Boserup did not address except by way of saying that positive change is not shared equally by all groups (Boserup 1983). These new issues, however, emerged strongly in the wake of the Sahelian drought of 1968-1974. The contribution of the group of researchers who emphasized these issues is discussed after the following section on criticisms of mainstream theory.

Criticisms of the Mainstream Theories

The mainstream interpretation of the impacts of drought was criticized by French Marxists in a series of articles published after the Sahel drought of the early 1970s (Copans 1975 1974, Comité Information Sahel 1975, Meillassoux 1974) and later by English speaking Marxists (O'Keefe and Wisner 1976, Spitz 1978). The contention of the Marxists was that mainstream theory ignored key social issues that affect an individual's or group's risk and vulnerability to the effects of rainfall variation. Rather than causing imbalances between population and resources as the neomalthusians would have it, or imbalance and redressment through technological change as Boserup would have it, the Marxists viewed drought as causing a permanent imbalance in access to resources and as the catalyst in the development of new social classes based upon their control of resources (see Blaikie and Brookfield 1987).

Although overtly concerned with process (the process of population growth, the process of adaptation to climatic variation, etc.) and system (ecosystem, regional system, etc.), mainstream studies have been criticized by Marxist researchers for being ahistorical, aprocessual, unsystematic, and reductionist. According to the Marxists, mainstream research has dealt with trends rather than processes (the trends in population growth, deforestation, land degradation, the trend toward small families, rural to

urban migration, etc.). These trends, according to the Marxist critique, are not the results of modernization or economic development; rather, they are symptoms of wider social transformations that have at their root fundamental changes in land and resource ownership. These fundamental changes and social transformations are part of the process of expansion of Euro-American capital and drought accelerates these transformations.

Hewitt (1983) cites the following three points as criticisms of the mainstream approach to understanding natural hazards.

1. Natural hazards "...are characteristic rather than accidental features of the places and societies where they occur" (Hewitt 1983; 25).
2. Response and vulnerability stem from social factors "...rather than from the rareness and scale of [climatic] fluctuations" (Hewitt 1983; 25).
3. "...natural extremes...are, in a human ecological sense, more expected than many of the contemporary social developments that pervade everyday life" (Hewitt 1983; 25).

The Moral Economy Hypothesis

Marxist researchers turned to human social systems to examine the effects of rainfall variation on the internal structure of human groups and how structural changes were related to regional, national, and international economies (Cliffe 1974, Cliffe and Moorsom 1979, Comité Information Sahel 1975, Copans 1975, Derriennic 1977, Franke and Chasin 1980, Hewitt 1983, Meillassoux 1974, Shenton and Watts 1979, Vaughn 1987, Watts 1987 1983a 1983b 1980, Wisner 1981 1977). This new contribution to human-environment relations research situated response to drought within the wider context of the impact of capitalism and the development of local forces and relations of production. Marxist theory differs from its predecessors by placing its interpretation of drought-coping strategies within a wider, changing social matrix. Specifically, this interpretation places present drought response (or the inability to respond) in the context of the long-term breakdown of precapitalist economies caused by colonialism and the market economy (see Harvey 1981 1975 1974). The precapitalist economy has been termed a "moral economy" by some of these researchers (Scott 1976, Watts 1983a) and it is to the moral economy hypothesis that the remainder of this discussion is devoted. The moral economy hypothesis is based on the Marxist view of social change. The central tenet of the moral economy hypothesis is that the political, economic, social changes that have occurred since colonialism and the introduction of

capitalism have weakened the ability of people to respond to drought. It has been a conventional wisdom that, contrary to the moral economy view, the market economy has been the primary source of benefit in economic development and in the development of new, stronger, drought-coping strategies rather than an instrument in the general reduction in the ability to respond (Fleuret 1986, Kennedy and Coqill 1988, Skinner 1978, Turton (1977), Von Braun 1988).

The number researchers investigating drought from a moral economy perspective has been growing since the mid-1970s (Ball 1976, Bourgeot 1981, Comité Information Sahel 1975, Copans 1983 1979, 1975, Lofchie 1976, Meillassoux 1974, Shenton and Watts 1979, Susman, O'Keefe, and Wisner 1983, Vaughn 1987, Wisner 1981 1977, Watts 1987 1983a 1983b). Moral economy research differs fundamentally from that of the mainstream behavioral theory (see page 36) in that moral economy hypothesis deals with categories of individuals rather than individuals and there is a more deterministic historical and geographical view than do mainstream researchers. This means that the basic unit of analysis for moral economy hypothesis is not the individual but the social class (Johnston 1983).

According to the moral economy hypothesis, there are two views of the impact of drought on people. The first is that the effects of drought (and the effects of the environment in general) are interpreted by a society's social institutions and then distributed differentially

through the population. The tangible effects of drought reflect the ability of the social institutions to cushion society or to shift vulnerability to politically powerless classes (Susman, O'Keefe, and Wisner 1983). The second view is that, where capitalism is expanding, drought accelerates the breakdown of traditional social institutions, the transfer of ownership of the means of production to a new elite, and the commoditization of labor (Ardouin 1985, Bradby 1975, DeJanvry 1981, Dembélé 1983, François 1982, Franke and Chasin 1980, Hedlund 1979, Kitching 1982, Lallemand 1975, Muller 1980). Collectively, this process is called interrupting the reproduction of a precapitalist economic formation. This enables "...a relatively small number of people [to] appropriate a part of the surplus product which others produce [and to] control the conditions under which another class can produce" (Kitching 1982; 443)[2].

According to the moral economy hypothesis, colonialism and the introduction of capitalism had two general effects upon the local socioeconomy (Raynault 1977).

1. The breakdown of the social basis of production. This involved the breakdown of the traditional system of food storage and redistribution, the breakdown of the

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[2] Franke (1984) has indicated that capitalist relations of production may reinforce traditional exploitative relations rather than replace them with new classes.

traditional collective units (extended family), the emergence of wage earning activities, and the permanent alienation of land.

2. The breakdown of the technical basis of the subsistence system. This disruption disturbed the previous balance between intensive and extensive farming. The main ingredients of the new disequilibrium are the extension of cultivated area and the reduction of fallow length and area. The ecological consequences of this disequilibrium are the destruction of plant cover, soil depletion and exhaustion, an increased vulnerability to climatic hazards, and an increased competition between farming and herding.

3. The transfer of local drought response from local to national and international institutions. Because of the breakdown of response mechanisms at the local level, there has been a defacto transference of responsibility for drought response from the local level to state or international agencies responsible for drought relief and rehabilitation.

Because of the differential changes in individual and class abilities to respond small droughts have assumed the proportions of large droughts and vulnerability to the impacts of drought has increased generally and differentially according to class, according to the moral economy hypothesis.

Criticisms of the Moral Economy Hypothesis

Torry (1986 1984 1979a), one of the more articulate critics of the moral economy interpretation of the impacts of drought, holds that moral economy analyses "...give, at best, a very sketchy analysis" of drought and its most serious impact, famine (1986; 10).

> The actual event, the famine, is usually of peripheral concern, being merely alluded to or described in the sketchiest of terms, while the burden of analysis concerns economic and political oppression antedating the famine. From the slenderest of evidence, the reader must infer both the sufficiency and requisiteness of broad configurations of historical events for producing a certain pattern of consequences, namely famine, in empirical settings. One therefore is moved to wonder why all similarly vulnerable populations do not suffer famine equally (Torry 1979a; 240).

Torry holds that there is nothing inherently different about moral economy analyses that exempts them from operationalizing their theories and testing them. He faults Watts (1983a), for example, for not demonstrating through his data the processes he describes as occurring. Bennett

(1985) states that when such theories are operationalized they are "proven" by observing that poor people suffer before rich people during drought.

Since drought and such extreme drought-related impacts as famine occur in socialist, communist, and capitalist countries, it is wrong to presuppose a predetermined relation between famine and political economy. Torry contrasts the Chinese and Indian cases below.

> On political economic grounds alone the Chinese would appear less vulnerable than Indians to the severest symptoms of famine. In fact, just the opposite is the case because India has developed a superior emergency relief apparatus and a 'crusading press and hard-hitting opposition parties' lacking in China, that pressure the government into using this apparatus on a large-scale and in a timely manner. Over 16 million Chinese are estimated to have perished since 1959, owing to famine conditions, while there is no indication of more than a few thousand excess famine deaths in India for the same period (Torry 1979; 241).

Along similar lines, Cannon (1989) found that food crises and famines in socialist countries "...where precisely the removal of old economic and social systems was intended to reduce vulnerability, were found to be far from banished" (Cannon 1989: 269).

Too much emphasis has been put by moral economy researchers upon villagers as victims of oppression and not enough on the responsibility of the villagers for their own losses (Torry 1979a). Africans are viewed as passive

respondents to change with no power to act on their own behalf.

Government or international assistance is ignored in the moral economy hypothesis as a response (Torry 1986). Hay (1988) found in Botswana that the National Drought Relief Program of Botswana was successful in replacing lost income and in preserving productive assets of households in drought areas (see also Morgan 1985).

Moral economy interpretations ignore the immense benefit of the market economy to producers in Africa. Braudel states that the market is of utmost importance for the well-being of people and that "wherever the market is absent, or insignificant, one is certain to be observing the lowest plane of human existence, where each man must himself produce almost all he needs" (Braudel 1982: 59). Mehretu (1989) states that, as a general rule in Africa, those areas most involved with the market economy suffer least stress during times of drought and other crises which have economic repercussions. Kennedy and Cogill (1988), Von Braun (1988), and Fleuret (1986), for example, found use of the market through cash cropping or market-oriented production of other commodities an effective coping strategy to cushion household food security in the face of environmental variation in sub-Saharan Africa.

There is a problem of scale in many moral economy analyses often termed the problem of specification. This

problem has to do with the macro level of many moral economy analyses. McLean (1989: 188) holds that:

> Analysis at the level of continental aggregation has outlived its usefulness in the context of hunger and famine. Theories of disarticulated economies do not explain the different situations faced by, for example, Ethiopia, Kenya, and Tanzania.

Many questions also remain about the assumptions in the moral economy hypothesis concerning the breakdown in the technical basis of production, precolonial political stability, and even the demise of the extended family (see Chapter Three and also Cole 1989a, Le Roy 1983, Lewis 1978).

The moral economy model of proletarianization (the last stage in Watts (1983a) model) rests on an unstated assumption: the existence of a free land market. In this model, the head of household, marginalized by the market and pushed to ruin by drought, sells the family land and permanently migrates away from the traditional homeland. Where a free land market does not exist the cycle of impoverishment, land sale, and permanent out-migration depicted in the model cannot be completed.

The moral economy hypothesis may be criticized for its selective view of history. The assumption of a prior state, "the precapitalist economic formation", "natural economy" (Bradby 1975), or "moral economy" (Scott 1976, Watts 1983) without micro-level investigation biases the interpretation of present and future states particularly when the character

of the precolonial state is an assumption based on rather scanty evidence. Precolonial relations in the so-called precapitalist economic formation between state and individual, landowner and labor, and master and slave have been termed a "moral economy" by Marxist researchers (Watts 1983a, Scott 1976) which cares for vulnerable people during extreme food stress. There is evidence to cast doubt on the general applicability of the "moral economy" model (see Bazin 1974, Park 1971, Roberts 1980c) and some researchers are now contending that the precolonial, premarket society was structurally incapable of coping with extreme food stress (Cole 1989a, Torry 1987). Watkins and van de Walle (1983: 10) state that "...most pre-industrial economies were particularly vulnerable to crises." The authors suggest that these economies possessed production systems that had the following characteristics:

1. Few, if any, surpluses.
2. A lack of diversification.
3. A lack of systems of insurance and solidarity as have been developed by the modern state.

An almost continual condition of competition in the precolonial period between small, often ethnically different, groups reduced spatial mobility during periods of food crisis such that localized food shortages often became famines. The use of such formerly common drought-coping strategies as the pledging of children to unaffected groups

or individuals for grain has disappeared with economic diversification, increased mobility, and the cessation of intergroup conflict. Furthermore, in overemphasizing the role of the market economy, the moral economy hypothesis ignores how the ability to respond to drought was conditioned by premarket political, social, and environmental contexts. Historical depth has ironically been lacking in moral economy studies. For example, it will be argued in the present study that Islam, as an alien ideology which violently replaced traditional agrarian religions in many areas of Africa during the precolonial period, undermined people-environment relations and made people more vulnerable to drought (see Chapter Three). The increased spread of Islam in West Africa, particularly since the 1950s, replacing traditional institutions, is a confounding variable that the moral economy hypothesis fails to include in analyses and comparisons.

Lastly, is the assumption of a "premarket" period for West Africa a useful distinction to make today? Available evidence indicates that West Africa, particularly the states centered on the Niger and Senegal basins, had a well-integrated regional trade network for centuries and hierarchies of markets were commonplace (Baier 1980, Braudel 1982, Curtin 1984, Lovejoy and Baier 1975, Roberts 1980a, Roberts 1980d, Wolf 1982).

The moral economy hypothesis has served to underline the importance of examining social factors in investigating

drought. Marxism, the foundation of the moral economy hypothesis, provides a heuristically useful, general paradigm with which to interpret the impact of the market upon nonmarket economies but its usefulness is limited by its many assumptions and its lack of an empirical grounding. It has been used to demonstrate that drought can have the same effects and may accelerate the effects of the introduction of the market economy. The value of the Marxist paradigm lies in its general nature. In micro-level analyses it has often failed to detect the processes that are supposed to occur according to theory.

Models of Drought Response

Empirical evidence from around the world has contributed to the formulation of several models of response to drought. In the discussion that follows, the results derived from eight field investigations will be presented and then a conceptual model of response in general (Burton, Kates, and White 1978) will be discussed.

Cutler (1986), Rahmato (1987), De Waal and El Amin (1986), and Corbett (1988) developed stage sequence models of drought response reflecting initial, medial, and terminal responses (see also Spitz 1980, Tobert 1985, and Toulmin 1986). The theory behind these models is that an individual experiencing the impacts of drought goes through a series of responses depending on the length and severity of drought.

These stages are presented in Table 2.1, adopted from Corbett (1988).

What is unsatisfactory with the sequences of response presented in the table is that, although they depict a series of responses to a severe drought, they do not address the issues of changes in drought-coping strategies over time. Watts (1983a) (see also Longhurst 1986) is more specific in the development of his model for drought response. In addition to the notion of time he added the "commitment of domestic resources" and the "reversibility of drought response."

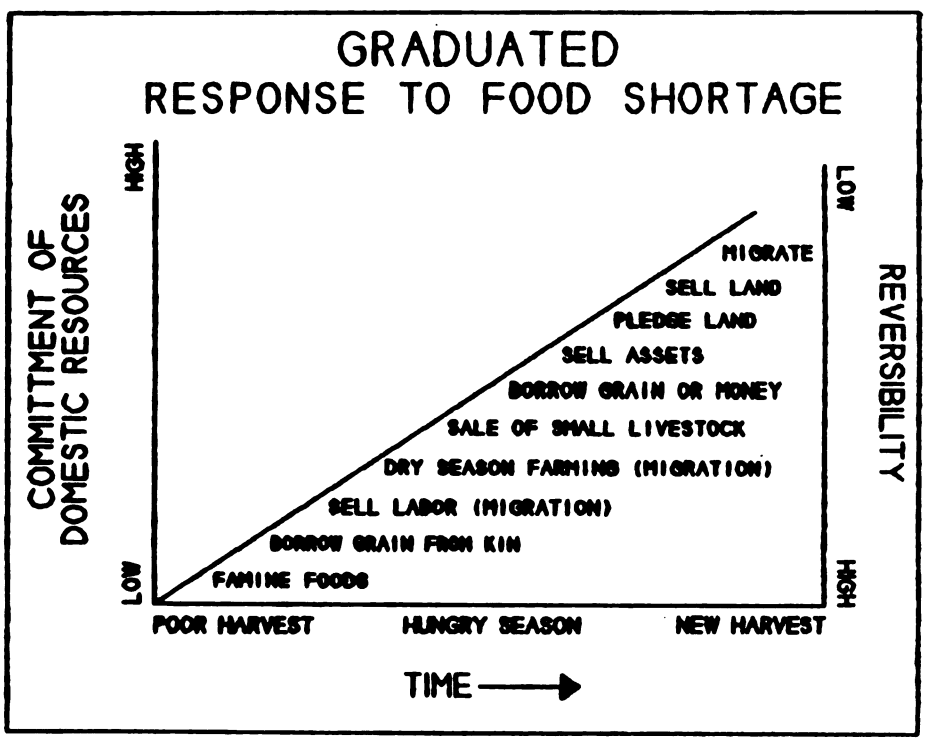
Table 2.1. Sequences in adoption of drought-coping strategies.

STAGE	DROUGHT-COPING STRATEGIES			
	CUTLER MODEL	RAHMATO MODEL	DE WAAL AND ELAMIN MODEL	CORBET MODEL
1. INITIAL: INSURANCE	Sale of livestock Labor migration Artisanal prod. Credit from merchants Barter exchange with neighbors and relatives Credit from relatives	Food rationing Wild foods Interhousehold food and livestock transfers	Wild foods Sell surplus animals Borrow money or food from relatives Wage labor Sale of possessions Migrate to distant pastures	Change in cropping and planting practices Sale of small stock Food rationing Wild foods Interhousehold transfers Artisanal production Wage labor migration Sale of possessions
2. MEDIAL: DIVESTMENT	Sale of tools Sale of breeding animals Sale of household goods Sale of land	Temporary wage labor migration Sale of cattle or camm Sale of personal effects Sale of housing for firewood or construction	Sale of subsistence animals Borrow money or food from merchants Sale of remainder of possessions Wage labor Out-migration for wage labor or charity	Sale of livestock Sale of farm tools Sale/mortgaging of land Credit from merchants Food rationing
3. TERMINAL: DESTITUTION	Mass migration to towns and roadsides	Outmigration of household	Dependance on charity Starvation	Distress migration

SOURCE: Cutler (1986), Rahmato (1987), De Waal and El Amin (1986) and Corbett (1988)

Figure 2.1 represents a model of the drought-coping strategies employed for one agricultural season after drought by the poorest segments of a Nigerian village.

Figure 2.1. Graduated response to food shortage (Watts 1983a).



According to Watts, only three percent of his sample ever employed the entire sequence of strategies. The strategies represent a process of economic marginalization on a continuum of response beginning with the use of famine foods in the early stage of food stress to complete divestment of assets and permanent out-migration in the late

stages of response. The strategies are defined in terms of the commitment of domestic resources and their reversibility. Although this is an improvement on the models presented in Table 2.1 it also lacks a deeper temporal dimension. In addition, the model is focussed principally on divestment strategies. According to Corbett (1988) (see Table 2.1) farmers are much more creative than Watts describes in their insurance strategies. Bramner (1987) in a study of drought response and agricultural innovation in Bangladesh found that farmers made ten creative agricultural responses to drought.

1. Adopting new crops.
2. Changing in the location of fields to reflect different soil-moisture conditions.
3. Conserving of soil moisture by plowing after rainfall and weeding.
4. Irrigating formerly rainfed crops by pump, shadduuf, or bucket.
5. Cultivating irrigated vegetables.
6. Expanding the cultivated area of famine millets.
7. Increasing the cultivated area of foxtail millet.
8. Increasing the cultivated area of finger millet.

9. Planting Amaranthus spinach.

In addition to these active responses, Bramner argues that the scattered nature of the fields in his study area represents the farmers' passive response to potential drought. Because rain does not fall uniformly in space, farmers scattered their fields over large areas to increase the chances for adequate rain.

In a study of Sahelian and Sudanian economic strategies in drought response in Burkina Faso, Reardon, Matlon, and Delgado (1988: 1071) found that "households spread income risk not only across occupations but also across locations". Farmers in the more arid Sahelian zone had a more diversified economy and greater food security than farmers in the Sudanian zone. Income generating strategies used in the study area to minimize risk of drought in Burkina Faso were (not in order of importance):

1. Crop production (as opposed to pastoralism).
2. Local agricultural wage labor.
3. Artisanal production of mats, baskets, and woven products.
4. Gathering wood for sale.
5. Providing and selling services such as prepared foods, transport, and vehicle repair.

6. Interhousehold gifts, remittances from temporary migrants, and food aid.
7. Remittances from migrants who permanently live elsewhere.

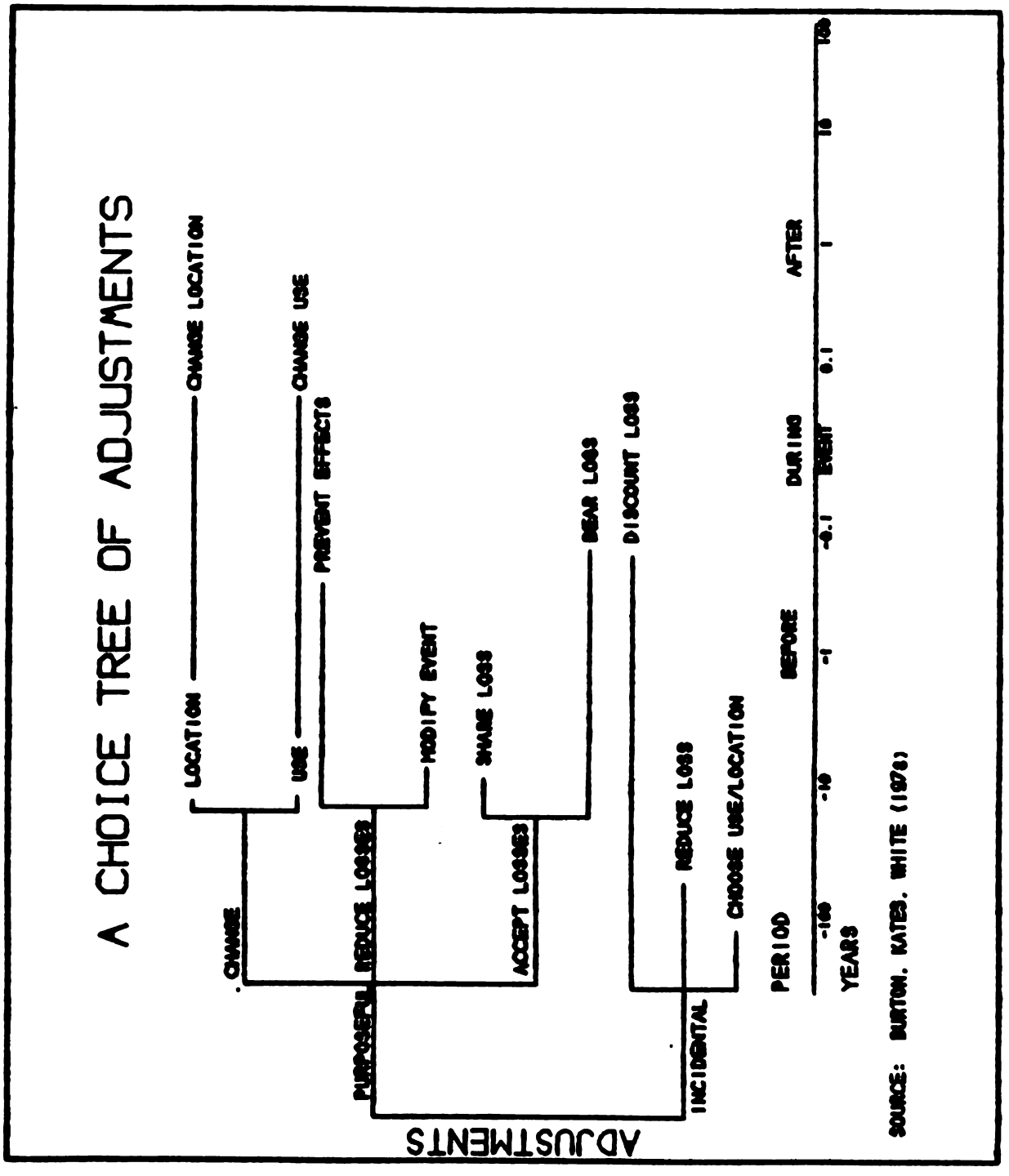
An unstated assumption in the studies presented above is the idea that people do not use "drought"-coping strategies except during times of drought and during high levels of food or economic stress. With the exception of certain agricultural strategies (and it can be argued that every crop year calls for a new set of agricultural strategies), almost all of the strategies mentioned above on Table 2.1 under the Initial Stage are employed during some part of any ordinary year. What changes during a year of food stress is the intensity of involvement in an activity. Households are continually under stress of one sort or another and responses are a daily way of life. Corbett (1988: 1110) argues that most drought-coping strategies are intended to maintain the income-generating capacity of the family intact "rather than simply maintaining current levels of food consumption." Although the desire to maintain income-levels is reasonable to assume, none of the stage studies, perhaps with the exception of Corbett's "change in cropping and planting practices", mentions the possibility of innovation of any sort. Bramner (1987) in a study of drought and agriculture, mentioned above, lists several innovations that he describes as responses to environmental

stress. Bramner discovered these innovations because he approached drought response from the farming system level rather than from the refugee level.

Burton et al. (1978) developed a conceptual model of response to natural hazards (Figure 2.2). Interestingly, this is the only model discussed that does not present response to a natural hazard as an ordered sequence of events in time. The model is not deterministic in that it admits new behavior (innovation) as a response. Furthermore, the model is insensitive to scale; that is, it may be used in analyzing a regional farming system, an individual farmer's entire range of options or, simply the agricultural strategies or the wage labor strategies employed by one farmer at one point in time. In addition, it is more comprehensive than the Watts model in that the long-term temporal perspective is accounted for while the time perspective of the Watts model is only one year.

There are two categories of adjustments in the model: incidental and purposive. Incidental adjustments reflect long-term decisions about location and land use. Purposeful adjustments, on the other hand, may be characterized as managerial decisions and responses that may be made during the life of one individual, before, during, or after a hazard.

Figure 2.2. A choice tree of adjustments.



Although it is not explicitly stated, an individual or group responding to a hazard may use all three purposeful strategy sequences. He or she may accept some losses, reduce some losses, as well as change location or land use. Unlike previous models, which generally start at the beginning of a natural hazard, the model of Burton, Kates, and White makes provisions for prior states of preparedness in the response category of Incidental Adjustments and in some elements of Purposeful Adjustments. I will return to discuss scale and prior states of preparedness in Chapter Five in a discussion of what Burton, Kates, and White would call an incidental adjustment: the creation of the environment by farmers.

Summary

The interpretation of the impacts of drought has been discussed in this chapter. Interpretations of the impacts of drought have changed over the last century. Some debate exists between, what are termed above, the mainstream and moral economy approaches concerning the role of drought in social change. It is held by mainstream researchers that drought may stimulate the creation of new drought-responses and that the market may be a positive force in the development of new drought-coping strategies. The moral economy hypothesis, on the other hand, view drought as an event that accelerates and exacerbates a process associated in the moral economy hypothesis with the market mechanism: the development of two mutually antagonistic classes; one

acquiring most of the resources and the other becoming increasingly marginalized and vulnerable to drought as it is depossessed.

In addition to an examination of interpretations of the impacts of drought in the present century, the moral economy model and mainstream models of drought-response have been examined in this chapter. The limitations of both types of models were discussed and the model proposed by Burton, Kates, and White (1978) identified as a wider, more comprehensive model of drought-response than the Watts model, which can be considered a short-term subset of the Burton, Kates, and White model.

Statement of the Problem

There are three distinct ethnic groups living presently in the study area, each of which possesses its own land-use system with specific resource requirements linked to opportunities in a diverse local environment. Traditionally, livestock owners and fishers have been wealthier than farmers, the disadvantaged group. Production systems in the study area during the historical past have expanded and contracted according to political, economic, social, and environmental considerations (see Chapter 5). The precolonial, pre-Islamic period was characterized by the expansion of population, the expansion of farming, fishing, herding, trade, and regional economic integration during the Ghana, Mali, and, more recently, the

Bamana empires. Each of these three periods of expansion and integration came to an end. The coming of Islam in the middle of the 19th century ushered in a period of population decline, a contraction of productive activities, and regional economic disintegration and increased vulnerability to the impacts of drought. Islam was the first systemic shock that traditional West African agrarian cultures endured. The revolution of Islam was anathema to traditional agrarian religions; it brought new ideology, political institutions, and administrative practices. It was not linked to the soil as were the previous beliefs, it was, instead, a religion centered on the town and commerce.

Since the debut of French administration at the turn of the century, sub-Saharan agricultural and pastoral systems have experienced a process of spatial expansion into unused or marginal areas. This process of expansion is considerably different from preceding processes of expansion because it is occurring under different conditions of growth, social organization, and technological transformation. Expansion may imply a process of ecological degradation and eventual outmigration (the neomalthusian argument), the marginalization of powerless groups and the creation of a landed and an outmigrating landless group (the moral economy argument) or increased intensity of agricultural exploitation as drought stimulates the search for new forms of sustainable production (the Boserupian argument). At issue are the impact of this transformation

upon the ability of individuals to respond to drought and the impact of drought upon this transformation.

The discussion above is concerned with the interpretation of the impact of drought and changes in human response over time. What role do more micro-level factors play in influencing the choice of drought-coping strategies and how do these choices change over time? Is there a common interpretation we can advance to account for the observable micro-level differences? Each of the ethnic groups in the study area has its own traditions, distribution in space, production systems, and circumscribed areas of activity. What role does ethnicity play in the adoption of drought-coping strategies and how does adoption change over time? Is tradition a bar to innovation? Each ecozone, or location, in the study area offers a range of economic opportunities that are dependent upon the physical characteristics of the land in that zone (resource endowment), location, or management. Physical characteristics include the depth of the water table and soil type. Locational considerations include proximity to the Niger river, surface water, or intermittent stream areas. Management reflects the ability or desire of the people who occupy an area to develop it to serve their own needs. Does location influence the choice of drought-coping strategies? Does distance imply that an individual will adapt only those opportunities available in his or her immediate area (on the village land) or are there other

factors that override the opportunities of place? Does the availability of opportunity in each zone either constrain or promote the use of new and different drought-coping strategies?. How does wealth alter the local opportunity and the effect of tradition? Does response to innovation vary by wealth? How does the response of the poor change over time? And finally, what can we make of any differences that are found; how can we interpret any differences that exist? The purpose of this study is to address these questions.

CHAPTER THREE: POLITICAL, ECONOMIC, SOCIAL, AND ENVIRONMENTAL CHARACTERISTICS OF THE STUDY AREA

In this chapter the environmental and socio-economic characteristics of the study area are presented and discussed. Certain of these elements, ethnicity, location, and wealth are hypothesized to be important influences on the choice of drought-coping strategies. Detailed historical material about the study area is presented in order to present a picture of the political, social, economic, and environmental conditions of the precolonial period. This material is important to our understanding of drought response today where different political, social and economic conditions now prevail. An understanding of historical background is essential to our understanding of questions of human vulnerability to the impacts of drought today and in the past.

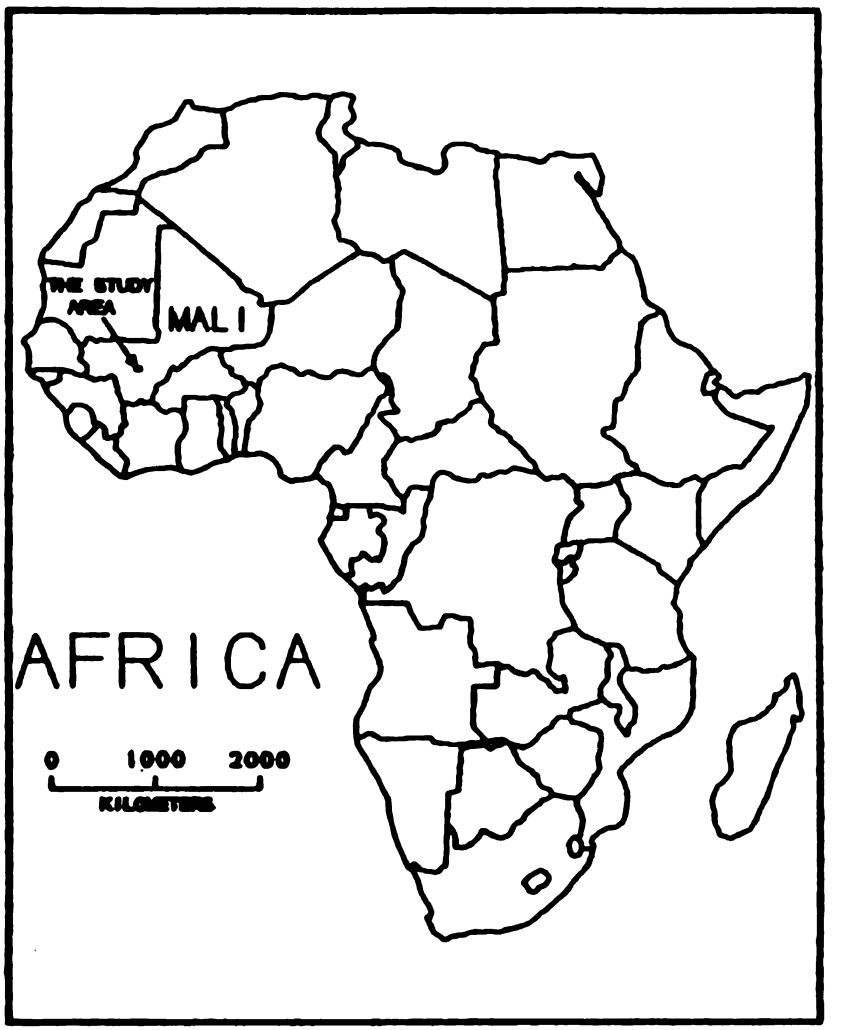
In the sections below, the location of the study area is presented first and reasons for its selection as an area of research. Climate and seasons in and around the study area and recent drought experiences are presented and discussed. The geophysical characteristics of the study area are then presented. The last section of this chapter is concerned with the ethnic and cultural elements of the study area. A discussion of population prefaces a

presentation of the ethnic groups which live in the study area and their characteristics.

The study area is located in south central Mali along the Niger River. The Republic of Mali is a land-locked country located in central West Africa (Figure 3.1 below). Northern Mali includes vast tracts of the arid Sahara while humid southern Mali receives an average of over 1000 mm of rainfall per year. The distribution of Mali's diverse flora, fauna, and human populations are dependent upon rainfall or proximity to the Niger, Sénégal, or Bani rivers.

The study area is an irregularly shaped polygon located between 7°25'W and 7°47'W latitude and from 13°14'N to 13°22'N longitude in the Sudano-Sahelian vegetation and rainfall zone of Mali, West Africa (Figures 3.2 and 3.3). Located along the Niger River, the study area from east to west is 36 km in length at its maximum and 28 km at its minimum; its width from north to south is 15 km at its maximum and 12 km at its minimum. It is approximately 500 km^2 in area. Figure 3.2 below presents a map of Africa which identifies Mali and the study area.

Figure 3.1. Africa and Mali.



The study area is located 21 km west of Ségu[4], the now-legendary former capital of the animist Bamana state. Figure 3.2 below presents the study area.

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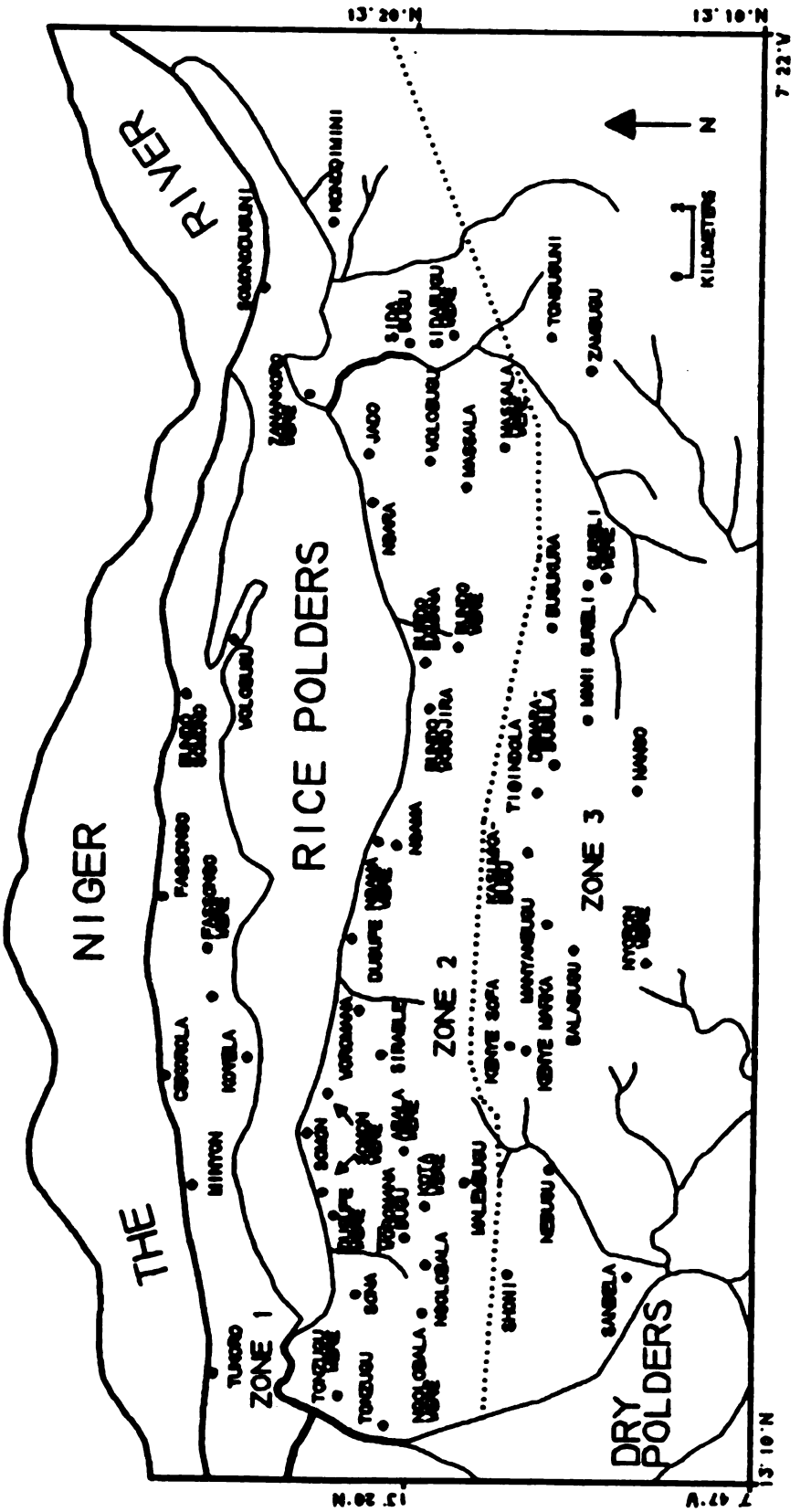
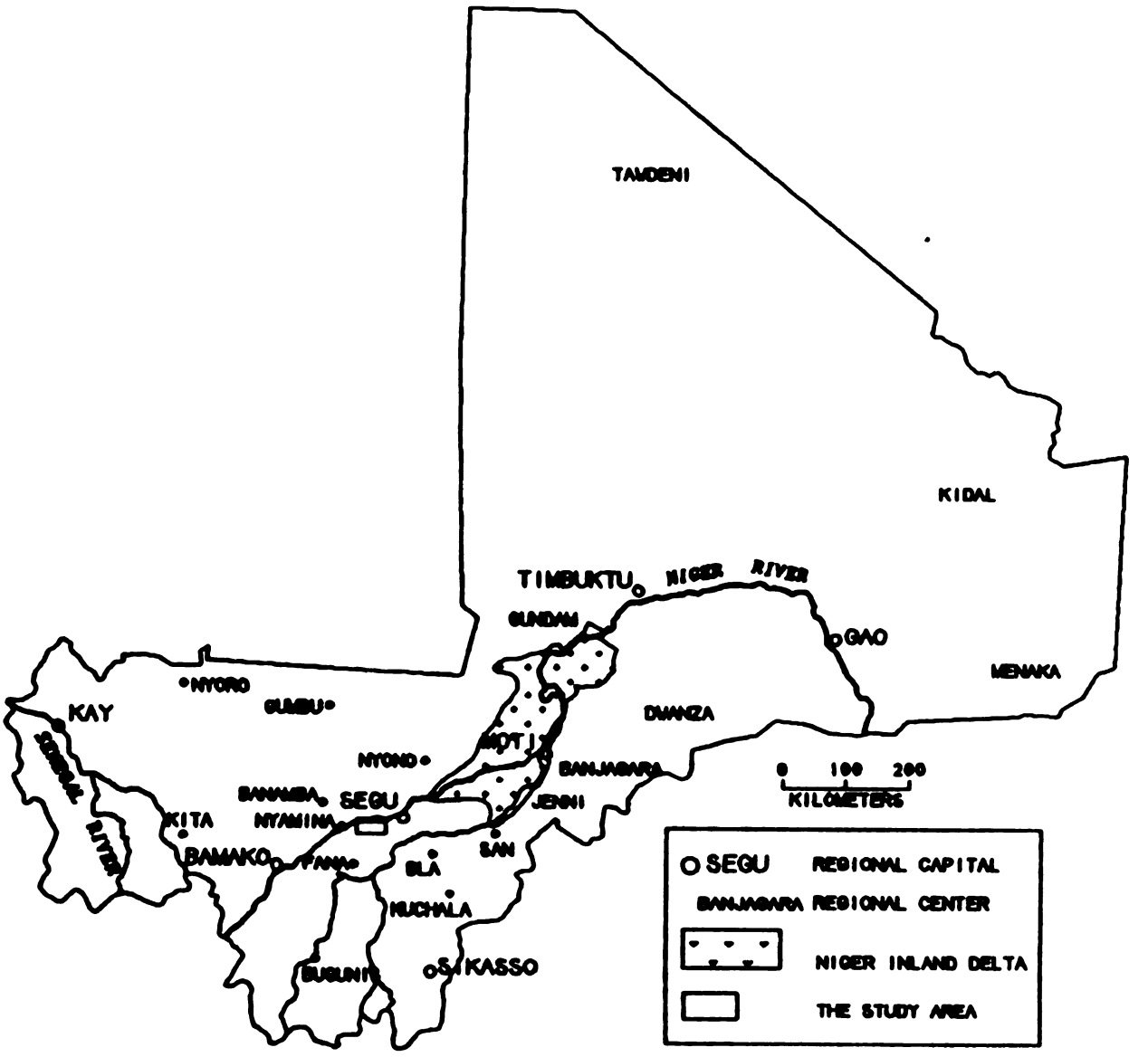
[4] See Appendix J for a note on the orthography used in the text.

Figure 3.2. The study area.



This study area was chosen for several reasons, chief among which is that the region has supported a relatively dense and culturally homogenous population for many centuries, unlike the Sahelian zone to the north which was relatively sparsely populated until internal colonization took place under colonial and post-colonial administrations (Pitôt 1952). Another reason for choosing the present study area is the range of possible response to drought is greater than in more marginal areas of Africa, again unlike the Sahelian zone. A third reason is that social organization and the land-use system in the area truly represents a "traditional" system, unlike completely Islamicized areas where traditional agrarian values have been eroded. It must be stated, however, that the study area is undergoing a transformation; the old agrarian religions are being replaced with Islam, particularly as the centers of power and political life in modern Mali are controlled by Muslims. A last reason for choosing the study area is that it can be bounded in a logical way culturally, environmentally, economically, and historically into a region about which generalizations can be made.

Figure 3.3. Mali and the Study Area.



Climate and Seasons

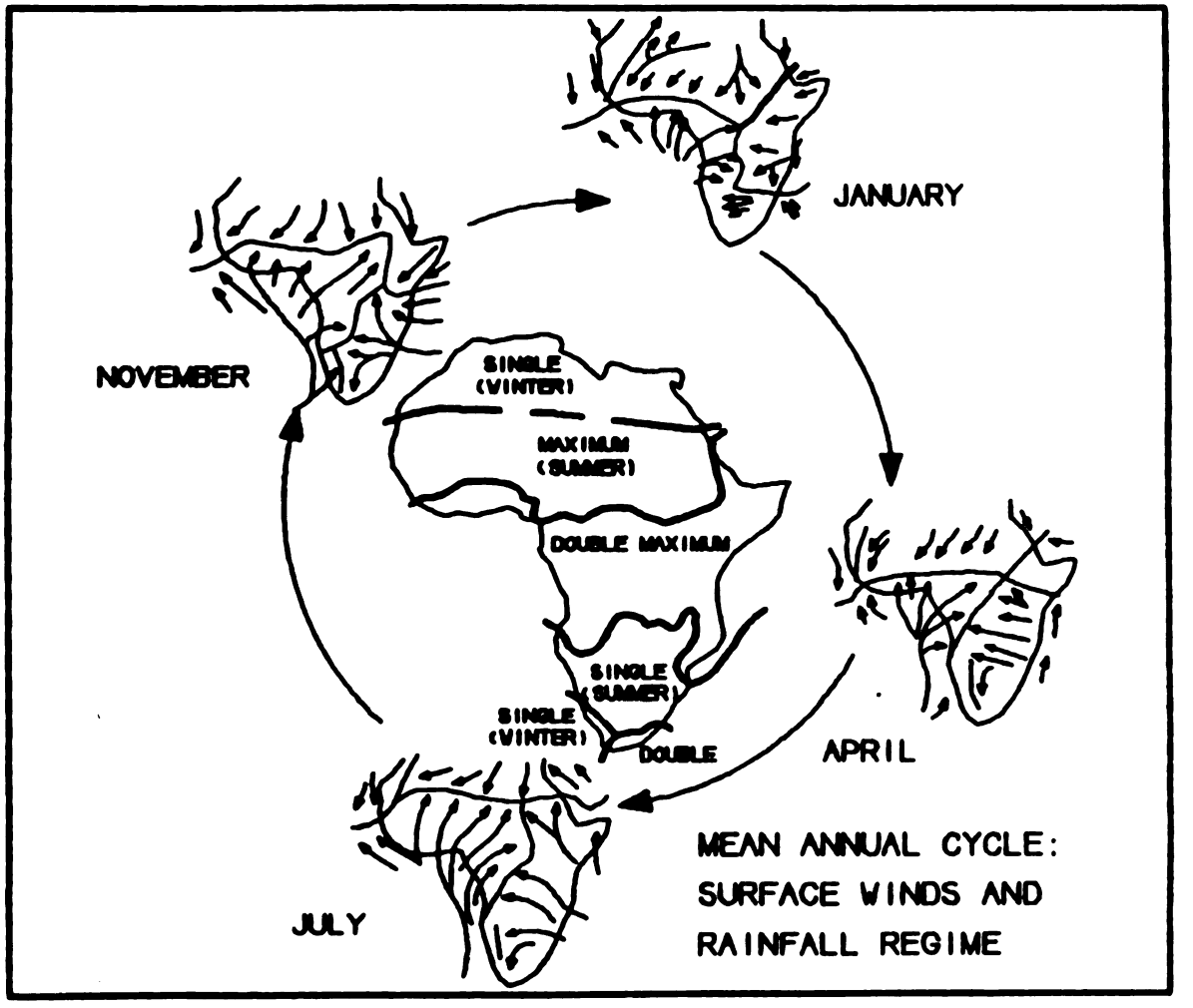
Seasons in Mali are conditioned by the north-south movements of the Inter-Tropical Convergence Zone (ITCZ), which bring humid air from the equatorial region to the subtropics. In general, the amount of rainfall received at any one point away from the equatorial region is a function of distance: the further north or south from the equatorial area the less rainfall. Rasmusson (1987: 5) states that:

> The planetary-scale circulation features of the tropics play a fundamental role in determining the climatology of African rainfall. Large parts of the continent are influenced by the Atlantic or the more massive Indian Ocean monsoonal circulations. The zone of converging winds from the two hemispheres, loosely referred to as the Intertropical Convergence Zone (ITCZ), migrates northward and southward and changes its orientation with the waxing and waning of the seasonal monsoons. Over the Atlantic and West Africa, the ITCZ remains north of the equator throughout the year. Over the Indian Ocean and eastern Africa, it executes deep seasonal swings into each hemisphere.

Figure 3.4 illustrates the ITCZ-dependent distribution of rainfall in Mali from south to north. During the rainy season (samiya tuma), from June to September, the ITCZ (the thick horizontal line in the figure that transects northern Africa in July) is at its most northward extent. The northward movement of the ITCZ is slower and more regular

(six months) than its return toward the Equator (four months) (Kamété 1980).

Figure 3.4. Mean annual cycle: surface winds and rainfall regime (Rasmusson 1987).



The ITCZ brings humidity and scattered thunderstorms, often of a violent nature. These thunderstorms appear to move along paths or tracks from south to north which causes rainfall events to be linear and local. A relatively cold season (fonéné tuma) approximately 3 months in duration follows the rainy season. The cold season marks the retreat of the ITCZ and the beginning of the re-establishment of the hot and dry regime of the subtropical high pressure belt and its desiccating winds, the harmattan. The major atmospheric characteristic of the cold season and a sharp contrast to the atmospheric clarity of the other seasons, are dense clouds of dust that dramatically reduce visibility. The hot, dry season (tiléma tuma) becomes established by the end of February. Figure 3.5 presents rainfall isohyets for Mali.

Figures 3.6 and 3.7 illustrate annual rainfall between two stations located near the study area. The first is Ségu Station, located twenty-one kilometers to the east of the study area at 13°27'N, 6°16'W. The second is Nyamina Station, located twenty-two kilometers to the west of the study area at 13°19'N, 7°59'W. The tables show the annual deviations about the long-term mean of 700 mm of rainfall for the years 1953 to 1985 for Ségu station and 1936 to 1983 for Nyamina station. There are two characteristics of the rainfall patterns that are of note: interannual variation is great; and since around 1970 interannual variation has

been entirely below the mean except for one year at the Ségu station.

Intra-annual rainfall is unimodal and is distributed principally in the summer months of June, July, and August. Figures 3.8 and 3.9 below illustrate the long-term monthly rainfall pattern for both stations mentioned above and include each month's average of the annual rainfall.

Figure 3.5. Rainfall isohyets, Mali.

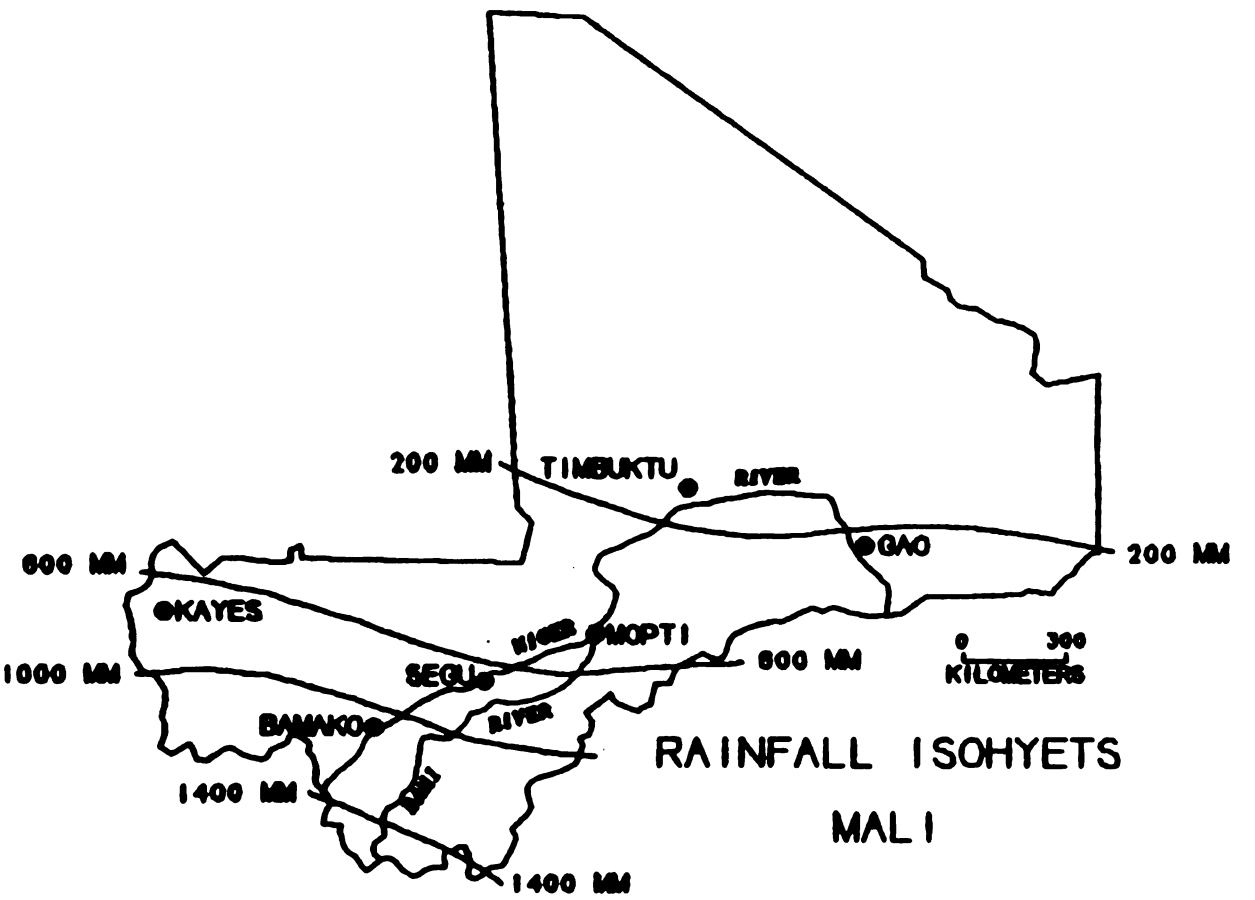


Figure 3.6. Annual rainfall in millimeters, Ségu station, 1953 to 1985.

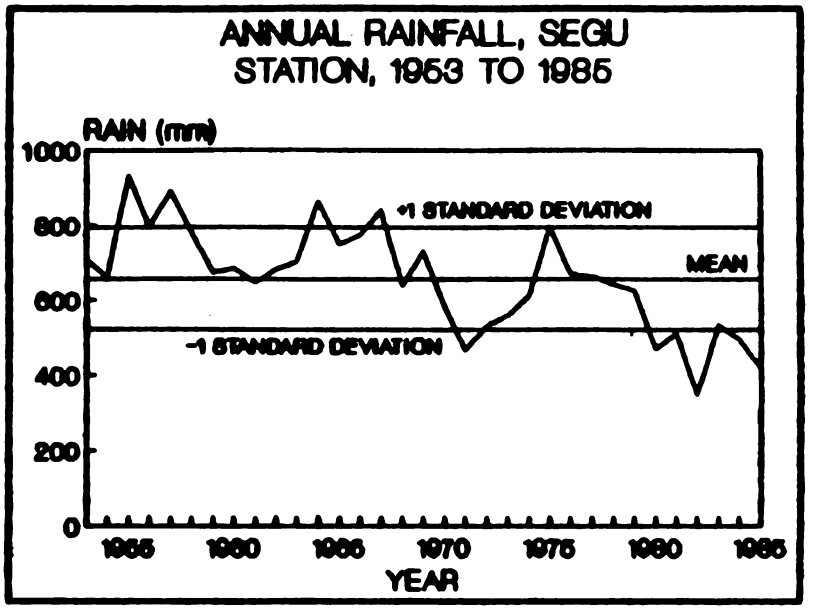


Figure 3.7. Annual rainfall in millimeters, Nyamina station, 1933 to 1983.

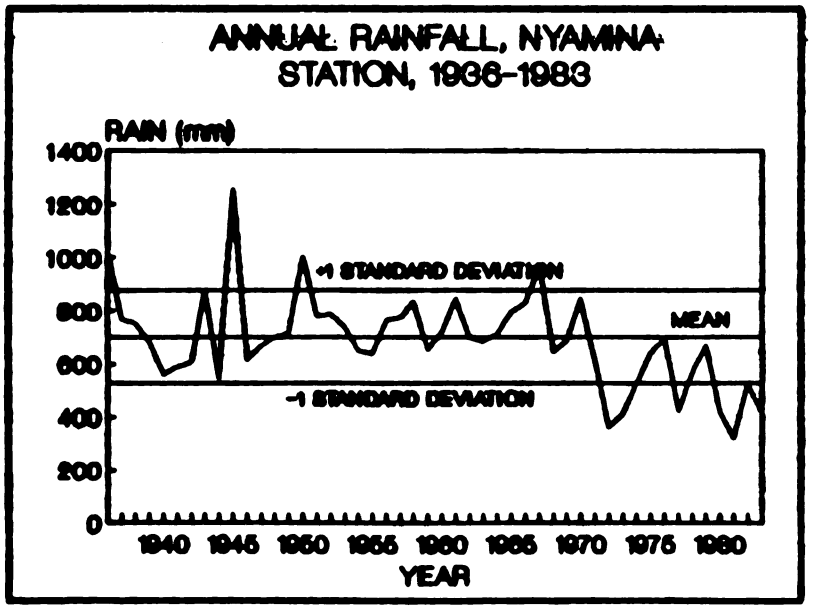


Figure 3.8. Mean monthly rainfall for Ségu Station, 1953-1985.

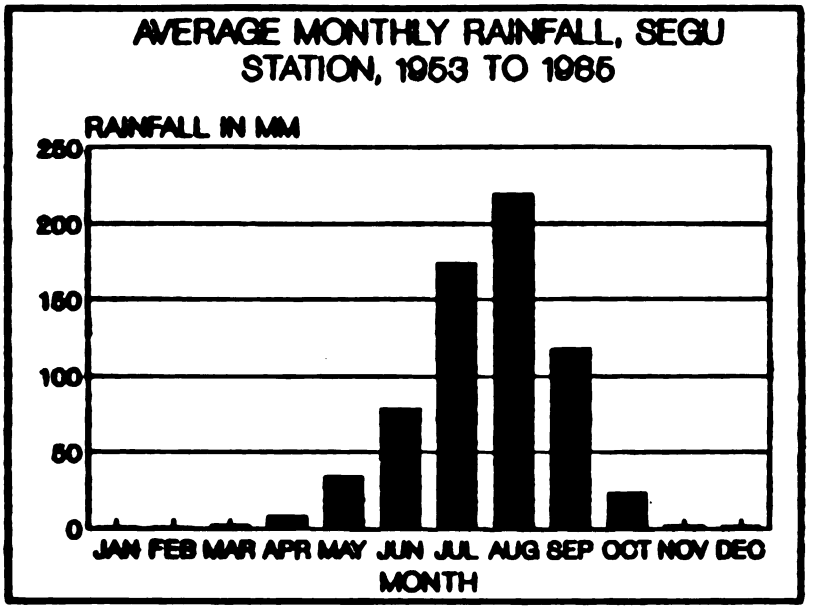
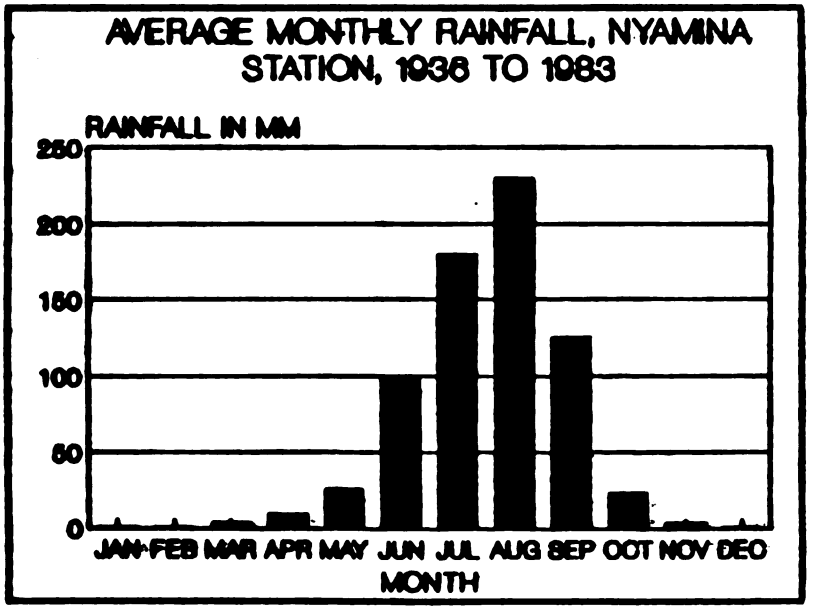


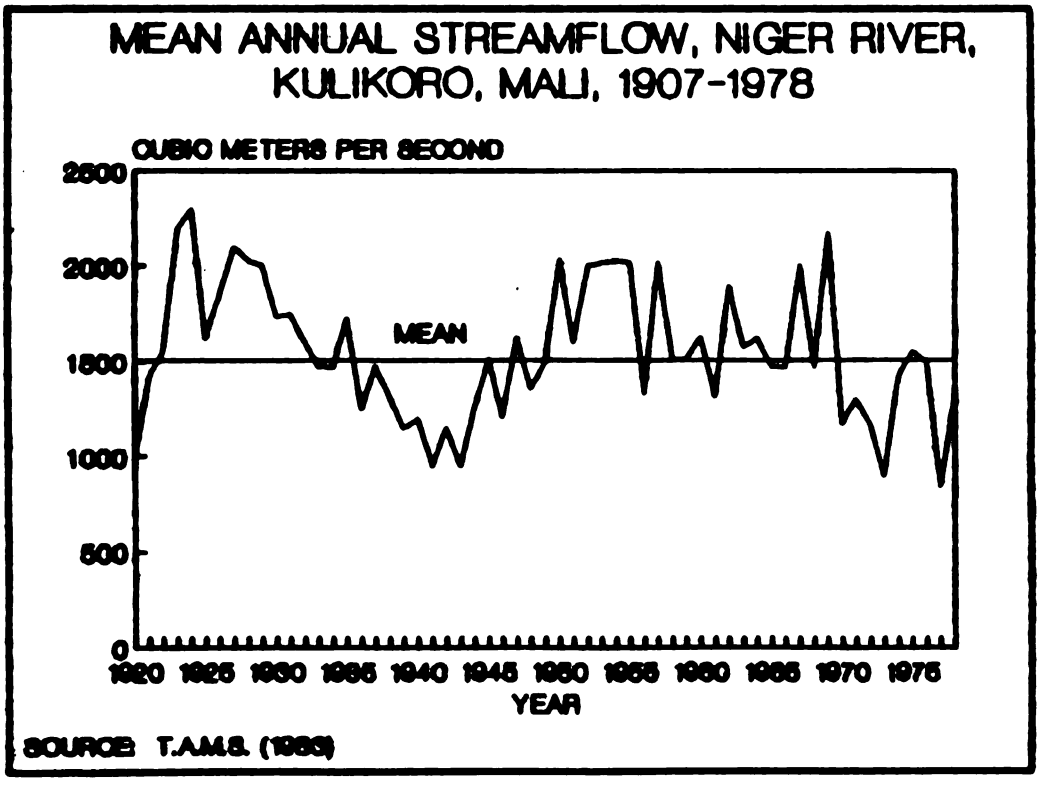
Figure 3.9. Mean monthly rainfall for Nyamina Station, 1936 to 1983.



The annual flooding of the Niger River is important in the study area. Without annual floods the intensity of land use and the density of vegetation in the study area could

not be sustained. The floods of the Niger River provide the basis for irrigated rice cultivation in the study area as well as the cultivation of manioc, sweet potatoes, vegetables, and beans along the edges of irrigated areas. Subsurface water associated with annual flooding of the Niger permit the cultivation of high-value mangos along the edges of the Niger, irrigated areas, and where the water table is moderately high (see the discussion of ecological zonation beginning on page 66 for further exploration of the relationship between water and agricultural opportunity). Figure 3.10 below illustrates Niger River flow from 1907 to 1978.

Figure 3.10. Mean Annual Streamflow, Niger River, Kulikoro, Mali, 1907-1978.



Recent Drought in the Study Area

The average annual rainfall for the two rainfall gauging stations closest to the study area, Segu and Nyamina stations, is 656.5 and 646.6 mm respectively. Since the early 1970s total rainfall has decreased by 29% on average and year-to-year rainfall variability has increased (see ICRISAT 1984, Nicholson 1985 1983, NOAA 1985, Virmari et al. 1980, Winstanley 1976). The coefficient of variation for the Ségu station for the period 1953 to 1985 is 21% and that for Nyamina station for the period 1953 to 1983 is 24%. The coefficient of variation expresses the standard deviation as a percentage of the mean and is a useful measure of the reliability of rainfall. It is axiomatic in that as mean annual rainfall decreases variability increases and, not surprisingly, the coefficient of variation for the Ségu station increased by 58% from the more humid 1953-1969 period to the drier 1970-1985 period. The coefficient of variation for the Nyamina station increased 100% over comparable time periods. The change in the rainfall regime since the end of the 1960s and early 1970s as expressed by the mean, standard deviation, and coefficient of variation for the study area is illustrated in Table 3.1.

The annual average difference between the two periods for the Ségu station is 191.9 mm and 241.8 mm for the Nyamina station. Such decline is equivalent to an annual loss of all the rainfall for the month of July for the Segu station and all of the rainfall for the month of August for

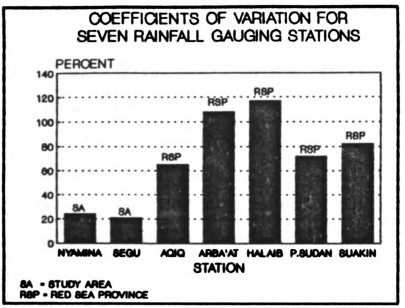
the Nyamina station. Variability, or the reliability of rainfall in any given year, has increased dramatically as the standard deviations and coefficients of variation illustrate. These changes have important implications for people who depend on the natural environment for their livelihood. This will be discussed further in Chapters Five and Six. The rainfall in the study area is more reliable than in other, more marginal, areas of Africa. In one of the most environmentally marginal areas of Africa, Red Sea Province, rainfall reliability as expressed through the coefficient of variation, is much lower than in the study area. The average annual rainfall for Red Sea Province is less than 100 mm of rain. Figure 3.11 illustrates these differences with data from the study area and Red Sea Province.

Table 3.1. Means, standard deviations, percent change, and coefficients of variation for Ségu and Nyamina rainfall gauging stations, various dates.

STATISTIC	SEGU STATION			NYAMINA STATION		
	1953-69	1970-85	%Δ	1953-71	1972-83	%Δ
MEAN	749.5	557.6	-26%	740.2	498.4	-33%
SD	86.5	105.7	22%	90.1	119.5	33%
CV	12.0%	19.0%	58%	12.0%	24.0%	100%

SOURCE: Service Météorologique, Bamako.

Figure 3.11. Coefficients of Variation for Seven Rainfall Gauging Stations.



The flooding of the Niger River decreased in the early 1970's as did rainfall (see Figure 3.10). Although no figures on flooding are available for the early 1980s, flooding probably decreased. Decreased flooding in the early 1980s is indicated by the fact that Opération Riz, the Malian parastatal responsible for rice cultivation in the study area, adopted a three-pronged strategy to conserve floodwater. It closed the western polders (the Casier de Tamani) to rice cultivation, deepened intake canals, and diked out of the irrigated area hundreds of hectares of formerly-flooded polders located along the southern edge of the rice polders.

Physical Characteristics of the Study Area

The study area is composed of two valley terraces bounded by the Niger river in the north, a ferruginous (lateritic) upland in the southeast and south, sand dunes in the south and a seasonally-inundated zone in the west (Figure 3.2). The dominant physical agent in the area is the Niger River. With the exception of the sand dunes along the southern portion of the zone, all landforms have been created and shaped by the action of water. Intermittent water courses of secondary importance are Sidabugu Ko in the eastern and Tonzugu Ko in the western parts of the study area.

Elevation on the ferruginous upland southeast of Konodimini is approximately 320 meters above sea level. Large, linear dunes, important for certain crops extend from the laterite outcrops to the westernmost part of the zone. The dunes have been heavily eroded in many places, often to the original soil depth. Elevation along the dune is 291 meters above sea level. The seasonally inundated swamp that bounds the study area on the west today once formed the southernmost of the rice polders of the Zone de Tamani of Opération Riz, however they have been abandoned since the early 1980s. Elevation along these abandoned polders is 286 meters.

The study area can be divided into four zones based on their ecological characteristics. These zones reflect

differing landforms, soil types, depth to the water table, and rooting depth; factors which have an important influence on drought response. Soil type, for instance, may be the determining factor in crop selection. A high water table creates possibilities for intensified agriculture and arboriculture that do not exist in areas where the water table is low or, in areas where there is a laterite soil horizon, rooting depth is shallow. These ecozones, for the present purposes, are termed the River Zone, the Polder Zone, the Middle Valley Zone, and the Outer Valley Zone. The imposition of discrete "zones" over apparently continuous space is a device used by geographers to make sense of the world. For some variables used in classifying the ecozones, there was no strict dividing lines between the zones defined. For example, if we take the depth to water table in the Middle Valley Zone we find that it varies from 15 to 18 meters near the polders to 25 meters several kilometers to the south. Likewise, the watertable in the Outer Valley Zone varies from 35 meters to over 40. For other variables, for example, soil type, boundaries were relatively clear cut. Of overriding importance in defining these zones was the coincidence of more than one difference. For example, in the Outer Valley Zone, in addition to having a water table of over 35 meters, there is a lateritic hardpan (sometimes thicker than 2 meters) below the surface of the earth, laterite outcrops, as well as sandy soils. Table 3.2. below presents the variables with which the

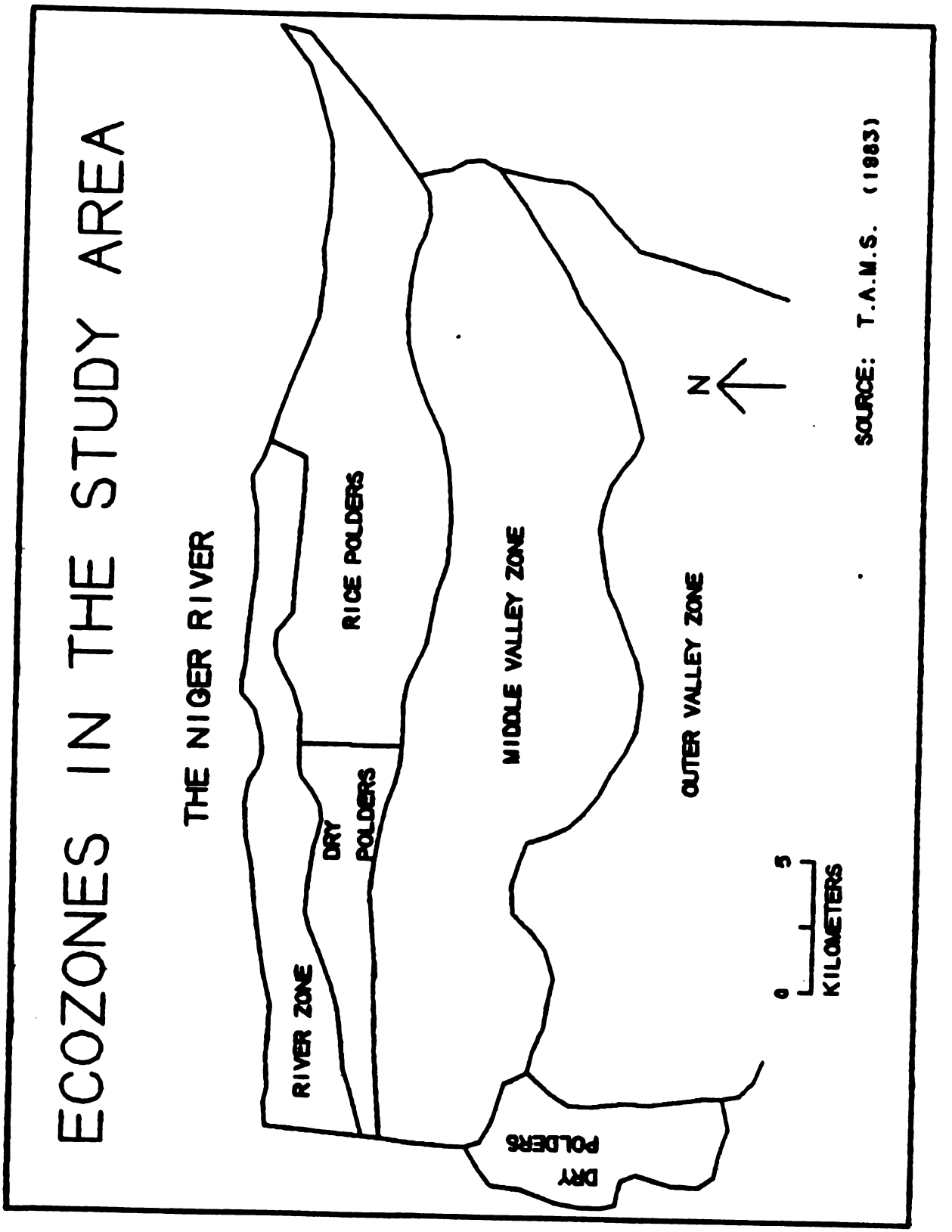
classification was made and Figure 3.12 illustrates the location of these zones.

Table 3.2. Soil, water, vegetation, and land use characteristics of four ecological zones in the study area.

ZONE	SOIL TYPE	DESCRIPTION	DEPTH TO WATER TABLE (m)	VEGETATION	USE
River (Zone 1)	Ultic Haplustalfs (70%)	Plains of loamy material	2-5	Sclerocarya birrea, Piliostigma reticulatum	Ag.
	Plinthic Haplustalfs (15%)	Plains of silty and loamy material	2-5	Vitellaria paradoxa, Andropogon gayanus	Ag.
	Typic Haplaquepts (5%)	Flooded land	0	Vetiveria nigritana	Past. -Ag.
	Aquepts, Aqualfs (10%)	Hydromorphic lands not flooded or rarely flooded	2-5	Acacia seyal, Piliostigma reticulatum	Past.
Polder	Typic Tropaqualfs (100%)	Flooded land	0	Paddy rice	Ag.
Middle Valley (Zone 2)	Ultic Haplustalfs (70%)	Plains of loamy material	3-10	Sclerocarya birrea, Piliostigma reticulatum	Ag.
	Plinthic Haplustalfs (15%)	Plains of silty and loamy material	3-10	Vitellaria paradoxa, Andropogon gayanus	Ag.
	Typic Tropaqualfs (5%)	Intermittent streams	0	Vetiveria nigritana, Panicum anabaptistum	Ag.- Past.
Outer Valley (Zone 3)	Typic Cairustalfs (30%)	Land underlain by laterite	30-40	Combretum glutinosum, Andropogon gayanus	Ag.
	Aridic Cairustalfs (20%)	Land underlain by laterite	30-40	Pterocarpus lucens, Lodetia togoensis	Past.
	Aridic Haplustalfs (20%)	Eroded dunes	>30	Combretum glutinosum, Bombax costatum	Ag.

SOURCE: T.A.M.S. (1983).

Figure 3.12. Ecological Zones in the Study Area.



The section below briefly describes the physical characteristics, typical vegetation, soils, and major land uses important to the classification of the four ecological zones of the study area. It is worth noting that it is difficult to determine with certainty what constitutes the natural vegetation of the study area because of its long history of human habitation. For this reason a distinction will be made only between managed tree species associated with agriculture (anthropic vegetation) and other vegetation.

The River Zone

The River Zone has an area of approximately 50 km^2. It is located between a former channel of the Niger, the rice polders, and the Niger river. It begins east of Somonoduguni where the former channel joins its present bed. It ends west of Tukoro at the beginning of the rice polders and mouth of the former bed. The water table is from 2 to 5 meters below the surface.

The River Zone is characterized by numerous depressions that are filled by flood or rain water during the rainy season though there are areas that do not flood in the west of the zone. Villages are situated on the natural levées produced by the Niger. Soils are of four types (see Table 3.2): 1) flooded soils, 2) hydromorphic soils, 3) plains of loamy soils, and 4) plains of silt and loam soils. The

first type, flooded soils, is found on a narrow strip on both sides of the river:

> ... which is the first area to be inundated by annual floods. Because this unit is the prime recipient of annual alluvial deposits, the soils may contain varied depositional horizons of different textures. The unit supports a perennial grass vegetation dominated by Vetiveria nigritana (Tippetts et al. 1983; B56).

Generally, this soil unit is used for pasture; however, near villages it is used increasingly for irrigated garden cultivation of sweet potatoes, local tomato (nkoyo), tobacco, onions, tomatoes, and mango and citrus orchards.

The second soil type is composed of hydromorphic soils.

> It occurs frequently but usually is not extensive in any one location. An important general characteristic [of the soil] is extremely hard consistency in the lower horizons. The surface is often eroded due to sheet flooding. Vegetation is patchy. In places the unit supports a moderately dense to dense vegetation of tall shrubs and small trees. These areas are interspersed with moderately to severely eroded patches with a little soil surface crust, that support little or no vegetation (Tippetts et al. 1983; B54).

The dominant land use of this unit is bush pasture. Given its location near the river and the high daily densities of river-bound livestock from the Middle and Outer Valley Zones, the degraded condition of the vegetation is understandable.

The third type of soil-vegetation unit is composed of plains of loamy soils. This unit occurs infrequently in the eastern part of the River Zone. It achieves its maximum extent around the village of Tukoro at the western extremity of the study area. This unit forms the major dryland agricultural area of the first zone. Two major characteristics of this soil are the presence of plinthite concretions and hydromorphic mottles in the lower horizons (due to the high water table).

The fourth type of soil-vegetation unit in the River Zone is composed of plains of silt and loam soils. These are the best soils of the zone for agriculture. The dominant tree species growing on units three and four in this zone is Vitellaria paradoxa (shé). Other anthropic species are Acacia albida (balazan), Adansonia digitata (sirasun), Ficus, Tamarindus indica (tamarhindi), and Parkia biglobosa (néré).

Since the second world war and particularly since independence in 1960, mango orchards have been increasingly planted around villages in this zone (as well as along the northern part of the Middle Valley where there is seasonal inundation and a relatively high water table). A relatively high water table and deep soil enable the mangos to survive the long dry season and periodic droughts. Somonoduguni is an extreme example of the transition to mango cultivation due in large measure to two factors: the economic attraction of a high value crop, and to the devegetation of

today's rice polders and peripheral areas in the 1950s for monocropped rice. Much of the rice polders was forest before the 1950s. Higher parts were used to in the shifting cultivation of dryland crops in unmanured outfields. Rice was also grown in low areas. Land formerly used for millet, sorghum, maize, peanut, rice, and other crop production was taken by the colonial government and transformed into rice polders in the mid-1950s. Today the inhabitants of Somonoduguni live on a small island and cultivate every spot with high value crops such as mangos and vegetables. They also cultivate on islands in the river.

The River Zone possesses several characteristics that have relevance for drought and drought impacts. The availability of moisture (open water and high water table) is greater than in the other ecozones that form the study area. The availability of moisture is important for agriculture, livestock, fishing, and transportation. Soils in areas of seasonal inundation are enriched by the deposition of silt and there are several large islands in the Niger River that are flooded annually that provide a virtually drought-proof source of food and market vegetables. Nevertheless, good farming soils for rainfed agriculture in the River Zone are scarce because of the limited area available. Farmers do cross the Niger River to cultivate rainfed crops on the north bank of the river. Livestock have an almost year-round (depending on the annual flood and rainfall) supply of grazing in the River Zone

although the area of grazing is limited. Fishing is an economic activity that can only be carried on in the River Zone and fish are an important commodity in trade throughout Mali. The Niger River also provides a transportation and trade route that is 2600 miles long, from the highlands of Guinea to the Golf of Benin.

The Polder Zone

The Polder Zone is approximately 96 km² in area and is located in a former channel of the Niger River. The polders begin west of Tamani and extend to just east of Somonoduguni. The major intake gate and canal linking the polders and the Niger River is near the village of Tamani and the main drain for the polders is at Somonoduguni. The polders are fed primarily from the annual flood of the Niger and rainfall contributes relatively little to the flooding of the polders, although it is of essential importance in softening the rock-hard soil so that fields can be prepared for planting and in germinating the rice. The polders are flooded when the rice plants have attained about 10 cm in height, ensuring that the young plants will not drown. The zone includes a depression that was linked by canal to the Niger and the other polders which is no longer in use for rice production. The western polders from the depression mentioned above to the village of Dugufé have been closed since 1982 because of the small size of the annual floods.

Soils of the Polder Zone are mainly flooded soils; however, there are areas where hydromorphic soils can be found, for example, on the periphery of the polders and along an arc from Zanankoro Wéré to west of Wolokoro. The flooded units are flooded to a maximum depth of three to four meters and are used for rice production.

> The physiography is flat and water is impounded due to either the depressional, poorly drained nature of the land or due to artificial diking. The unit is inundated for a minimum of three to four months, then drained for harvesting (Tippetts et al. 1983; B56).

Hydromorphic units are not generally inundated, however, they border areas that are inundated and have a high water table in relation to more distant areas. The most common use of hydromorphic soils is for pasture but they are sometimes used for sorghum cultivation. At the mouth of Sidabugu Ko the hydromorphic soil is used for manioc cultivation. The water table in the dry season ranges from 2 to 5 meters below the soil surface.

The present study is concerned with the contiguous polders that are located within the study area, the Konodimini, Ngara, and Tamani polders. These three polders and the Farako polder across the river together form the Zone de Tamani of Opération Riz/Ségu. Opération Riz/Ségu is an organization created by the Malian Government in 1972 to reorganize and promote rice production along the Niger and Bani Rivers. It offers an integrated rural development

package emphasizing rice production but investing in "Community Development" programs such as family gardening, adult literacy, and well-baby clinics.

Until the 1950s the polder area was mostly forested and a large area north of the village of Ngara was a national forest reserve. In the 1950s all of the trees in the inundatable areas of the polders were removed, dikes were constructed, and floodgates installed (CCCRAPA 1954). Increasingly, hydromorphic and flooded soils along and in the polders are being cleared and planted in mangos. They are increasingly being used for the cultivation of manioc as well. Manioc is grown in small enclosures and its cycle is one year from planting to harvesting. Prior to 1973, manioc had been grown on loose sandy soils which permit the tuber to grow quickly and attain large dimensions in a short period of time. Manioc can no longer be grown on sandy soil because of drought - the average annual rainfall of the 1970s and 1980s was 200 mm less than that of the previous 30 years. The presence of hydromorphic soil is important in terms of drought response because the available moisture in the hydromorphic soils permits a crop to be grown under the present rainfall conditions.

The Polder Zone has several characteristics that are relevant to drought and drought impacts, the most important of which is water and water control devices (floodgates, canals, and dikes. The engineering of the Polder Zone was intended to control water to ensure good harvests of rice.

Despite this fact, the areas of the Polder Zone highest in elevation, the western third and central littoral have become vulnerable to drought due to low floods since the early 1970s. The Casier of Tamini, the highest area, was closed in 1983 and made into a water holding basin and flow regulator for the eastern Casiers of Ngara and Konodimini. Approximately 300 hectares along the southern border of the Casiers of Konodimini and Ngara have been diked off because of continually poor flooding and are no longer cultivated. Opération Riz is increasingly permitting farmers to plant rainfed crops in the closed areas. Despite the risk of drought, rice fields are highly prized in the study area due principally to their high returns and remain an important source of income.

The Middle Valley Zone

The area of the Middle Valley Zone is approximately 160 km^2. It is a valley terrace located at a higher elevation than the Polder Zone. Soil units in this zone (see Table 3.2) are composed of plains of loamy soils, plains of silty and loamy soils, and flooded soils along the rice polders and intermittent streams. Sandy soils are found in limited parts of the zone. There are no ferruginous hardpans. The water table ranges from 3 to 18 meters. This zone is used primarily for agriculture and the vegetation is primarily anthropic.

The plains of loamy soils and plains of silty and loamy soils are the most important units for agricultural production in the study area. They have been carefully managed by the farming communities in the zone to protect crops from moisture loss. They support an anthropic vegetation of Vitellaria paradoxa, an important women's cash crop and source of familial cooking oil and soap, and Acacia albida, a useful leguminous fodder tree (Charreau and Vidal 1965). Vitellaria paradoxa is found in an outer ring and Acacia albida is found in an inner ring around a village (see Figure 3.13 below). Other useful trees found are Adansonia digitata and Ficus spp. Trees and live fences (relatively rare today), form a protective envelope around crops that slows desiccating winds and reduces temperature maxima and minima. Fallows are a jumble of colonizing species[8]. Land units near the polders, intermittent streams, or low spots are increasingly being planted in mangos. The replacement of traditional anthropic tree species such as Acacia albida and Vitellaria paradoxa by mangos has proceeded to such an extent around the village of Ngara, for example, that one-half of the area around the village has been converted to mango production. Land use around a typical Bamana village is illustrated in the

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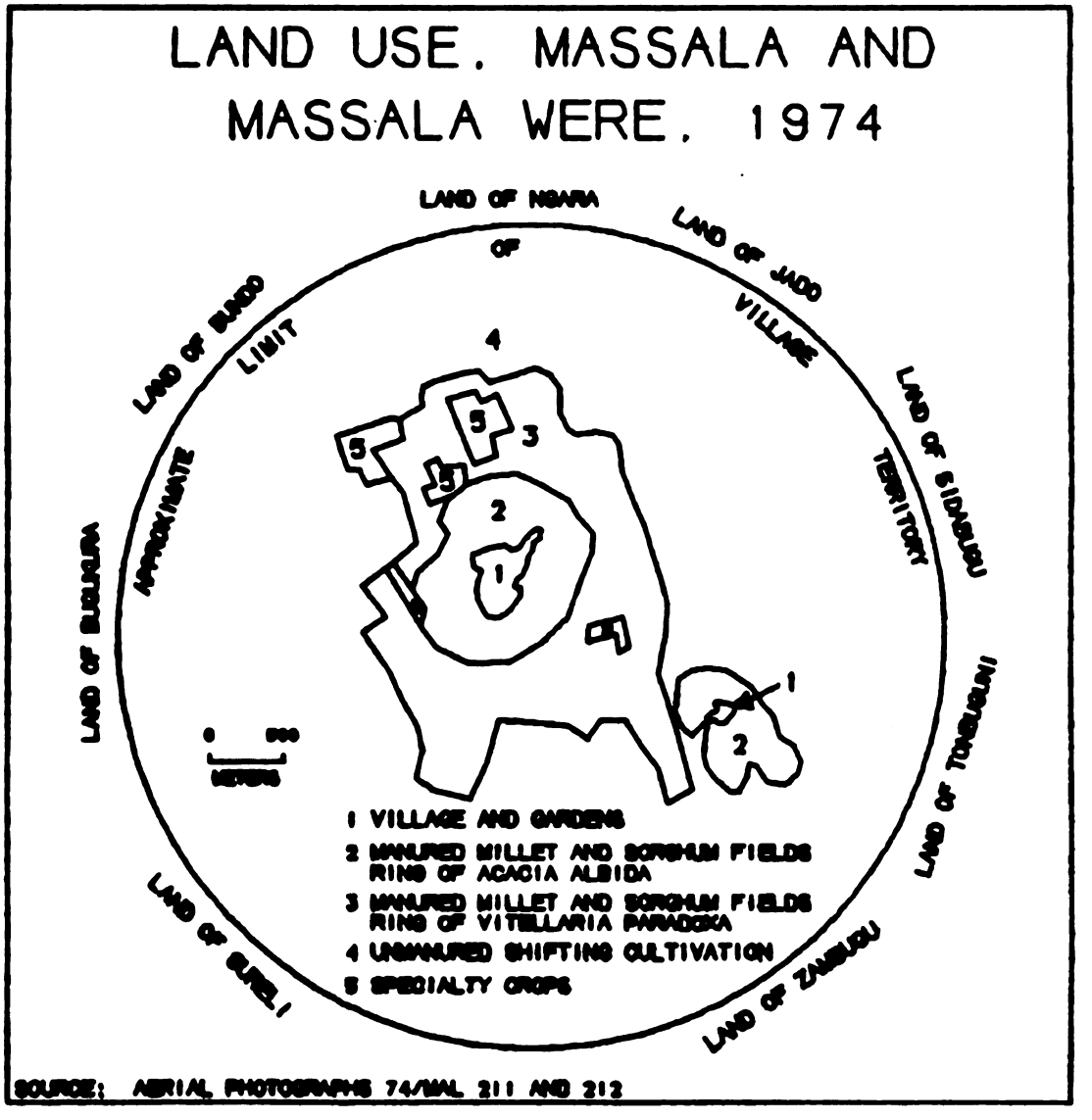
[8] Cissé and Hiernaux (1984) provide a detailed discussion of species establishment and succession for a period of fifty years in an area northeast of the study zone.

following figure taken from vertical aerial photographs from a mission in 1974.

Figure 3.13. Land use, Massala and Massala Wéré, 1974.



Two villages are depicted in the figure, Massala, a Bamana village, and Massala Wéré, a village of captives who herd livestock for the Bamana in Massala. The pattern of land use is annular around the villages, the rings of Acacia albida and Vieillaria paradoxa are clear, although there is a visible influence of local roads on the development of the villages.

The Middle Valley Zone has several characteristics that have relevance to the discussion of drought and drought impacts. The most important characteristic is moisture availability in seasonally inundated streams or along the rice polders. The availability of moisture is less than in the River Zone and more than in the Outer Valley Zone. These areas of relatively high moisture availability are used to cultivate specialty crops for the market such as manioc, sweet potatoes, mangos, and vegetables. Although the water table is much lower than in the River Zone, it is sufficiently near the surface to support a relatively dense tree population. Some of the products of the trees are used in artisanal production and some trees have a beneficial effect on the soil. As the Middle Valley has the best soils in the study area, the trees are an added advantage against drought in comparison to the less well-wooded Outer Valley Zone.

The Outer Valley Zone

This zone is approximately 155 km². It is located on a river terrace higher than that of the Middle Valley Zone. This zone, like the Middle Valley Zone, is used primarily for agriculture and the vegetation is primarily anthropic. Three differences distinguish it from the Middle Valley:

1. It is underlain by laterite. Hardpans are sometimes as thick as six meters and outcrops are common in the south of the zone.
2. The water table ranges from 30 to 40 meters in depth. Wells extend to or into bedrock.
3. Sandy soil and sand dunes are found throughout the zone.
4. Cultivation is less continuous than in the Middle Valley Zone, perhaps due to the higher densities of farmers along the polders.
5. Vegetation is less dense. The high depth to water table in the Outer Valley Zone causes lower densities and smaller trees. In addition, rooting depth, although varying from place to place, is limited by the laterite hardpan.

Two of the principal soil units in the Outer Valley are relatively shallow and are underlain by laterite (see Table 3.2). These soils are gently sloping to sloping and are often gravelly or stony in texture. Dominant tree species are Combretum glutinosum, Bombax costatum, and others. On

sandy soils, the dominant tree species is Acacia albida in open stands. Cultivation of land underlain by laterite is done on lower, gentler slopes. Principal crops are sorghum and millet. Sandy soils are almost entirely cultivated. Typical crops are millets, sorghums, groundnuts, and, most recently, watermelon. Occasionally, manioc is planted in low areas where the clay content is higher. However, the practice of planting manioc on sandy soil, once common, has almost died out because of the lack of rainfall since the early 1970s. Ordinarily, manioc prefers a sandy soil, however, since the drought, farmers plant on hydromorphic soils in low areas where runoff has contributed to the soil moisture or near inundated areas. where soil moisture is generally higher. When it is grown in hydromorphic soil, manioc does not attain the same thickness that it attains when grown in sand.

Compared to the other ecozones, the Outer Valley is the least productive agriculturally. Its soils are the poorest in the study area; however, farmers in the Outer Valley have adapted their agricultural practices and other economic activities to the ecological constraints of the Outer Valley. Drought-tolerant millet is cultivated on the vast sand dunes found in the Outer Valley. Watermelon, the most lucrative cash crop in the Outer Valley, is also grown on the sand dunes. Watermelon is a recent introduction and many farmers were experimenting with it throughout the study area when the fieldwork for the present study took place in

1985. An advantage that the Outer Valley has over the other two zones is the presence of vast areas of bush; these areas provide browse and grazing for livestock. There are also two forest reserves, rich in grazing and browse, south of the study area to which the Outer Valley Zone has the best access. A major limitation of the Outer Valley is the low water table and absence of inundated areas where specialty crops could be grown. The proximity of the Outer Valley to the Bamako-Ségu highway is important for the roadside sale of produce and for seasonal migration.

Each of the ecozones discussed in this chapter possess characteristics important to drought response. The people who live in each of these ecozones have developed strategies to cope with drought that are based on the unique characteristics of the environment around them. In the River zone, water is more abundant and more intensively used than in the other two zones but land is limited. Transportation is more readily available and an almost drought-proof resource is available - fish. In the Middle Valley, water is less available than in the River Zone but fertile land is abundant. Agriculture is the most important activity in the Middle Zone. The Outer Valley is the most disadvantaged ecological zone in the study area: not only is water relatively more scarce than in the other two zones but the land is poorer. However, the people of the Outer Valley engage in a wide range of economic activities and have adopted a mix of food and cash crops that grow well in

the limited conditions of their environment. The important relationship between location and the adoption of drought-coping strategies in the study area is treated more extensively in Chapter Five.

Cultural Characteristics of the Study Area

The study area is occupied by four groups of different ethnic origin but only distinctive ethnic groups: the Bamana farmers, Peul herders, Somono fishers, and the Bamanized Marka. Historically, these ethnic groups had a similar tripartite social structure composed of a nobility, castes, and captives. This structure has been altered in most ethnic groups by the virtual elimination of captive labor at the turn of the century. The size and locations of the ethnic groups, the villages in which they live, and their principal economic activities differ considerably. Table 3.3 below illustrates the average population per village in 1976 and 1985 for Mali, the Ségu Region, the arrondissements of Ségu and Barwélé, and the study area for the Somono, Bamana, and Peul ethnicities. There are no figures for the fourth group, the Marka because in only two villages in the study area do they form a majority. The figures for 1985 are derived from the 1976 figures using a 2.7 percent growth rate (Horn 1983). The formula to calculate a future population from a known year is as follows:

$$P_t = P_0(1 + r)^t$$

Where,

P_t = the population in 1985.

P_0 = the population in 1976.

r = the growth rate.

t = the number of years between 1976 and 1985.

This method of population projection is called the Geometric method and is used where the population growth rate is known but observations of actual population are confined to one year (see Shrivastava 1980 for an elaboration of methods of population projection). It should be mentioned that population projections are estimates and are influenced by births, deaths, and migration rates. Formal studies in demography control for births, deaths, and migration. A formal demographic study goes beyond the scope of the present research.

Table 3.3. Average village size, 1976, 1985: Mali, Ségu Région, Ségu Arondissement, Barwélé Arondissement, Somono, Bamana, and Peul.

Unit	Average Village Size	
	1976	1985
Mali	524	683
Ségu Region	443	578
Ségu Arrondissement	481	628
Barwélé Arrondissement	442	577
Somono (study area)	1300	1697
Bamana (study area)	930	1214
Peul (study area)	394	514

SOURCE: Government of Mali (1976).

The population distribution in the study area was greatly influenced by three events.

1. The rise of the Ségu warrior state in the seventeenth century.
2. The Umarian conquest of Ségu in 1861.
3. The French conquest of Ségu in 1892.

The expansion of Ségovian hegemony from the seventeenth to mid-nineteenth centuries added to the Somono and Peul groups by the creation of technical fishers and herders from captives of the state and increased the accumulation of agricultural captive labor in the study area. A technical

fisher or herder is one who does not belong to the ethnic group ordinarily associated with that activity. For example, the Peul are associated with herding. A Mossi war captive can learn the technique of herding (which many did) but never acquire the ethnic status of Peul.

The period of the Bamana empire was one of economic expansion and regional integration. The Umarian conquest, on the other hand, brought instability and economic contraction as the Umarians sought control of regional economic linkages by dislocating and destroying them. Many villages in the study area were destroyed during this period while other villages relocated on the northern side of the Niger River which remained under the control of the Bamana royalty until the French defeated the Umarians at Ségu in the 1890s. The French conquest brought social and technical change that transformed production and created wider regional linkages, markets, and international integration (Roberts 1980b). The French forcibly settled armies of combatants and encouraged the foundation and uniform distribution of settlements across the land to increase the use of the land. In many cases these new settlements were formed from liberated captive laborers (Leynaud and Cissé 1978). These events will be discussed in more detail below.

The Somono

The Somono are a group of Muslim, Bamanakan-speaking fishers and traders who live along the Niger River and Niger Inland Delta. Ndiaye (1970b) considers them to be a multi-ethnic fishing caste of the Bamana. Pageard (1960) described the Somono as an independent ethnic group. Gallais (1958) characterized the Somono simply as semisedentarized agropisiculturalists. A recent study (Jeay 1980) defined the Somono as neither a unique ethnic group nor a homogeneous social group. The issue is still unclear. According to field work done in 1985, it was found that Somono ethnic origin varied from one village to another. In Somonoduguni, for example, most respondents were of the Somono Kané, and Jiré clans, known as typical Somono clans. Fassongo and Minyon, in contrast, were characterized by Marka (Soninké) surnames (Nyaré, Sogoré). Bamana surnames were rare. The Somono with Marka surnames maintained that their ancestors came from the Gana Empire, which was located in the northern Sahel and existed from the seventh to eleventh centuries. Local people maintain that the original Somono are the Kané and Jiré clans and that those with Marka surnames came at a much later date. The officials at Opération Riz have adopted a flexible definition of the Somono: anyone who fishes as a major economic activity.

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Somono social structure is an example of the dynamics of inter-group relations in cultural development. Somono social structure has been influenced by impositions made upon the Somono by other groups. There are three classes to the Somono social structure, the free-born nobles (horon), captive laborers (forobajon), and house slaves (woloso). These groups are discussed below.

During the sixteenth century when the Ségu region was ruled by the Soninké (Marka) "...members of some Marka families became full-time fishers and were given exclusive use of certain parts of the Niger River by the Marka rulers" (Jeay 1980; 8). These people and their descendants are considered the true Somonos. This group forms the highest Somono social class, the free-born nobles (horon). This corresponds to the Bamana class of the same name.

The second class of the Somono social structure is composed of captive laborers. This class was created by the Ségu kings and notables (famaw) and arose in the following manner. Starting at an early period of the Ségu Bamana warrior state, the Somonos were given captives by the crown who were to become fishers. These "technical fishers" were treated as free persons. Most of the captives had Bamana surnames. Today they are considered as free Somono; however, they do not have the prestige of the original Somono families. The third class of the Somono social structure is that of the house slaves (woloso). The word woloso in Bamanakan means born in the master's house. These

people are descendants of slaves bought in the market (sanionw or jonfin). The house slaves are still tightly linked to their Somono masters today and are still considered part of the masters' household. The fourth class of the Somono hierarchy is composed of descendants of captives who adopted fishing as principal occupation after the abolition of slavery. A fifth fishing group exists according to Jeay, however, its members do not consider themselves Somono. They are, in fact, Bamana who have abandoned farming and adopted fishing because of its relatively high economic returns.

The Somono social structure is similar and yet different from the Bamana, Marka, and Peul structures in that there are no artisanal castes at all. The Somono go to blacksmiths in market towns, for example, or Bamana blacksmiths are called from one of the Bamana villages on the south side of the rice polders. Leatherworkers and potters are also absent from Somono villages.

In the study area, the Somono live in six villages along the Niger, Somonoduguni, Bundo Somono, Cékorola, Fassongo, and Minyon. The average village size is 1018 persons. If Bundo Somono is excluded (population 177) the average village size jumps to 1300 persons. These villages are enormous compared to the Bamana and especially the Peul villages. The Somono are (as are the Peul) "guests" of the Bamana. As guests they must petition the Bamana dugukolotigiw when new land is needed for farm field

expansion, for example. The dugukolotigi (plural dugukolotigiw) is the oldest living descendant of the man who first founded an agricultural community. This person is generally the mayor of the village. It is this clan of this person that has the power to allocate usufruct rights to expanding (or fissioning) families or newcomers.

Most Somono farm as well as fish. Many trade or transport goods and people. The Somono fish in the dry season (when the density of fish per unit of water is highest) and farm in the wet season. They grow primarily millet, sorghum, and maize as food crops and onions, tobacco, tomatoes, mangos and rice for cash.

During the 18th century Mamari Kulibali founded the Bamana warrior state of Ségu. The Somono became allies of the Ségu state. They paid taxes of dried fish and in return were given a monopoly on fishing and transportation (Roberts 1981, Ward 1976). According to Park (1971), the Somono played an essential role in the expansion of the empire in the areas of transportation and warfare. They were as feared in battle as the Ségovians.

Observations made during the early colonial period indicate that the Somono were relatively more prosperous than their Bamana neighbors who only practiced agriculture. In the French census of 1895 villages were classed into one of four ranks based upon their "wealth". Class one was "poor" and class four was "rich". Ward observes that:

> ...even in the central Ségu region only the Somono and a few villages could be included in the last category. Everyone else appeared to fall in the first category because of the economic condition of the region after decades of warfare (Ward 1976; 260).

Rouch (1950) found that fishing groups "...benefitted greatly from the peace imposed by the Europeans. Before their arrival the fishers "...practically never left certain strictly defined fishing zones" (Rouch 1950; 10). The colonial peace enabled them to expand their activities beyond the limits to trade and transportation imposed by the Umarians after their capture of the Ségu region in 1861 (see below). Pageard noted in 1960 that "...the richest families are increasingly turning to commercial activities such as transportation, and north-south exchanges of kola and dried fish" (Pageard 1960; 18). Ndiaye (1970b) termed the Somono fishers of necessity rather than of choice and that they prefer to mix fishing with other, more remunerative, activities.

The Somono were, as were other trading groups in West Africa, early converts to Islam. The relationship between the Somono and the animist Bamana state must have been discordant at times; however, the alliance between the Somono and the Bamana was lasting. After the Umarian conquest of Ségu, the Somono remained uncooperative with the new administration; consequently, entire villages of Somono

were displaced and cooperative Bozo (Sorko) fishers from the Niger Inland Delta were settled in their place.

The Somono are an important and distinct ethnic group in central Mali and in the study area. The Somono practice a wide range of economic activities in the River Zone and along the Niger River that are important to their ability to cope with drought-induced stress: fishing, trade, transportation, agriculture, labor migration, and a limited amount of animal husbandry. It is the particular mix of activities that the Somono have developed over time in the River Zone location and the relatively greater abundance of water compared to the other zones, that make the Somono different from the other ethnic groups examined in the present study. Fishing is an economic activity with a high return that is practically drought proof: only when the breeding areas in the floodplains of the Niger River dry up, an unlikely event, will fishing become risky. Unlike the agriculture practiced by the other ethnic groups in the study area, Somono agriculture is almost entirely oriented toward cash crops. Although some food crops are grown, most of the limited area in the River Zone is devoted to such high value crops as mangos, rice, watermelon (on sandy islands), and garden vegetables. Somono farmers use the same strategies as all farmers in the risky Sudano-Sahelian climate: spatial dispersal of plots, quick-growing varieties, and use of as many farming "niches" as possible in order to anticipate the wide range of conceivable

moisture conditions in a given year. In addition, the Somono have a unique migration response to stress that is different from the other ethnic groups in the study area: the young Somono men migrate seasonally to fish in (in order of preference) the Ivory Coast, Ghana, or along the Atlantic coast.

The Bamana

The Bamana are a group of sedentary farmers who live in south central Mali. The Bamana population, at two million persons, is the largest in Mali. The traditional Bamana heartland forms a triangle centered upon the Niger and Bani watersheds from the Ivory Coast to the Niger Inland Delta. It is composed of three major regions: Ségu, Bélédugu, and Baniko. The seat of power for the precolonial Bamana warrior state was the city of Ségu (Bazin 1974, Roberts 1980c). The Ségu Bamana warrior state arose out of an alliance between members of a youth organization (ton) and slaves. Biton Kulibali organized the youth group and slaves as a military force in rebellion against the gerontocratic rule. As a joint effort between noble and slave, the distinctions between slave and noble blurred and all came to be called slave of the association (tonjon). Soldiers of slave origin became kingmakers. The warrior state survived by pillage and the capture of new youths who were sold or incorporated into the army. During the expansion of the Ségu empire, villages that submitted to the advancing armies

were not harmed. Every village family was required to pay a yearly tax and punitive expeditions were sent against villages that refused to pay or were late in paying their taxes.

Traditional Bamana social organization is a hierarchical structure composed of three groups, nobility, castes, and slaves. (Grayzel 1977, Monteil 1924, Ndiaye 1970a 1970b, Sidibé 1959). Political responsibility, however, in Bamana society in precolonial times as well as today:

> ...centers on the traditional village chief. This position is usually held by the oldest male of the oldest generation of the family that originally cleared the land. The authority of his family stems from the fact that from them later families obtained their right to settle and use the land. In reality, the actual power of, and respect for, any particular village chief depends as much on his own personality as on his family's status. Likewise, the actual status of the family is determined not only by their historic position, but also by their present wealth and influence, which for the Bamana usually is equitable with the number of male workers the household can mobilize (Grayzel 1977; 50).

The three groups that comprise the Bamana social structure are interdependent and theoretically discrete, however, Gallais (1962) found that individuals of servile ancestry changed their ethnic affiliation under the anonymity of the town.

1. The nobility (horon). The nobility is composed of free people of both noble and non-noble birth. The word horon is from the Arabic hurr (plural, ahraar), noble, free born. The nobility must adhere to a normative code of conduct which is centered upon honesty, courageous acts, and hard work.

2. The castes (nyamakala). This group is composed principally of artisans and trades-people. Typical trades are ironworking, leather working, and carpentry. Praise-singers (jéli) and oral historians are nyamakala. The nyamakala, especially the blacksmiths, played an important role in the pre-Islamic agrarian religion. Rite of passage ceremonies from age-set to age-set are done by the blacksmiths. They play a pivotal role in secret societies, notably the komo.

3. The slaves (jon). The use of captive labor was a common and necessary part of village life in the precolonial Bamana state. There were three classes of slaves: house servants (woloso), field hands (forobaion), and exchangeable goods (jonfin or sanjon). Slaves were a necessary part of production because of the risks inherent in agriculture in the semiarid environment (Grayzel 1977).

In the study area the heaviest concentrations of Bamana are found in the Middle Valley Zone along the southern edge of the Polder Zone. Bamana grow millet, sorghum, maize, and fonio (Digitaria exilis) as food crops. Beans (Dolichos unguiculatus) and squash are intercropped with millet,

sorghum, and maize. Fonio is monocropped. Rice, peanuts, chickpeas (Voandza subterranea), manioc, sweet potatoes, and mangos are grown as cash crops. Other crops grown are hemp, henna, and vegetable gardens of okra, tomatoes, and nkoyo (Lycopersicum esculentum var. cerasiforme).

The response of the Bamana today to drought-induced stress revolves around the accumulation of agricultural surpluses, assets gained by cash crop cultivation, and assets purchased from returns to seasonal labor migration. By and large, the most important goal for the Bamana family, unlike the Somono and Peul, is the accumulation of a large cereal surplus. Livestock, although relatively new to the Bamana, are used as an investment for income gained from a variety of sources. Taxes are paid with livestock and, during drought years when crop yields are low, livestock are sold to purchase cereals. The Bamana may be considered more vulnerable to drought than the Somono or Peul because the annual return on the resource on which the Bamana depend, rainfed cereals, is so variable. The Somono, in contrast, have relatively drought-proof economic activities, for example, fishing. The Peul, much less involved in agriculture than the Bamana, have livestock as their principal asset which can be moved away from drought stricken areas.

The Marka

The Marka (Soninké) is an ethnic group originating, like the Peul, outside the study area. Their principal occupation is farming. The Marka in the study area form two groups. The first group is composed of Bamanized Marka and the second is composed of soldiers of the army of El-Hajj 'Umar Tal or their descendants. The former group have lived in the study area for centuries. The latter group is from Kaarta in eastern Mali or Futa Toro in the Sénégal River valley. This group was settled by the French when hostilities were ended in the 1890s between the French and the Umarians (then in control of Ségu).

The social structure of both groups is the same as the other groups, tripartite. It is most similar to the Bamana structure because of the presence of castes. The above discussion of the Bamana ethnic group can be equally applied to the Marka. Marka populations are greatest in the western sides of the Middle and Outer Valley zones. The strengths and vulnerabilities to drought of the Marka are the same as those for the Bamana.

The Peul

The Peul traditionally are pastoralists or semisettled agropastoralists (Brasseur 1978). In the study area most Peul are sedentary. Some of them are descendants of Peul persons captured in the wars between Ségu and Massina while others are technical Peul. This latter class of persons,

created in the same manner as the Somono captive laborers (forobaionw), were used to herd animals for the Ségovians and other Bamana. They are called Forobafla. Two other small groups of more recently-settled Peul are found in the study area: Muslims from Macina who fought against the Umarians (Peul de Modi), and non-Muslims who fought the Umarians (Peul de Kéléké). All three groups were settled by the French after the cessation of hostilities in 1898. None of the Peul speak Fulfulde or Pulaar. These languages have been forgotten and only Bamanakan is spoken today.

Peul villages are generally attached to a Bamana village and the name of the Peul village reflects this attachment. For example Bundo Wéré is the village of Forobafla for the Bamana village of Bundo, Tonzugu Wéré is the Peul village attached to Tonzugu (but Fassongo Wéré is the Peul village attached to the Somono village of Fassongo).

The Peul herd cattle, sheep, and goats. Cattle are the animals of preference but in recent times many Peul have chosen to herd sheep and especially goats because of their fast reproduction, mobility, and easy convertibility into cash. The goat is a favorite animal because of its drought resistance. Stenning characterizes the farming and herding system of the Peul as:

> ...a dual mode of subsistence in which farming and stock-raising at once complement and circumscribe each other. Farms are made according to local

> practices of shifting cultivation [but are] smaller than those held by the sedentary population, and planted with grain crops instead of cash crops or local market crops. At the same time, herds are likely to be smaller than those [of] pastoral Fulani and...to be moved in a restricted cycle of transhumance (Stenning 1959; 6-7).

Peul villages in the study area are found on both sides of the rice polders, although their highest concentration is in the Middle Valley zone (Brasseur 1968). The principal grazing zones are along the river and in the rice polders (dry season), in fallows and in uncultivated areas (wet and dry seasons), and in the forest reserves (forêts classées) that are located on the plinthic uplands to the south of the study area (wet and dry seasons).

Peul society has a hierarchical structure similar to Bamana social organization (Bathily 1936, Ndiaye 1970a, Ware 1979).

1. Noble cattle herders. This group is characterized by their individualism, independence of work units, leisure class mentality, and disdain for manual and communal labor (Gallais 1969). Herding is the preferred profession (Hickey 1975). Grayzel (1977; 216) characterizes them as a "proto-capitalist 'bourgeois' class" (see Balikci 1981), and Sarr (1976) and Azarya (1976) describe their social structure as feudal. The characterization of the Peul as proto-capitalist perhaps arises more from the nature of the reproduction of livestock and captives and the relationship

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of the Peul to this reproduction than from anything intrinsic to the Peul character itself. Wealth for the Peul is measured in livestock and captives. Livestock and captive labor are a form of reproducible capital as well as a means of production. In reproducing themselves both livestock and captive labor produce a surplus that the Peul may harvest because he owns them. The captives owned by the Peul were settled in agricultural villages and lived in quasi-serfdom. The captives had (and still have in some cases) annual group and individual duties to perform for their masters. It is for these two reasons that the terms "proto-capitalist" and "feudal" have been associated with the Peul.

2. The second group is composed of castes. This group is similar to the Bamana castes with the exception of the weaving castes. The Peul have a separate caste to do weaving (the maabo) while the Bamana do their own weaving.

3. The slaves. There are, in general, two types of captive labor: the house slave (maccudo) and the agricultural slaves (rimaiibe). The agricultural slaves are war captives or descendants of captives settled in hamlets. Their function is to provide home bases for the migratory Peul and linkages with the southern Sahel and Sudan. In the study area there are no rimaiibe. This is because the Peul are themselves captives or newcomers there. They have no sociospatial polity outside of the village administration. There are no Peul patriarchs that are village founders

(dugukolotigiw). The land in the study area belongs to the Bamana, and the Peul, as "guests" (dunaw), have no rights in it. If a Peul needs new land to cultivate he must ask the chief of the Bamana village to which his village is attached. Political responsibility for the Peul rests with the village leader. Choice of village or hamlet leader is dependent upon age, family prestige, personal reputation, wealth, and length of residence in the community (Grayzel 1977, Stenning 1959).

The Peul have probably the most drought-resistant economy of all the groups present in the study area. This is because of the large livestock holdings typical of the Peul. Livestock possess a high value, they are reproducing capital, and they are mobile - they can be evacuated from drought stricken areas. The Peul drought response reflects Peul culture in that it revolves around livestock (livestock sales, loans, migration). Agriculture, however, is an activity that the Peul have increasingly adopted since settlement in the study area, gaining greater control over subsistence; in the purely pastoral arrangement - the Peul ideal - animal products are exchanged for cereals.

It is important to understand cultural factors in interpreting response to drought. It has been made evident in this chapter that the different ethnic groups in the study area possess unique characteristics developed through tradition that are reflected in the way in which each group responds to drought. The response of the Somono is centered

on activities related to the Niger River: fishing, transportation, and trade. The response of the Bamana focuses on the production of large agricultural surpluses. The response of the Peul revolves around livestock. Although many changes have taken place from the precolonial period and "traditional" activities are blurring as diverse opportunities arise, it can be maintained that ethnicity is an important variable that influences the choice of drought coping strategies today.

Contexts for Drought Response from the Precolonial Period to the Early 1980s

The section below presents the regional historical background on the political, economic, social, and environmental contexts of social organization, agricultural production, and drought response from the seventeenth century to the present. The objective of this section was to examine the political, economic, social, and environmental impacts on the ability of people to respond to drought. Much of the Marxist literature on response to drought has treated the precolonial period in a culture's history as a period in which a "moral economy" predominated. People who support the moral economy hypothesis for Africa hold that under the precolonial "moral economy", people were less vulnerable to the effects of drought because they avoided risk, helped each other, and had a government that

came to their assistance when famine threatened (Scott 1976, Watts 1983a). The moral economy argument was first presented for precolonial Vietnam (Scott 1975) and extended to Africa (Watts 1979, 1983a). In the moral economy hypothesis, the colonial economy is held to have increased the vulnerability of people to the effects of drought. People who do not support the moral economy hypothesis for Africa (Cole 1989a, Skinner 1978) hold that the modern economy may provide alternative opportunities for adaptation which may be more diverse than the choices available during the precolonial period. One of the objectives of the present study was to investigate these claims in the Mali context.

In the first section the three foundations of the social organization of production, the extended family, the age-set, and captive labor are discussed (de Ganay 1956, Monteil 1924). After the discussion of the foundations of production, the precolonial political context for drought response is presented along with a discussion of drought-coping strategies. The French conquest and impact on the region and study area are then presented as well as drought-coping strategies of the colonial and post-colonial periods.

Human Organization

There were three social foundations on which production in the precolonial period was established.

1. The extended family.
2. Age-sets.
3. The use of captive (slave) labor.

The first two foundations, the extended family and age-sets, are very strong institutions today and still form the basis of production. Captive labor, however, has been replaced by technical improvements, specifically the plow.

The Extended Family

The extended family as the basic unit of production and consumption was the most important institution in precolonial and postcolonial society. The local economy was centered upon the extended family as the unit of management, production and consumption. The extended family during the precolonial period was a grouping of individual households related by blood, nonrelated dependents, slaves of each household, and slaves of the entire extended family. Today, the extended family has lost its captive labor. All ethnic groups in the study area had the same patriarchical extended family structure. The extended family was headed by a patriarch, or fa, who controlled the familial resources, the reproduction of the unmarried youths (by controlling bridewealth and ultimately marriage altogether), the familial shrine, and formal relations with nonfamily individuals or groups and the community. The elder members of a family or clan formed a familial council for the direction of intrafamilial affairs. This involved the

organization of work on communal fields (foroba), organization of food preparation in order to share the workload between the households of the extended family, the allocation of resources during times of scarcity, and judiciary action at the familial level. The prosperity of the family and its continued reproduction and existence were the overriding goal of the family elders. A strong patriarch could dominate the other elders; otherwise, the family council prevailed. The patriarch-council organization was a system with checks and balances designed for long-term familial management. The patriarch was a manager who had to be aware of the range of variables affecting his family, the farm, and opportunities and constraints at the local and regional levels. Most importantly, perhaps, the patriarch controlled the fissioning process by which an extended family breaks into smaller, nuclear families, each with its own foroba (Grayzel 1976).

The extended family had usufruct rights to as much land as its members could farm (Coadon Le Brozec 1983). Individuals could possess private plots for nuclear family or individual use. These fields, called jonforow (slave fields) were used during the precolonial period to shift some of the burden of slave subsistence from the master to the slave. The slave was permitted to work on his own fields at night or on Friday providing work on the collective fields was completed (Monteil 1924). It is for

this reason that privately-worked plots were sometimes referred to as sufèforow (night-fields). The word jonforo today means private property of any sort and as such may be considered as inimical to the familial collective enterprise. Excessive cultivation of private plots is considered by many Bamana today to be detrimental to the cohesion of the extended family. Farmers feel that too much individual initiative poses a threat to the survival of the extended family, however there was (and is) a rationale for the existence of private plots that goes beyond selfishness. The extended family provides only a modest standard of living for the extended family members from the familial collective resources (foroba). It did not, and does not today, have to provide for all of the needs of its members. It is in the attempt to provide more than the familial minimum that the private plots should probably be conceived.

The extended family formed (and still forms) the basic unit for drought response in the study area. It was organized in the same way as a firm is today: a head or group of elder family members make management decisions relating to production and consumption, and, during periods of drought and scarcity decisions are made and strategies undertaken to maintain production and income in some form in order to assure consumption levels. The extended family is the last structure of mutual aid and support to dissolve when drought becomes deadly famine.

The Age-set

The second foundation of production was the age-set. The function of the age-set (which is found, incidentally, throughout Africa) was to aid in the internalization by young men and women of behaviors important to the survival of the family and community: respect for elders, mutual aid, hard work, the value of agriculture, and initiation into the local cult (De Ganay 1956, Lewis 1978). Age-sets formed a hierarchy of discrete classes that provided the skills necessary for productive membership in society; from adolescence to adulthood to old age (which is the highest and most respected age-set). The first object of this education was to create physically capable and ecologically knowledgeable workers to constitute the bulk of the labor in this labor-scarce society. During the pre-Islamic period, important religious ceremonies were associated with each stage in the annual crop cycle and each stage in the life cycle of age-sets (ton). Today, the pre-Islamic agrarian religion is no longer practiced and the practical nature of the age-sets seems more apparent than it might have seemed when it was imbued with ritual. The ton was the mutual aid organization par excellence. For example, with respect to agriculture the ton had certain responsibilities to the village, although this varied from village to village. The men's ton was responsible for the threshing of the harvest for everyone in the village. In practice, the members of the active ton who engaged in the communal harvest were men

aged from 14 to 45 years. The women's ton did the winnowing at the threshing site. The ton harvested the fields of poor families gratis in order to assist the less fortunate and they harvested the fields of rich families in order to make money.

While the age-set association (ton) was the essential extra-familial building block of society it also posed a potential threat to the authority of the patriarchy (Monteil 1924, Roberts 1980d). The eighteenth century ton leader (tontigi), Mamari Kulibali, for example, allied slaves and noble youths in a militaristic ton and created the Ségu warrior state that subsequently subjugated the Bamana gerontocracies. This warrior state survived until the Umarian conquest of Ségu in 1861. Slaves and nobles alike became tonjonw, slaves of the association, and they lived by pillage during the dry season and by farming during the wet season. Roberts (1980d) states that many were averse to agricultural work. Many youths abandoned their families and travelled to Ségu to join the association while others were forced to join. The tonjonw were the major force that enabled Ségu to extend its political hegemony as far as Timbuktu. They established villages or settled in existing villages in all regions.

The elders in a village and their families constituted an integrated religious community aimed at the day to day functioning of the community and its survival during periods of instability and stress. There were three institutional

levels of organization that facilitate community functioning and survival. At the lowest level, the young unmarried men and slaves provided labor for the production of crops and other manual labor. The second level, the extended family, the lowest-level managerial unit, controlled the labor of the youths and slaves (precolonial). The third level was that of the village which controlled the family or clan units. There were administrative, judiciary, and religious decisions to be made at this level that affected the well-being of the entire community. Not one of these levels could have existed without the others. Together they formed an authoritarian but viable unit of interdependencies.

1. The young men were dependent upon the elders for food, wives, knowledge, direction, and religious or secular sanction.
2. The family or clan was dependent upon the young men for labor.
3. The family or clan elders were dependent upon the community for protection, administration and judiciary activities, the functioning and allocation of village aid societies (composed of young men and directed by the elders), the village level coordination of herding and farming throughout the year to minimize crop damage by animals, and the collection of taxes and fines.

The age-set system was (and still is) a super-familial organizational framework for West African society. Although the age-sets have had and now have many different functions, one function is of particular importance to the present study, mutual aid. The age-sets combined together in what is called a ton (association) to form a village-level mutual aid society that, for example, helped village members harvest their crops and people undergoing difficult times. The members of the age-sets most often pooled their labor power to assist others but sometimes they combined to make money, usually spent on entertainment for the village. The role of the age-sets during drought was to ensure the food security of the most vulnerable members of the community. During the precolonial period members of the ton of one village transferred their own drought vulnerability and that of their village to others by raiding other villages and selling captured booty and slaves. This dry-season economic activity has been replaced by seasonal labor migration.

The Use of Captive Labor

The third foundation of the precolonial production system was the use of captive labor. Captive labor was indispensable to the survival of the family unit. Roberts (1980c) and Bazin (1974) have argued that enslavement was a productive activity essential to the existence of the Ségu Bamana state. Slavery provided the labor necessary to assure the continued existence of the Bamana clans in the

sometimes hostile Sudano-Sahelian climate (Grayzel 1977, Klein and Lovejoy 1979). Bamana farming was subject to chronic and seasonally acute labor shortages and the use of captive labor was an adaptation to this reality. Slaves were a very highly valued form of self-reproducing capital whose value derived from the present and potential labor inherent in each slave (see Lovejoy and Hogendorn 1979). Boutillier (1968) observed that:

> Land was not generally a scarce good and was not the object of transactions. It was the captive, however, that was the principal factor of production. The prosperity and industriousness of a group were in proportion to the number of captives it possessed (Boutillier 1968; 519, 517).

Slaves were used to produce year to year subsistence, a marketable surplus, crafts, trade, they performed ceremonial functions in certain social and religious rites, and could be sold or pawned (<u>ténémada</u> or <u>tonomada</u>) during periods of distress (see Boutillier 1968, O'Sullivan 1980, Meillassoux 1975, Miers and Kopytoff 1977, Ortoli 1939, Park 1971, Poussibet 1979, and Roberts and Klein 1980 for discussion of West African slavery). As such, slaves were an indispensable part of the mix of precolonial drought-coping strategies, albeit one that caused great human suffering. The master could shift some impacts of drought from his own family to those of his captives by overexploitation, pawning, or sale of his captive labor. The use of slave

labor promoted the slave-owner's ability to respond to drought but constrained or eliminated that of the slave.

Precolonial Agricultural Production

The farming system in the study area was developed over a long period of time and reflects the constraints and opportunities of semi-arid agriculture in Africa (see Ruthenberg (1976) for a discussion of African farming systems. Production in the precolonial period centered upon food and cash crops just as it does today: millet, sorghum, fonio, maize, beans, rice, cotton, manioc, sweet potatoes, karité (shé), indigo, henna, vegetables, and condiments. The industrial or cash crops supplied material for household manufacturing, provided artisanal products for the market, provided goods for exchange in weekly markets, and contributed to the family coffers in the form of cowries (the medium of exchange) or other forms of accumulated wealth (see Gauvry 1982 for the interesting story of karité).

The system made intensive use of manual labor and space through the building of deep, square ridge furrows which were designed to impound water on the fields and channel it to the subsoil. The ridge system reduced soil erosion, captured organic matter, and retained humus. It minimized yield variability between high and low fields caused by interannual rainfall variability. During drought, some high fields would retain enough moisture to produce a crop.

During years of high rainfall, some low fields would not be flooded and drowned. Soil moisture storage made the growing season longer than the present 3.5 to 4 months. Live fences of trees and bushes under a wooded parkland of Vitellaria paradoxa and Acacia albida minimized evaporation losses and created a humid microclimate (Pullen 1974, Wilkin 1972). The permanent vegetation in the fields acted as baffles to the wind, minimized diurnal temperature and moisture variations, protected crops from burning, recycled nutrients from the soil, and produced useful and marketable products. Crops were intercropped in order to obtain soil nutrient benefits (legumes and cereals), to create a favorable microclimate for sun intolerant plants, to reduce erosion, and to lengthen the growing season. All of these strategies to conserve moisture were developed to minimize losses during drought. Local people developed this system over time based on micro-level ecological knowledge in order to minimize drought impacts on their subsistence base.

The Precolonial Political Context for Drought Response in the Ségu Area

The country that today is called Mali has been governed by many administrations. It formed part of the medieval Gana and Mali empires. In the nineteenth and twentieth centuries, it was ruled by many small competing groups, generally on an ethnic basis. The precolonial period in the region in which the study area is located was characterized

by periods of stability and expansion and instability and contraction, where famines were frequent and "the least shortage had serious repercussions" (Cissoko 1968; 814). The eighteenth century and the first half of the nineteenth century were periods of stability and economic expansion based principally on political stability brought by the Ségovian armies and control of an increasing supply of labor. During most of the eighteenth and more than half of the nineteenth centuries, much of Mali was ruled by the Bamana warrior state in Ségu and the Peul theocracy at Hamdallai. In the 1860s both of these states were crushed by the jihad (holy war) of el-Hajj 'Umar Tal. Tal's religious reformist and politically expansionist jihad swept into western Mali from the Sénégal valley, toppled the Bamana state in 1861, established a theocracy at Ségu, destroyed the theocracy of Hamdallai, and for everyone, ushered in a period of social upheaval unlike any seen before.

Religious War, Political Instability, and the Umarian conquest of Ségu

The political, commercial and agricultural expansion that occurred during the relatively stable Ségu empire crumbled with the conquest of El Hajj Umar Tal. The Umarian conquest was the result of one of many religious upheavals that occurred from the seventeenth to the twentieth centuries in West Africa (Lewis 1972, Trimingham 1962). The

reasons for its occurrence will not be discussed here; rather, the impact of the Umarian jihaad on the Ségu empire and its economy will be briefly examined. Much of this material has been discussed in previous sections. A brief contrast of Islam with the agrarian religion that was practiced prior to Islam will first be presented; then the impact of the Umarians upon the political and economic stability of the region will be discussed.

Islam is the antithesis of the agrarian communalism and the agrarian religion of the Bamana. Islam transcends local ecology and it had no role to play in the traditional productive processes of nineteenth century Ségu. It provided a different cosmological framework, power structure, figures of authority and esteem, and even history from that provided by the agrarian religion and as such was a divisive force on all levels. Soleillet (1887; 320) observed that the Bamana "...prefer their traditional beliefs and do not permit any element of discord among them." Perinbam (1969) described Umarian rule as "...an alien Islamic superstructure which was imposed on heterogeneous communities and which did not relate organically to them except on peripheral or functional levels" (1969; 153).

Roberts (1980d; 414) states that the "...Umarian jihad was largely conducted by an alien conquest army which had no ties to an agrarian base." Because of the lack of local ties, the Umarians were forced to depend upon warfare to

finance their state. "A policy of razzia...came to dominate Tokolor military operations" (Roberts 1980d; 415).

It was the general political instability that the Umarians created after 1848 through organized military campaigns, the interdiction of the desertside trade, razziya, and heavy taxation that had the greatest impact on local and regional populations.

> Following the Umarian conquest of the Middle Niger valley, between 1860-1863, the regional economy suffered. [Producers] appear to have relied upon the production of subsistence at the expense of occupational specialization (Roberts 1980a; 144-145).

When Ségu fell to the Umarians in 1861, inhabitants of the Ségu region fled and migrated north of the Niger River and established new farming communities (B. Traoré 1985). Only villages that were large, well fortified, and heavily armed could resist the invaders.

> Endemic insecurity interfered with the desertside trade and interrupted the free movement of goods to the kola regions of the south (Roberts 1981: 189).

After the Umarian conquest, the Somono lost their monopoly over trade and transport on the Middle Niger. The Umarians sought to physically force the Somono out of the region and replace them with Bozo from the Niger Inland Delta. The Umarians did not trust the Somono and did not

want to entrust critical transportation to a group that was previously allied to the Ségovians (Jeay 1980).

When one of the trading groups, the Marka, responded by revolting the result was "...the collapse of the flourishing commercial cities of the region. The revolt also deprived the Umarian state of the substantial taxes the Marka had traditionally paid the Bambara" (Roberts 1981; 189).

Farming during this period was accomplished in heavily armed groups with armed guards posted to watch for talibé or tonjon (M. Traoré 1985). Political instability caused distant cultivated areas to be abandoned necessitating a greater reliance upon infield agriculture and alternative activities. This caused what might have been considered "normal" drought impacts to assume the proportions of famines.

Before the Umarian conquest the study area formed part of a larger, regional network of communication and specialized trade. The study area was linked during the precolonial period by markets located within or near the study area[6] to a regional network of exchange extending from Ségu to the Atlantic coastal states in the south and to Timbuktu in the north. They were linked to an international trading network that extended north and east of Timbuktu to

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[6] Precolonial markets within the study zone were Konodimini, Suban, Massala, and Soya (Gallieni 1885, Soleillet 1887). Other, larger, market links located within 20 kilometers of the study zone were Ségu, Barwélé, and Nyamina.

the Ottoman world and Europe and from the Atlantic states to Europe (Baier 1980, Curtin 1984, Lovejoy and Baier 1975, Lovejoy 1980, Roberts 1980c, Swanson 1975, Wolf 1982). Roberts (1981) summarized the impact of the Umarian conquest upon this network:

> The inability of the Umarians to establish internal security undermined economic specialization and threatened the very nature of the [local] social formation itself. In place of the established zones of commercial activity in the Middle Niger valley, with linkages to the local economy, the Umarians encouraged a westward (and "homeward") orientation [to trade] (Roberts 1981; 188).

Precolonial Drought-Coping Strategies

The previous discussion has been presented to illustrate the social, political, and ecological environments that constrained or promoted drought-response in the Ségu region of Mali before the European colonial period. Although it is impossible to reconstruct individual drought response histories, social, political, and ecological understanding of previous periods is helpful in understanding drought-coping strategies during those periods and especially in drawing contrasts with present social, political and ecological conditions and current drought response.

The entire production systems of the agricultural Bamana, the agropastoral Peul, and the agropiscicultural Somono can be considered as intergenerational drought-coping

strategies. These are what Burton, Kates, and White (1978) in their model of drought response would call incidental adjustments. The mobility of the herd and the fishing boat are two strategies that rapidly distribute risk over space. Farm fields cannot be moved in such a manner and different incidental adjustments are used to protect immobile space from risk. A humid microclimate created by stands of Vitellaria paradoxa, Acacia albida, and live fences protects crops from drying winds and sun. Moreover, the use of deep, cross-tied furrows helped to channel moisture to the subsoil and minimize variation between high and low areas.

Drought-coping strategies in general can be divided into three groups.

1. Adjustments of the production system.
2. Spatial strategies.
3. Social strategies.

Adjustments of the production system, may or may not be technical. They may involve, for example, growing a greater or lesser surplus for storage or by changing the surplus good. Technical adjustment could involve lengthening the distance between plants when reseeding after drought during the early part of the rainy season (Oguntoyinbo and Richards 1978). Drought-resistant varieties (Onwueme 1978) and moisture conservation techniques may be used (Bein 1980). They may involve change from a long-cycle to a short-cycle variety of crop or even the complete abandonment of a crop

and the adoption of new crops (Skinner 1978). Generally, during the precolonial period a person did not abandon one production system for another. A farmer did not become a fisher nor a herder unless enslaved.

The creation of humid microclimates and the use of deep, tied ridges are examples of adjustments of the production system. The rings of V. paradoxa and A. albida that surround every village are an artificial matrix that creates the preconditions for long-term, sustainable production. Live fences helped reduce surface water movement by presenting a barrier to surface water flow and by collecting rainfall with leaves and branches and channeling it to the ground. The shallow, plowed furrows used today, in contrast, immediately channel water from the fields to the paths and road network and ultimately to the lowest points possible. This loss of soil moisture reduces the length of the growing season.

The use of deep tied ridges is a short-term adjustment of the production system. It can be changed annually. During the precolonial period the use of deep, tied ridges minimized the effect of interannual variations in rainfall on crops. Tied ridges prevented the runoff of rainfall and channelled it instead to the subsoil. In years of high rainfall, the mortality of crops in low areas was reduced, and during years of low rainfall crops in high areas would not lose scarce rainfall to runoff. It is rare to find tied ridges in the study area today.

The spatial scatter of farm plots is the most typical example of spatial strategies. A major characteristic of rainstorms in the Sudano-Sahelian climate is the uneven distribution of rain. Typically, the storms move from south to north on narrow tracks that may be as narrow as one hundred meters. Possessing many spatially dispersed plots enables a farmer to minimize risk of total crop loss. Another strategy is to possess plots in low areas as well as in high areas. If rainfall is above average the crop in the low area is lost but the crop in the high area is not. Conversely, in a season of below average rainfall, the crop in the low area produces and the other one does not.

Social strategies are used generally to regulate shortfalls caused by an unanticipated outcome to or failure of the other two strategies (Colson 1979, Hankins 1974, Jodha 1978). This group of strategies can be characterized by a range of responses from the use of bush foods (Berhaut 1974, Bernus 1980, Bhandari 1974, Cole 1987, Corkhill 1949, Gast 1972, Irvine 1954 1948, Tayeau et al. 1955) to the pawning of the greatest asset of Sudano-Sahelian production systems, captive or familial labor (Ortoli 1938, Watts 1983a). The most characteristic strategy of this group of strategies is mutual aid between family or friends. In extreme hardship, however, when mutual aid was no longer possible, the slaves of the family absorbed the shock of drought; that is, the vulnerability of the noble nucleus of the production unit would be shifted to the slaves. They

would be sold (Lovejoy 1983, Savonnet 1958) or just abandoned when their food consumption threatened the subsistence of the noble family (De Kersaint-Gilly 1924). If the family had no slaves a family member or productive asset (Abasiekong 1981) would be pledged for a sum of money or grain. Migration during the precolonial period was generally not possible because of the risk of enslavement by strangers outside one's home area.

A Period of Political Stability: the French Administration of Ségu

After French forces defeated the Umarians in Ségu in 1892 they were, as were the Umarians in their time, left with the task of restructuring the society. They broke down the defensive walls of villages, forcibly settled belligerent armies in agricultural communities, took censuses and surveys, introduced taxation, and learned about their new possession. Although taxation was nothing new, the French were very systematic about its collection, first in kind or in cowries[7]. Perhaps the only positive thing about French taxation in comparison with Umarian taxation was that it was predictable and not as onerous as Umarian exactions (Traoré 1985). Although the Umarians adopted use of the Bamana annual tax (disongo), they often practiced an

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[7] It was not until the 1930's that the cowrie currency was eliminated (Johnson 1970). Cowries are still used in ceremonies and as a symbolic exchange from former slave to former master.

onerous informal taxation of the population (Mage 1868, Roberts 1981, M. Traoré 1985). After the colonial conquest slave raiding and pillaging became a part of the past. The French did nothing immediately regarding the institution of slavery itself other than the establishment of villages where a slave could go to be free (Bouche 1950 1949, Boutillier 1968). The French feared that the abolition of slavery would cause social upheaval and a drop in production; however, when the slaves of their own accord walked off the plantations and farms in 1906 (Roberts and Klein 1980) production did not fall.

The French reopened the Niger to trade, the trading network was tightened, and travel was made safe; however, the commercial centers of Timbuktu and Sinzani never regained their former glory (Roberts 1980d). Although the south-north (desertside) trade was re-established and increased, it was soon dwarfed by trade by the trade between the Sudano-Sahelian states and the Atlantic coastal states and the trade with Europe. This trade was rudimentary at first but later consisted of large quantities of primary and manufactured goods.

The main economic change that the French instituted was the dismantlement of the slave economy. The collapse of slavery and the release of its enormous labor pool called for the reorganization of socio-economic relations around some other process of surplus production. For those who farmed and those who would farm, the French introduced the

plow (Le Moigne 1979) as a labor saving device and market agriculture as a money-making enterprise. For people who were uniquely pastoral, the collapse of slavery caused an income loss and labor scarcity that were not provided for by the colonial authorities. This important (and up to the present, ignored) variable may have exacerbated the impact of drought in the early 1970s on pastoral peoples but its significance is difficult to assess because the institution of slavery was not rigorously abolished with the Peul as with other groups (Diallo 1985). Slavery still exists in much of northern Mali where the Peul are the dominant ethnic group. Agricultural villages established by the Peul and peopled with captives still exist. Every year an annual tax is paid to the Peul owner by the captives (Diallo 1985).

To facilitate trade, the French established markets throughout West Africa. In the study area five new markets were established in the last fifty years: Ngara, Bundo, Dugufé, Somon, and Nango in addition to the preexisting markets of Konodimini, Massala, and Fassongo*, within the study area and Ségu, Barawélé, and Soya near the study area.

Production since the French conquest and up to present has been centered upon family labor and use of the plow. Family labor reproduces itself slower than captive labor

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* The market of Fassongo does not exist today. Villagers in Fassongo do not recall its existence. Soleillet, who reported its existence in 1878, probably meant instead the market at Suban, across the river from Fassongo.

(which can be increased from the market). The total costs of familial reproduction are borne by the family itself and assuring this reproduction is the main concern of the members of the household in this labor scarce culture. It is fortunate that mutual aid associations, the ton, carry out some of the agricultural labor for the entire village and often assist elderly or poor people in overcoming their labor constraints. The family, however, has undergone many changes since the French conquest, for example, the head of the extended family has been said to be losing control over individual family members (Strasvogel 1949). Le Roy (1983) attributes this loss of control to the breakup of the extended family and to the emigration of independence-seeking family members. Lewis (1978) contends, in contrast, that the Bamana extended family is not breaking up under modern pressure.

According to the model of the breakup of the extended family (see Raynault 1973), the desire for independence:

> ...manifests itself by an autonomy in production and consumption. The possible departure of his dependents is a subtle form of blackmail that constrains the familial patriarch to accept, most often against his own wishes, the formation and development of familial production and consumption subgroups. The growth of familial autonomy, favorized by the introduction of cash crops represents the second form of loss of decision making power by the patriarch (Le Roy 1983; 201).

Despite this apparent loss of control, the head of the extended family has maintained control over family wealth (see Vincent 1982); "...the absolute or relative difference of his cash-flow level and those of his dependents is crushing" (Le Roy 1983; 202).

The French were interested in controlling productive activities at the level of the producer so that they could accumulate investible wealth for the metropole (Suret-Canale 1971). Farmers, however, grew most of what were to become known as cash crops prior to French administration. They grew cotton, peanuts, rice, millet and sorghum, generally in intercrops. The French were interested in increasing the production of some of these crops for the international market. They set up trading stations and began buying products at the station or in the countryside with the help of agents. During the 1930s interest in large irrigation projects developed and the Office du Niger was established to exploit the dead delta of the Niger River north of Markala in the Region of Ségu. In the study zone during the 1950s, the French developed irrigated rice production along the Niger. The floodgates and engineering works were completed in the late 1950s and land was apportioned according to individual labor in the construction of dikes (Bingen 1985, B. Traoré 1985).

> ...each villager would acquire rights to polder land in proportion to the amount of labor contributed. Specific criteria for land distribution depended upon the

> availability of land in each area, but the general distribution formula gave each household head one hectare for every 12 cubic meters of land moved (Bingen 1985; 31).

Bingen states further that this allocation system enabled some people to obtain large tracts of land, certain local families, traders, religious leaders, and members of the administration. This was rectified in a reorganization of Opération Riz in the early 1970s where the land was redistributed according to the following criteria: family size, ownership of agricultural equipment, and distance from the rice polders (Togora 1985). As a general rule, it was the farmers located along the rice polders who obtained rice fields. These farmers were likely candidates for rice field ownership because they owned the land that was transformed into rice fields in the first place, and, in the second place, would have had a loss in income if they did not cultivate on the scheme. Participation in the Opération gave them access to credit and cash, and by extension, plows, carts, draught animals, and fertilizers. The majority of people living in the villages located along the southern edge of the polders are Bamana and the majority living along the northern side are Somono. This increase in the control of resources in comparison with the Marka and Peul may have meant an increase for the Bamana and Somono in wealth. It is not certain what the effect was upon the Peul. Fewer Peul obtained rice fields than the Bamana.

Peul villages located near the polders lost land. Zanankoro Wéré, an extreme case, became an island surrounded by rice; however, this is a relatively new village created by noble Peul who settled in the area during the 1930s (Traoré 1985). Another point to consider is that the Peul do not have a history of agriculture; cultivation is for the captives of the Peul. In terms of the effects of the scheme on grazing, it is clear that permanent bush pasture was dramatically reduced, however, grazing of highly nutritious annual grasses and rice stubble was created on a large scale. For the Somono, the impact of the creation of Opération Riz was dependent upon their location relative to the polders. Somonoduguni, for example, located near one of the lowest areas in the polders lost most of its lands devoted to food crop production. These lands were permanently alienated by the Opération for rice production. However, the Somono of Somonoduguni cultivate on the north bank of the Niger and on islands in the river itself and, of course, cultivate rice on the land formerly used for food crops. The islands are ideal sites for almost any type of cultivation. Fassongo and Minyon were affected little by the creation of the polders.

The characteristics of the present agricultural system in the study area are:

1. Labor is used more intensively than during the precolonial period. The plow has

replaced the captive and the productivity of the individual farmer has increased tremendously.

2. Spatial extensivity. There has been an expansion of cultivated area.
3. The use of family and hired labor instead of slaves.

The use of manure, composted grass and leaves has increased in the study area. This may to be an attempt to address the demands made by increased cropping and soil and humus losses. With the wealth generated from the expansion of rice cultivation, the production of mangos (and other cash crops), and seasonal migration for work, farmers have invested in livestock (author's study 1985). The increased livestock population has enabled the farmers in the study area to intensify their production by applying more manure to their fields.

A related problem to increased cropping (if increased cropping can be characterized as a problem) has been the decline in the use of live fences; in order to maximize plowed area per field, live fences have been abandoned. Where remnants still exist it is only on sides of plowlines. Vitellaria paradoxa and Acacia albida have been maintained in the fields but some farmers, where the ecological conditions are right, have replaced them with mangos.

Colonial and Post-Colonial Drought-Coping Strategies

Differences in the drought-coping strategies used between the precolonial and postcolonial periods can be divided by strategy. It was mentioned on page 120, in the section in which drought-coping strategies were discussed, that there are three groups of drought-coping strategies: spatial strategies, adjustments of production, and social strategies. The notion of incidental, or long-term, adjustments of production was presented in reference to two strategies:

1. The artificial environment of managed tree species and live fences that were used by the precolonial producers to create a humid microclimate for crop production.
2. The use of the cross-tied ridge and furrow system.

Major changes in incidental adjustments as mentioned above concern these two strategies. The former strategy has changed because the use of the plow precludes the fencing of plots (at least on two sides) and, in the River and Middle Valley zones, mangos are increasingly being planted where soil and water conditions permit, increasingly replacing fields formerly devoted to cereals and stands of Vitellaria paradoxa and Acacia albida. Returns per hectare of mangos are approximately eight to ten times greater than per hectare of cereals and this price differential justifies the

costs according to respondents (author's study 1985). Furthermore, mangos require little maintenance and are very resistent to drought. This agricultural change must be considered as positive.

Other differences between the precolonial and present periods include spatial mobility. During the precolonial period, movement outside one's home area was fraught with danger. Away from family friends, a person risked enslavement or death. After the French conquest and the re-establishment of peace, movement was facilitated especially with the building of modern transportation infrastructure. One respondent reported during the survey in 1985 that people today are less vulnerable to drought than during the precolonial period principally because of the transport infrastructure which allows people to leave during the dry season to find employment during ordinary times and particularly during periods of stress.

A major difference between the precolonial and the present periods is the presence of supportive supralocal organizations that reinforce production systems and give or sell cereals during drought. The Malian government does both of these and has, for example, attempted to control the effects of drought through the use of "drought-proof" irrigation projects financed by the international donor community (CILSS 1983, McIntyre 1981). In the study area these efforts have been manifested in a recanalization project aimed at deepening the main feeder canals so that

polder inundation begins at a flood height of 2.70 meters rather than the previous level of 4.0 meters (the level set in the more humid 1950s). Recently, the Malian government has begun development of "trilateral" food aid. This system encourages the regional interlinkage of West African countries in the production, exchange, and distribution of food aid (Afrique Agriculture 1984, Bèche and Minier 1984, CILSS 1982, Le Courrier 1984, Stratégies Alimentaires 1984, Telex Afrique 1984). There is a community development program associated with Opération Riz in the Study area which addresses issues such as malnutrition, literary, and skills acquisition at the household level.

Summary

This chapter focussed on a geographical and historical description of the physical resources in the study area, the dominant cultures, social organization, and drought. Three ecological zones were identified in the study area based on the physical characteristics of the zones: the River Zone, the Middle Valley Zone, and the Outer Valley Zone. Three ethnic groups were found to live in the study area, the Bamana, Peul, and Somono. The Bamana are principally farmers, the Peul are principally herders, and the Somono are principally fishers. The human organization of production was examined in this chapter, particularly the institution of the extended family, the age-set, and slavery. Drought-coping strategies and the political

context of drought response during the precolonial period was discussed and contrasted with the colonial period.

CHAPTER FOUR: METHODS: SAMPLE, INTERVIEWS AND ANALYSIS

Research methods employed in the present study include regional geographic methods (regional differentiation), historical research, informal interviews with knowledgeable local people and government officials, and the use of formal questionnaires. The objective of the regional geographic approach was to define the study area in the physical, cultural and environmental dimensions. The objective of the historical research, conducted in the United States, Mali, and France, and the informal interviews conducted in Mali was to develop a historical overview of the precolonial and colonial political, economic, social, and environmental contexts in which drought response occurred in and around the study area. This was done to provide historical depth for comparing the results obtained through other research methods, informal interviews and questionnaires, focused on drought response during the early 1970s and the early 1980s in the study area. The objectives of the formal interviews by questionnaires was to obtain the responses of heads of household in the study area on drought response during the drought in the early 1970s and the record drought experienced in the early 1980s. The drought year according to the respondents was the year prior to the research. The intention of this diachronic approach was to examine change in drought response over time.

The archives used in Mali were the Archives Nationales, the archives of the Service Metéorologique, and the archives of the Bureau de Population in Bamako. The Archives Nationales were the source of useful information about the Ségu area at the time of the French conquest, the Bureau de Population held the village-level results of the census of 1976, and the Service Metéorologique held the past and present rainfall data for the study area. The files of official reports were examined at Opération Riz/Ségou, the Arrondissement de Ségou, ICRISAT in Bamako, the International Livestock Center for Africa (ILCA), and the United States Agency for International Development in Bamako. The libraries used were the Bibliothèque Nationale in Bamako, the ILCA library in Bamako, the Projet Inventaire des Ressources Terrestres library in Bamako, the ORSTOM library in Paris, the Antenne Sahel library in Paris, the Michigan State University library, and the Sahel Documentation Center at the Michigan State University library.

The land-cover, land use, and physical geographical classifications of the Mali Land and Water Resources Report (Tippetts, Abbett, McCarthy, and Stratton 1983), also called the PIRT report, were used to delimit the physical boundaries of the study area and also to identify discrete ecological zones based on soils, the distribution of vegetation, and moisture availability within the study area. Fieldwork was undertaken to verify the strength of the

ecological classification obtained from the Mali Land and Water Resources report (Tippetts et al.): the water table was measured (by using lengths of rope) in 48 villages throughout the study area and the distribution of soils and vegetation examined by field checking.

Informal interviews were a major source of anecdotal information about the study area and regional local history. Interviewees for informal interviewing were sometimes selected from the pool of respondents randomly selected for interview by questionnaire if a respondent happened to be particularly knowledgeable about drought, environment, drought response, and local, regional, and national history. Many local people identified themselves or, more often than not, were identified by others, as having particularly pertinent knowledge for the study. For example, local people suggested that Bakari Traoré of Ngara be interviewed because of his intimate knowledge about the creation of the rice polder scheme in the study area because he had worked with the French engineer who designed and built them in the mid-1950s.

It should be noted that the author sought out and interviewed migrants from the Ségu area who were living in Bamako when the present research began in early 1985 but before any fieldwork was begun in order to obtain a clearer picture of life in the study area and to obtain the migrants' perspective. These migrants helped interpret the family names of the residents in the study area so that

classification according to ethnic affiliation could be accomplished.

Less informal interviews were conducted with government officials, locally and in the national capital, Bamako. Of particular importance were a series of meetings which took place during a 13-day trip to the study area when village chiefs, councilors, and interested representatives were interviewed about drought and drought-coping strategies. These meetings served as an introduction of the research and researcher to the people in the study area and the results of the interviews formed the basis for the questionnaire used in the formal survey which was begun after pretesting some two months later.

Some of the results of the historical research and the informal interviews are found in Chapters Four and Five below while others are presented in Chapter Six. Results obtained through the former methods provide the background for the interpretation of formal questionnaire data. Description of informal interview techniques may be found in Hammersley and Atkinson (1983). The methods presented below are those used for the preparation, collection, and analysis of formal questionnaire data.

The Sample

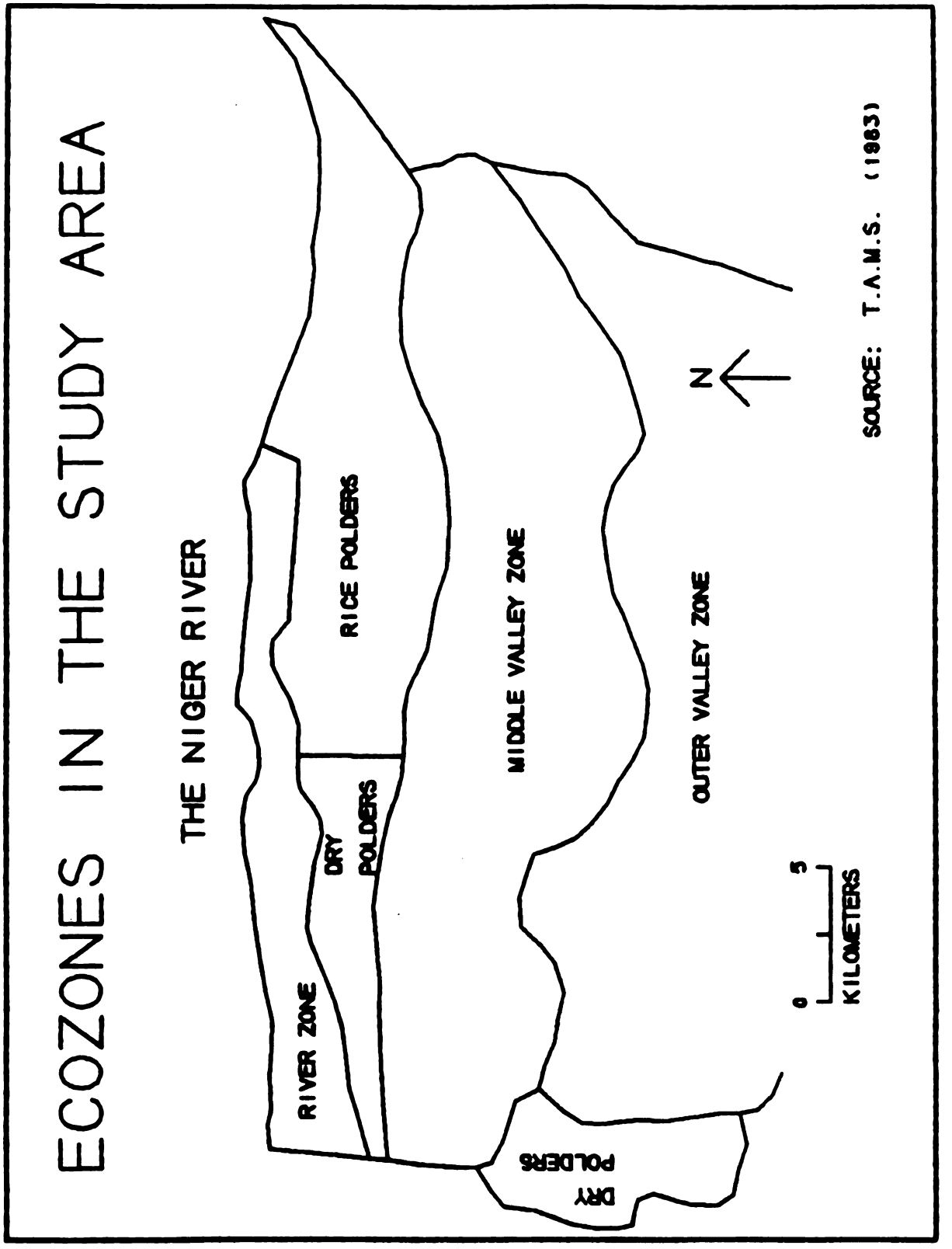
As a preface to the discussion of the sample, it would be useful to define terms that will be used throughout the remainder of this study. The sampling unit used in this

study was the household. By "household" it is meant the extended family unit including members of three or more generations living together or in proximity to one another in the same village. The word "family" is used as a synonym for "household" and "extended family".

Household data from the census of 1976 were collected at the Bureau de Population in Bamako in February, 1985. The data taken from the census records were the name of each head of household for all villages in the study area, the number of family members by sex, and the number of visitors by sex. Each head of household's name and location was recorded and he was given a number. The number of families in the study area according to the census of 1976 was 3092 which represents 20691 persons (Government of Mali 1976).

The study area was divided into four ecozones based upon physical differences (Tippetts, Abbett, McCarthy, and Stratton 1983): the River, the Polder, the Middle Valley, and the Outer Valley Zones. Three of the zones are inhabited and one is used for the specialized cultivation of gravity-irrigated polder rice.

Figure 4.1 Ecozones in the study area.



The primary difference between the zones has to do with access to water (river or groundwater), secondary differences are related to soil type (sand or silt loam). Since water is one of the most important resources in this semiarid environment, access to it and concomitantly access to the range of activities associated with it is important in drought response.

The population of the zones was further divided according to ethnic affiliation. Family names* were used to group the population according to this criterion (see Tables 4.1 and 4.2 below). It was found that the Bamana, Marka, Peul, and Somono ethnic groups live in the study area. These groups formed the basis of the random sample used to select the respondents for the drought-response questionnaire. The Marka were grouped with the Bamana because after the sample was taken an analysis of key demographic variables showed that there were no significant differences between the Marka and the Bamana on demographic variables, economic activities, or social structure (see Appendix B). Most of the Marka in the study area are, as mentioned in Chapter Three, Marakafin or Bamanized Marka and are virtually indistinguishable from the Bamana except for jamu or clan name.

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* Family names are becoming less reliable as indicators of ethnicity as mobility and anonymity increases, especially in urban areas (Gallais 1962). In rural areas such as the study zone surnames are good indicators of ethnicity.

The size of the sample of households to survey was calculated using the formula below (Isaac and Michael 1981) which gives the minimum sample size necessary to ensure that the sample is normally distributed (50% falls on either side of the mean).

$$\textit{Sample size} = \frac{X^2 * N * P(1-p)}{d^2(N-1) + X^2P(1-p)}$$

Where,

X^2 = A confidence level of .95 associated with a X^2 statistic for 1 degree of freedom.

N = The given population size (households).

P = Population parameter, .50.

d = Sampling error to be tolerated, .05.

The minimum sample size for a random sample according to the above formula for a population of 3092 households is 341. To be conservative, the sample size was increased to 550 respondents. A stratified random sample was taken based on the location of a household (ecozone) and its ethnic affiliation (ethnicity). A list of heads of household was compiled at the Bureau of Population in Bamako and heads of household were divided by ecozone and ethnic group. Respondents of each ethnic group in each ecozone were selected for sampling using a microcomputer programmed to generate random numbers. As Tables 4.1 and 4.3 indicate,

the distribution of the sample by ethnic group by zone corresponds rather well with the distribution according to the census.

Table 4.1. Total number of households in the study area by ethnicity and ecozone.

Ethnic Group	River		Middle Valley		Outer Valley		Total	Percent of Total
	House-holds	Percent	House-holds	Percent	House-holds	Percent		
Bamana	218	11	1185	57	673	32	2076	67
Peul	186	17	282	44	248	39	636	21
Somono	380	100	0	0	0	0	380	12
Total	784	23	1467	47	921	30	3092	100

SOURCE: Government of Mali, 1976.

Table 4.2. Total population in the study area by ethnic group and ecozone.

Ethnic Group	River		Middle Valley		Outer Valley		Total	Percent of Total
	People	Percent	People	Percent	People	Percent		
Bamana	1514	11	8033	59	3987	29	13534	65
Peul	798	19	2170	52	1192	29	4160	20
Somono	2997	100	0	0	0	0	2997	14
Total	5309	26	10203	49	5179	25	20691	100

SOURCE: Government of Mali, 1976.

Table 4.3. Sampled households in the study area by ethnic group and ecozone.

Ethnic Group	River		Middle Valley		Outer Valley		Total	Percent of Total
	House-holds	Percent	House-holds	Percent	House-holds	Percent		
Banana	33	9	198	55	132	36	363	61
Peul	22	15	96	66	28	19	146	24
Samo	90	100	0	0	0	0	90	15
Total	145	24	294	49	160	27	599	100

SOURCE: Author's study.

There were four problems encountered during the survey that were based upon the census sampling unit, the nuclear family, and demographic changes that occurred since the census. These problems were resolved by the use of the village tax register which lists all extended family heads of household. The problems and the solutions were:

1. Deceased respondents. To solve this problem the name below the deceased respondent on the village tax register was selected.

2. Selection of nuclear rather than extended family heads of household. The basic unit of sampling of the census of 1976 was the nuclear family head of household (chef de ménage) rather than the extended family head of household (chef de famille). Every head of household, whether nuclear or extended, was treated as a nuclear head in the census. Although this was perhaps a suitable method for easing the tasks of enumeration for a national census,

it made more difficult the tasks of researchers working with the extended family. Since the extended family holds land (and many other assets) in common with its constituent nuclear families and as nuclear families may possess land outside the purview of the extended family, there was potential for two errors in confounding extended and nuclear families. First, each nuclear family appears to work more land than it actually does because it will count as its own the land owned by the extended family as well as the private plots of its nuclear households (jonforow). This is equally true for all communally-owned assets such as livestock and agricultural equipment. Second, treating more than one nuclear head of household from the same extended family household amounts to counting some of the same resources twice.

The method adopted to respond to this sampling problem was to select the extended family head corresponding to the nuclear family head that had been randomly selected or to select the name below the selected nuclear heads of household on the tax register when more than one respondent from an extended family had been chosen.

3. The ratio of extended to nuclear family heads of household. The extended family head is the actual head of the entire family including all nuclear subgroups. Because the ratio between the actual extended family heads of household and the nuclear family heads of household is small, in some villages the number of respondents called for

by random selection from the census (based on nuclear families) exceeded the actual number of extended family heads of household in the village (see number 2 above). The sampling problem was that in some villages the sample called for more extended family heads of household than were actually there. The method adopted to address this problem was to interview all true heads of extended household in the deficit village and make up for the shortfall by random selection of heads of household from the tax register in the next closest village.

The magnitude of this problem can be illustrated by a few simple figures. According to the Census of 1976, there were 3092 heads of household for extended families and 20691 people enumerated in the villages in the study area. The average family size according to these figures is 6.7 persons. In contrast, the average family size in the study area according to the sample is 17 persons. If the figure obtained during the sample survey is correct, and exhaustive fieldwork suggests no reason to doubt its correctness, the true number of extended families in the study area is closer to 1217 and the actual sampling fraction of households was 50% rather than 20%.

4. Fissioning. Fissioning is the breakup of extended families into nuclear families each with its own collective fields. Each nuclear family then becomes the center of a new extended family. This problem was rare and the method

adopted was to interview the former extended head of household if the other conditions above were satisfied.

Although there were many problems associated with the sample, it is felt that the sample is representative of the population of the study area and that the results are statistically valid. Whenever problems arose, for example, when sampling had to be conducted in alternative locations, the sample proportions of ethnic groups and ecozones in the sample were always maintained. In addition, the large sampling fraction of households sampled in the study area, 50%, lends strength to the results.

The Interview Schedule

The interview schedule (see Appendix A) consisted of thirty-six questions. It was pretested in a Peul and a Bamana village. Each head of household was asked questions concerning family demography, possessions, crops and areas sown in the early 1970s and in 1984, what drought coping strategies were employed within his extended family during the drought periods of 1972-1973 and 1984-1985, et cetera. Drought-coping strategies, the central point of the questionnaire, were organized into eight groups of relatively similar strategies (Table 4.4).

Table 4.4. Drought coping strategies used in 1973 and 1984.

1. ASSISTANCE	Aid from family or friends
	Government aid
2. AGRICULTURAL STRATEGIES: CASH CROPS	Grew more cash crops
	Grew short-cycle groundnuts
	Grew tubers
	Vegetable gardening
	Grew watermelon
	Grew mangos
3. AGRICULTURAL STRATEGIES: FOOD CROPS	Grew less cash crops
	Grew short-cycle millet and sorghum
	Grew short-cycle beans
	Grew fonio
4. LABOR AND MIGRATION	Head of household migrated
	Family members migrated
	Took wage labor at home
	Caste occupations
	Artisanal production
5. DIVESTMENT OF LIVESTOCK (REPRODUCIBLE ASSETS)	Sold cattle
	Sold sheep or goats
6. DIVESTMENT OF OTHER ASSETS	Sold agricultural or other equipment
	Sold boat
	Sold jewelry
	Sold other asset
7. STIGMATIZED STRATEGIES	Ate wild foods
	Begged
	Pledged asset or family member
8. OTHER	Fished (for sale)
	Petty trade
	Livestock trade

SOURCE: Author's study (1985).

The Interviews

The study area was divided into three interviewing zones of approximately equal size in which the villages of Jado, Dugufé, and Somon were chosen as home bases for work in each interviewing zone. Heads of household were interviewed in 36 of the 43 villages in the study area; there were no randomly selected heads of household for 7 villages in the study area. The interviews were carried out during two different time periods. In the first interviewing period, from mid-March to the end of May, about 500 interviews were completed. Four enumerators were employed during this period. The beginning of the religious fast month of Ramadan was the reason for the termination of interviewing. Interviewing began again at the end of July and continued until October. Only one interviewer was employed during this time. Approximately 300 interviews were obtained from the remaining interview zone of Somon. The total number of interviews was 765. 166 of these 756 questionnaires were rejected because of errors or incompleteness, leaving a total sample of 599 heads of household. The rejection of these 70 of the 166 questionnaires may have introduced bias into the study. For example, the 70 heads of household who were randomly selected in the village of Nango in the south of the Outer Valley Zone, refused to be give honest answers to the interviewers and instead gave ridiculous responses. The

reasons why they refused are unclear but the Commandant du Cercle stated that the village has had a history of refusing to cooperate with the government. The villagers feel that they should have more land in the rice polders and also accuse the government of ignoring their demands for a school. If these villagers were different from the rest of the sample in some major way their refusal to cooperate means that difference or differences would not be captured by the survey and we would not have a statistically valid representation of the variation in the study area; instead a possibly important piece of the picture would be missing.

Variables

Variables hypothesized to be important influences on the response to drought were location in one of three ecozones, membership in one of three ethnic groups, and wealth. The wealth variable was calculated from the net value of the assets possessed by a family. Assets consist of hectares in cash crops, food crops, number of livestock equivalents, and pieces of agricultural or other equipment (for example, plows, carts, harrows, and fishing boats). Each asset was valued at its surrender value according to the market prices prevailing in the study area at the time the survey was undertaken, and, in the case of agricultural land, an annual rent value was calculated according to the crop planted, average yield, and market values for the commodities produced. Market values for assets were

assessed informally at the principal market in the study area in the village of Konodimini. Table 4.5 presents the assets and values used in the calculation of the wealth variable.

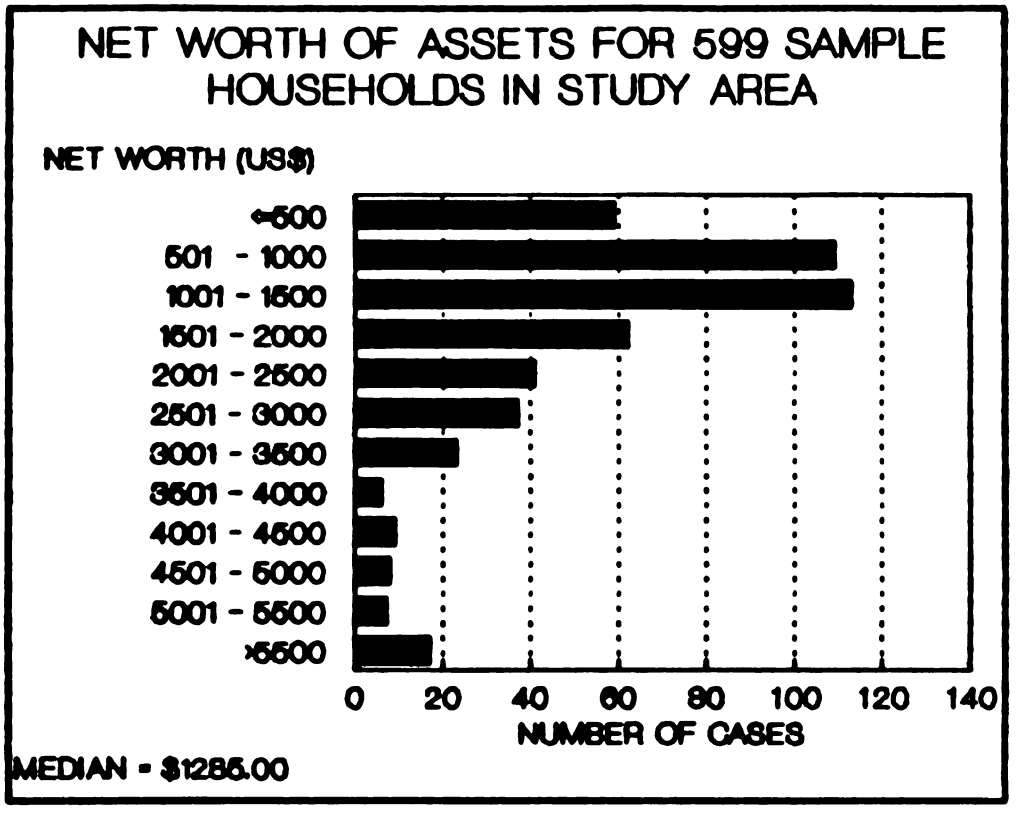
Table 4.5. Assets used in calculating wealth for sample households and their value in $US.

TYPE OF ASSET	ASSET	VALUE
LIVESTOCK	1 Tropical Livestock Unit (TLU)	100.00
EQUIPMENT	Plow	50.00
	Cart	70.00
	Harrow	40.00
	Boat	500.00
AGRICULTURE (per hectare)		
Class 1 crops	Mangos, market vegetables	200.00
Class 2 crops	Cotton, groundnuts, manioc, rice, sweet potatos, watermelon	100.00
Class 3 crops	Fonio, maize, millet, sorghum	50.00

SOURCE: Author's study.

The median net worth for the entire sample according to the variables used above was 1285.00 dollars. The sample was divided into quartiles, from 0 to 775.00 dollars (the lowest quarter) was classed as poor, from 776.00 to 2140.00 dollars (the middle 50%) was ranked as average wealth, and greater than 2140 dollars (the upper quarter) was considered rich (see Figure 4.2).

Figure 4.2. Net worth of assets for 599 households in the study area, 1985.



SOURCE: Author's study.

Cash remittances from family members working in or outside the study area were not considered in the calculation because of the difficulty in obtaining reliable data. This is not to say, of course, that the data obtained for the other variables used in the assessment of wealth are strictly reliable. For example, it is well-known that livestock owners when asked about their animal wealth underestimate the number of livestock they possess. They do this for a variety of reasons, for example, they may fear that information may reach the government and their taxes

will be increased. They may be fearful of the evil eye. According to local belief, the evil eye is drawn to a person's assets when that asset is either named or counted and destroys the asset. The evil eye in most cases is associated with covetous spirits (jinn) but may be associated with envious people (See Lane 1986 on the evil eye). Each respondent was visited twice and asked questions about his assets and, as a further check, cross-checking was done by comparing data given by the respondents to independent assessments by knowledgeable notables in each village. Lack of data on remittances, nevertheless, could introduce considerable bias.

The Analysis

The data were prepared for analysis on a spreadsheet, then read into the SPSS/PC+ statistical package. Descriptive statistics on demographic variables, crops and areas cultivated, livestock holdings, and assets were generated for the entire sample and by variable: location, ethnicity, and wealth. Tables presenting descriptive statistics are located in Appendices B through D. A hierarchical log-linear procedure was used to model the relationship between the variables and to test the hypotheses (see the example using the adoption of market gardening on page 156). Log-linear modelling is a technique used to examine the complex relationships that exist in multidimensional crosstabulations (Norusis 1988).

Development of log-linear modelling was pioneered by Goodman (1978) and Bishop, Fienberg, and Holland (1977). In the log-linear model all variables are considered as independent, predictor variables and the dependent variable is the frequency (number of cases) in a cell of the crosstabulation. In the present study, the number of cases means the number of households adopting a particular drought-coping strategy (called "household adopters" for the rest of this section). The number of household adopters in a cell is considered as a function of the variables in the crosstabulation: ethnicity, location, and wealth. The following formula expresses the log-linear model for the log of the expected frequency in the i^{th} row and the j^{th} column of a two dimensional table.

$$M_{ij} = \mu+\lambda A_i+\lambda B_j+\lambda A_iB_j$$

Where:

M_{ij} = the logged expected number of household adopters in a cell.

λA_i = the effect of the i^{th} A, B ... n category. This effect is expressed as $\mu_i-\mu$ and is the mean log of the expected number of adopters in a given

category minus the grand mean. Another name for this effect is main effect.

$\lambda A_i B_j$ = the interaction effect for the i^{th} A category and the j^{th} B category. The interaction effect equals:

$$\log M_{ij} - (\mu + \lambda A_i + \lambda B_j)$$

μ = the mean of the logs of the number of household adopters of all table cells.

The observed number of household adopters in a given cell is modelled exactly by the loglinear procedure in a model that contains all main effects and interaction terms. This model is called the saturated model. The unsaturated model, on the other hand, does not contain all possible parameters and provides a parsimonious description of the relationship between the variables. The formula for the unsaturated model is similar to that of the saturated model except that it lacks the interaction terms.

A common method of fitting the most parsimonious model to the data to describe the relationship between the variables is the Backwards Elimination Variable Selection Algorithm (Norusis 1988). This is similar to the variable selection algorithms used in regression analysis. The backwards elimination log-linear model begins with a saturated model and eliminates the highest to lowest order

interactions whose removal causes the least significant change in the likelihood-ratio X^2 statistic providing that the observed level of significance is greater than the criterion for remaining in the model. The observed level of significance used in the analysis was 0.05.

The Likelihood Ratio X^2 is used to test for the goodness of fit for a particular model. For large samples the Likelihood Ratio X^2 is equivalent to the X^2, however, the Likelihood Ratio X^2 may be subdivided into interpretable parts. If the Likelihood Ratio X^2 is high and the significance is below 0.05 one can reject the hypothesis that there is no relationship between the variables. If the model fits the next step is to examine cell lambdas for significant differences. To test the hypothesis that individual cell values are no different from zero the z-score or confidence interval is used. Lambdas with z-scores greater than 1.96 in absolute value are significant at the 0.05 level.

An example from the present data illustrates the testing of hypotheses with the log-linear procedure. Growing vegetables for the market is one of 29 drought-coping strategies employed by people in the study area in Mali. There are three ethnic groups in the study area; the Bamana are principally farmers, the Peul are principally livestock raisers, and the Somono are principally fishers. Does ethnicity play a role in the choice of this drought-coping strategy or are all ethnic groups equally likely to

choose vegetable gardening as a means of coping with drought? Table 4.6 below is presented below as an example using the log-linear procedure to test the null hypothesis that there is no difference between by ethnic group in the adoption of vegetable gardening.

The output of Table 4.6 is typical of that produced by the Log-Linear module of SPSS/PC+, however, the output obtained from the crosstabulation module in easier to interpret. Cell frequencies are transformed into natural logs in the log-linear procedure. Table 4.7 presents the natural logs for the frequencies presented in Table 4.6.

Table 4.6. Frequencies for vegetable gardening as a drought response by ethnic group, 1984.

VARIABLE	ETHNIC GROUP			ROW TOTALS
Gardening	Banana	Peal	Senano	
YES				
Frequency	28	0	20	48
Column Percent	7.3	0.0	22.2	8.0
NO				
Frequency	335	106	70	551
Column Percent	87.5	100.0	77.7	92.0
COLUMN TOTALS				
Frequency	383	106	90	599
Column Percent	63.9	20.4	15.0	100.0

SOURCE: Author's study.

Table 4.7 Natural logs for the gardening by ethnic group (frequencies).

VARIABLE	ETHNIC GROUP			MEAN
Gardening	Bamana	Peul	Somono	
YES	3.33	0.0	2.99	2.12
NO	5.81	4.98	4.25	5.01
Mean	4.57	2.49	3.62	3.56

SOURCE: Author's study.

The Likelihood Ratio X^2 statistic for this table is 41.74, a probability of 0.0000, and 2 degrees of freedom. This means that the independence hypothesis can be rejected. To identify cells which deviate significantly from the expected values, the log-linear output must be examined. Table 4.8 presents typical SPSS/PC+ output for the gardening variable.

Table 4.8. SPSS Log-linear output for vegetable gardening by ethnic group.

PARAMETER	COEFFICIENT	STANDARD ERROR	Z-VALUE	LOWER 95% CI	UPPER 95% CI
1. Garden=YES, Ethnicity=Bamana	0.331	0.248	1.331	-0.156	0.818
2. Garden=Yes, Ethnicity=Peul	-1.276	0.475			
3. Garden=Yes, Ethnicity=Somono	0.946	0.253	3.740	0.451	1.440

SOURCE: Author's study.

There are three interpretations that may be made of the coefficients produced in log-linear modelling. These interpretations are listed below.

1. The frequency in the i^{th} cell is greater than the expected number based on the frequencies of the variables that comprise the table. The value for this interaction is positive and is reflected in a positive coefficient in the output table.
2. If the frequency in the i^{th} cell is less than the expected number based on the number of the variables that make up the table, the value of the interaction will be negative and the interaction effect is said to be negative.
3. If the frequency in the i^{th} cell is neither more nor less than the number expected based on the frequencies of the variables that make up the table the interaction parameter is zero.

The results from the table above for vegetable gardening by ethnic group indicate that there is a positive but non-significant relationship between the Bamana and gardening, a negative and significant relationship between the Peul and gardening, and a positive and significant relationship between the Somono and gardening.

Limitations of the Analysis

The limitations of the present study are many and suggest that the interpretation of the data be undertaken with caution. First among the limitations was that data on drought-coping strategies were not collected in ratio form. The data collected on drought-coping strategies was nominal. Instead of, for example, kilograms of grain given as assistance from friends or relatives in 1973 and 1984, a proxy indicator was used that measured the fact that a transaction took place but not the intensity of the transaction. A smaller sample size might have permitted such data to be collected but the reliability of such data is uncertain. Are people able to recollect how many kilograms of grain were lent to them or how many goats were sold for a family marriage in 1973 because of the failure of the crops? At the time the field data were being collected the probability of collecting reliable ratio scale data appeared slim and proxy measures were adopted instead.

Another limitation is that the data on drought-coping strategies was not ranked on any scale, for example, "most used strategy", to "least used strategy". Instead, categorical variables were used to denote the use of strategies. Instead of measuring whether a particular response occurred or not, ranked responses would have measured the degree that response.

The use of recall data for the drought-coping strategies used in 1973 may be questioned. However, because

the drought in 1973 was so severe in its impacts, it was felt that people would remember quite well what had been their reactions at the time.

Field sizes were not measured directly and but were estimated by the farmers themselves. This course of action was taken for two reasons. First, the farmers were used to using hectares as a unit of measurement with Opération Riz and could be relied on to make accurate estimates and, second, the enormity of the field measurement task with a sample of 599 was daunting.

Interactions between ethnicity, ecozone, and wealth were not analyzed in this study because cell frequencies for all drought-coping strategies were too low. In log-linear and X^2 analysis, this problem is known as the sparse-cell problem and according to Issac and Michael (1981, 177) "... no frequency can be smaller than 5." A larger sample size would have helped allieviate this problem but with some of the less popular strategies the problem would still exist.

Another problem encountered in the analysis was how to treat the Somono population. There is not a continuous distribution of Somono in the study area; instead, they live in only one of the three ecological zones, the River Zone.

A last limitation is the lack of gender or intra-familial perspective on drought-coping. A gender perspective seems to me particularly important because of the different economic activities men and women undertake in difficult times.

Summary

In this chapter, the methods, sample, interviews, and analysis of data were discussed. Survey methods were used in the present study. A stratified random sample of 599 heads of household was taken from census records for the study area. A questionnaire was used to gather information on drought-response in the early 1970s and in the early 1980s as well as socio-economic and demographic data. Variables used in the analysis were the ethnicity of the respondent, the location of the respondent in one of three ecological zones, and the wealth of the respondent. Data were analyzed using the hierarchical log-linear method. Data analysis was done with the Statistical Package for the Social Sciences (SPSS) on a microcomputer.

CHAPTER FIVE: RESULTS OF THE RURAL SURVEY

Chapter Five is composed of three parts. Summary tables of results are presented first. These results are then discussed according to the type of drought-coping strategy.

Table 5.1 summarizes the use of drought-coping strategies in frequencies and percent for the entire sample in 1984 and 1973. Table 5.2 presents the drought-coping strategies that have significant second-order interactions with the three variables, ethnicity, location, and wealth. The data tables from which these significant relationships were obtained are located in Appendix G and Appendix H; the tables in Appendix G identify the subgroups within the variables that were significantly different, and the tables in Appendix H present the results of log-linear modelling of drought-coping strategies and the variables location, ethnicity, and wealth. Extremely minor drought-coping strategies, those adopted by less than 5 percent of the sample, are not discussed.

Table 5.1. Percent adopters of 29 drought-coping strategies for the entire sample of 599 households, 1984 and 1973.

DROUGHT-COPING STRATEGIES	1984		1973	
	n	%	n	%
ASSISTANCE				
Aid from family or friends	283	47.2	370	61.8
Government aid	65	10.9	144	24.0
AGRICULTURAL: CASH CROPS				
Grew more cash crops	24	4.0	8	1.0
Grew short-cycle groundnuts	44	7.3	1	0.2
Grew tubers	17	2.8	2	0.3
Grew vegetables	48	8.0	7	1.2
Grew watermelon	8	1.3	0	0
Grew mangos	9	1.5	2	0.3
AGRICULTURAL: FOOD CROPS				
Grew less cash crops	319	53.3	353	58.9
Grew short-cycle millet and sorghum	523	87.3	7	1.2
Grew short-cycle beans	46	7.7	0	0
Grew fonio	33	5.5	45	7.5
LABOR AND MIGRATION				
Head of household migrated	105	17.5	219	36.6
Family members migrated	409	68.3	290	49.1
Took wage labor at home	311	51.9	341	56.9
Caste occupations	13	2.2	17	2.8
Artisanal production	29	4.8	38	6.3
DIVESTMENT OF LIVESTOCK				
Sold cattle	90	15.0	189	31.6
Sold sheep or goats	407	67.9	414	69.1
DIVESTMENT OF OTHER ASSETS				
Sold agricultural or other equipment	37	6.2	80	13.4
Sold boat	2	0.3	9	1.5
Sold jewelry	6	1.0	31	5.2
Sold other asset	14	2.3	29	4.8
STIGMATIZED STRATEGIES				
Wild foods	8	1.3	58	9.7
Begged	0	0	1	0.2
Pledged asset or family member	6	1.0	25	4.2
OTHER				
Fished	19	3.2	31	5.2
Petty trade	4	0.7	6	1.0
Livestock trade	2	0.3	2	0.3

Table 5.2. Significant main effects between 29 drought-coping strategies and the variables ethnicity, location, and wealth.

DROUGHT-COPING STRATEGIES	VARIABLES	PERIOD	PERCENT ADOPTION*			X2	SIG.	DF
			1	2	3			
ASSISTANCE								
Aid from family or Friends	Ethnicity	1973	63	53	71	7.84	0.01	2
	Wealth	1984	54	48	38	7.59	0.02	2
Government aid	Ethnicity	1973	30	21	4	33.39	0.00	2
	Ethnicity	1984	16	3	2	33.31	0.00	2
AGRICULTURAL: CASH CROPS								
Grew more cash crops	No significant interactions							
Grew short-cycle groundnuts	Ethnicity	1984	9	5	2	7.52	0.02	2
	Zone	1984	2	9	8	9.93	0.00	2
Grew tubers	Ethnicity	1984	4	0	1	6.71	0.03	2
	Zone	1984	0	5	1	8.60	0.01	2*
Grew vegetable garden	Ethnicity	1973	0	0	4	8.73	0.01	2
	Zone	1973	3	1	0	6.12	0.04	2**
	Ethnicity	1984	8	0	22	41.70	0.00	2
	Zone	1984	22	6	0	53.95	0.00	2
	Wealth	1984	3	10	11	9.29	0.00	2
Grew watermelon	No significant interactions							
Grew mangos	Wealth	1984	0	1	3	7.02	0.02	2**
AGRICULTURAL: FOOD CROPS								
Grew less cash crops	Ethnicity	1973	65	49	51	12.87	0.00	2
	Zone	1973	46	63	63	12.67	0.00	2
	Zone	1984	44	55	59	7.05	0.02	2
	Wealth	1973	65	60	50	7.00	0.03	2
	Wealth	1984	43	58	48	8.57	0.01	2
Grew short-cycle millets and sorghums	Ethnicity	1984	91	95	57	65.14	0.002	
	Zone	1984	69	93	93	46.38	0.00	2
Grew short-cycle beans	Ethnicity	1984	10	4	4	7.03	0.02	2
	Zone	1984	6	12	1	22.49	0.00	2
Grew fonio	Ethnicity	1973	12	0	0	39.41	0.00	2*
	Zone	1973	0	0	28	117.93	0.00	2*
	Wealth	1984	3	5	9	6.30	0.04	2
LABOR AND MIGRATION								
Head of household migrated .	Wealth	1973	41	40	26	8.99	0.01	2
	Zone	1984	18	14	24	6.73	0.03	2

Table 5.2 (continued).

Family members migrated	Ethnicity	1973	58	26	51	43.81	0.00	2
	Wealth	1973	45	55	42	7.68	0.02	2
	Ethnicity	1984	71	57	74	11.61	0.00	2
	Wealth	1984	60	73	68	7.25	0.02	2
Took wage labor at home	Zone	1973	62	67	34	48.91	0.00	2
	Zone	1984	46	50	61	7.23	0.02	2
	Wealth	1984	50	56	44	6.91	0.03	2
Caste occupations	Ethnicity	1973	4	0	0	11.48	0.00	2*
	Zone	1973	0	4	3	9.85	0.00	2
	Ethnicity	1984	4	0	0	13.21	0.00	2*
	Wealth	1984	3	3	0	7.84	0.01	2*
Artisanal production	Zone	1984	6	6	0	7.95	0.01	2*
DIVESTMENT OF LIVESTOCK								
Sold cattle	Ethnicity	1973	40	18	17	35.96	0.00	2
	Zone	1973	19	24	56	60.25	0.00	2
	Wealth	1973	35	34	23	6.79	0.03	2
	Ethnicity	1984	17	16	4	11.98	0.00	2
	Zone	1984	8	17	18	7.63	0.02	2
Sold sheep or goats	Ethnicity	1973	61	82	83	32.90	0.00	2
	Zone	1973	84	77	41	81.99	0.00	2
	Wealth	1973	63	68	76	6.38	0.04	2
	Ethnicity	1984	66	76	64	6.04	0.04	2
	Wealth	1984	59	71	70	7.56	0.02	2
DIVESTMENT OF OTHER ASSETS								
Sold equipment	Zone	1973	8	18	9	12.76	0.00	2
Sold boat	Ethnicity	1973	7	0	0	97.62	0.00	2*
	Zone	1973	4	0	2	65.57	0.00	2
Sold jewelry	Ethnicity	1973	7	4	1	6.16	0.04	2
Sold other	No significant interactions							
STIGMATIZED STRATEGIES								
Ate wild foods	Ethnicity	1973	11	10	2	9.17	0.01	2
	Zone	1973	1	11	14	21.68	0.00	2
Begged	No significant interactions							
Pledged asset or family member	Ethnicity	1973	4	8	0	6.64	0.03	2**
	Zone	1973	0	6	4	8.41	0.01	2**
OTHER								
Fished	Ethnicity	1973	0	0	31	97.62	0.00	2*
	Zone	1973	19	0	0	65.57	0.00	2*
	Ethnicity	1984	0	0	18	49.53	0.00	2*
	Zone	1984	12	0	0	39.72	0.00	2*
Traded livestock	No significant interactions							
Petty trade	No significant interactions							

a Percent adoption of strategies by Ethnicity, Zone, and Wealth groups.
* Frequency in 33% of cells < 5 - statistics not reliable.
** Frequency in 50% of cells < 5 - statistics not reliable.

The drought-coping strategies employed in each of the locations, by each of the ethnic groups, and by each wealth class are discussed in the same order that the 29 drought-coping strategies were presented in Table 5.2.

Assistance Strategies

Aid from Family or Friends

In 1973, 62% of the sample reported receiving assistance from their family or friends. By 1984, this figure had dropped to 47% of the sample. This strategy, as useful as it was in 1973, was replaced by other more self-reliant strategies that addressed the subsistence crisis in a productive rather than consumptive manner. The principal strategy used to address the subsistence crisis after 1973 was the adoption of short-cycle millets and sorghums as food crops. Other strategies used in addition to the change from long-cycle crop varieties to short-cycle varieties were labor migration and wage labor.

The Peul in 1973 reported receiving aid from family or friends significantly less than the average response for the entire sample and the number of Somono reporting receiving aid from family or friends was significantly more than average. There were no other differences based on ethnicity nor were there any differences by ecozone.

If the possession of assets (livestock, land, equipment) in 1984 gives any indication of the potential for use of assistance from family or friends in 1973 or 1984,

then perhaps the reason for the neglect of this strategy by the Peul, the richest ethnic group among the three groups, and the greater use of this strategy by the Bamana and Somono, become clearer. The assets of the Peul are significantly greater than those of the Bamana and Somono.

Poor people (those people with assets less than $775.00) reported significantly greater use of this strategy than expected[10] in 1973 and 1984. This result suggests that mutual aid was a significant survival strategy for the poor in 1973 and during 1984. The response of rich respondents (those with assets greater than $2140.00), on the contrary, was significantly less than expected in both years. The rich, in contrast to the poor, were able to maintain their household economies without recourse to relatives and friends.

Mutual aid is one of the mechanisms used during adversity that is held by the in the moral economy hypothesis to have broken down under the impact of colonialism and capitalism (see Chapter Two). The evidence suggests that this is not the case in the study area; mutual aid is a significant strategy today. Mutual aid reflects the variability of drought impacts just as the spatial scatter of farm plots: people possess a wide network of relations over a wide area. Not everyone (even those of one "class") will be equally affected by drought in a region.

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[10] Expected values are the average values for the whole sample.

Government Aid

In 1973, 24% of the sample reported receiving assistance from the government of Mali. In 1984, however, only 11% reported being assisted by the government. In 1973, relief food was given gratis from the government but in 1984 people were required to pay for relief food and, although the prices charged did not represent the market value of the cereals, they undoubtedly deterred some families from taking relief in this form particularly as the relief food was unfamiliar to local tastes. A further possible explanation of the decline in use of government aid is that by 1984 people did not need it; the subsistence crisis had been met for most families through the adoption of short-cycle cereals and people were less vulnerable to drought than they were in 1973.

The number of Bamana respondents who reported receiving government aid in 1973 and 1984 was significantly greater than expected. The number of Somono who reported receiving government aid was significantly less than expected in 1973 but in 1984 their response was not significantly different from the expected value. There were no differences between the wealth classes in the use of government aid in either period. This is significant because one would expect that the poor receive more government aid than the rich. Perhaps the political risks of offering free or subsidized cereals to the poor and not to the rich were too great and equal access was given to both groups. A similar situation

occurred in Red Sea Province in the Sudan during a 5-year World Food Program relief program. The Beja agropastoralists, the principal beneficiaries of the program insisted on an equal distribution of relief between rich and poor and between tribes. They maintained that the reason for this was that god had provided the relief and all should share god's benefits.

Can a case be made that the food aid was donated along ethnic lines in 1973; specifically that the Bamana received more than their due share of relief? Thirty percent of the Bamana, 21% of the Peul, and only 4% of the Somono reported receiving food aid from the Bamana-controlled government during the 1973 drought. Although no definitive statements can be made, the hypothesis that there was a differential distribution of aid seems appropriate. This may reflect the greater vulnerability of farmers to drought compared to herders or fishers and the Government of Mali's response. In 1984, in contrast to 1973, aid was not given gratis to the heads of household but sold for a nominal sum per 100 kg sack.

Agricultural Strategies: Cash Crops

Increased the Cultivation of Cash Crops

The number of respondents reporting an increase compared to the predrought period in the cultivation of cash crops in 1973 was only 1% of the sample. In 1984 that

figure had risen to 4% of the sample. There were no significant interactions, however, between any of the variables.

A conventional wisdom on food versus cash cropping during times of environmental variation is that the food crops will be given precedence. This is because there are subsistence issues that must be addressed during drought and cash crops are generally drought intolerant. Food crops, in contrast, are most often drought tolerant; farmers usually grow or keep seed for several varieties with varying moisture requirements and length to maturity. The Chef de Zone for Opération Riz stated in 1985 that when the drought years began in the early 1970s farmers switched from spending about 80% of their time on the rice crop, a big money earner, and 20% on the millet and sorghum crops to spending about 80% of their time on the millet and sorghum crops and 20% on the rice crop. Despite the claims of the critics of cash crop cultivation, cash crops play (and have always played) a very important role in the economy in the study area. The importance of cash crops is seen in the speed in which alternative varieties of cash crops that require less moisture and mature faster than the customary varieties were adopted in the years following the drought in the early 1970s and particularly after 1980 when the second series of dry years occurred. According to respondents, most farmers, for example, kept planting the same long-cycle groundnut varieties after the drought in the early 1970s but

after 1980 when it "a state of permanent drought" (Diallo 1985) appeared established, the use of short-cycle varieties increased dramatically (see the example of groundnuts below).

Cultivation of Short-cycle Groundnuts

This strategy was used by less than 1% of the total sample in 1973, however, by 1984 over 7% of the sample reported growing short-cycle groundnuts as a strategy to cope with drought and there were some significant results. Results for 1973 are unreliable because 50% of the cells in the crosstabulation had fewer than five member items. Short-cycle groundnuts (peanuts and chickpeas) are new varieties that were brought to the study area in the early 1980s by local young men who migrated to Sénégal for employment in the late 1970s and who then returned. The groundnut basin in Sénégal is drier than the study area and, according to respondents, many short-cycle groundnut varieties are available. Migrants bring many types of crops to their home areas from their destinations in order to experiment with them (author's study 1985).

There were no significant differences between the ethnic groups, ecozones, or wealth classes in 1973. The Bamana reported growing short-cycle groundnuts significantly more than expected in 1984. This is perhaps to be expected as the Bamana are the most important farming group in the study area. The respondents in the River Zone reported

growing short-cycle groundnuts significantly less than expected; and people in the Middle Valley Zone, where most of the farming takes place in the study area, reported growing short-cycle groundnuts significantly more than expected in 1984. The villages in the River Zone, a tight band of land sandwiched between the rice polders and the Niger river, have the highest population on average than anywhere else in the study area and land is more scarce than in the other ecozones. The only part of the River Zone where land is available is in the western part of the Zone near the Bamana village of Tukoro. Most of the cultivation in the River Zone is millet and sorghum, rice, mangos, and vegetable gardens. Another reason for relatively less use of new varieties of groundnuts in the River Zone may have to do with soil that is heavier than the silt loams and sands of the Middle and Outer Valleys. Most of the groundnuts in the study area have been grown traditionally on the sandy soils of the Outer Valley Zone and it is interesting that farmers there did not report a significant increase in the use of short-cycle varieties. According to an interview with an Opération Arachide agent during the course of fieldwork (Ahmad 1985), the farmers in the Outer Valley Zone have been adopting a new cash crop, watermelon, in place of groundnuts (both peanuts and chickpeas) on the sandy soils. Watermelon is attractive because it is drought-tolerant, it does very well on sandy soils, and it is not taxed by the government. Farmers who work under the aegis of Opération

Arachide, in contrast, are required to sell their peanuts at government prices. Significantly, the only part of the study area where Opération Arachide has an extension program and an extension agent is in the Outer Valley Zone. Just as rice and, to a much more limited extent, mangos are the cash crops of the Middle Valley and River Zones, groundnuts (and watermelon) are the cash crops of the sandy Outer Valley. The rich reported cultivating short-cycle groundnuts significantly more than expected in 1984.

Vegetable Gardening

Vegetable gardening for the market, probably the most innovative and lucrative of the different cash crop strategies, was used by only 1% of the sample in 1973. In 1984, the use of gardening had risen to 8% of the sample. Results for 1973 are unreliable because 50% of the cells in the crosstabulation had values less than 5.

Water for vegetable gardening is obtained by dipping gourds or tin watering cans in the Niger River or polders. The bulk of the vegetables are destined for the Ségu market, although all vegetables varieties are also eaten; there are no exclusively cash crop vegetables grown in the study area. The only non-vegetable grown along the river is local tobacco and that is increasingly giving ground to more profitable vegetables. Some of the vegetables are planted on islands in the Niger River. Typical vegetables grown are tomatoes, onions, African tomatoes (nkoyo), and sweet

potatoes. Tomatoes are the greatest income earner by weight but onions are grown on a larger area.

The response of the Somono differed significantly from that which was expected in both 1973 and 1984. During both periods the Somono reported gardening more than expected; 1984 being greater than their response in 1973. The Peul respondents in 1984 reported growing gardens significantly less than expected.

Respondents in the River Zone reported growing gardens significantly more than expected in 1984 but not in 1973, while the respondents in the Outer Valley Zone reported significantly less use of gardens than expected in 1984. Poor people reported growing vegetables significantly less in 1984 than average and rich respondents.

Use of this strategy is dependent on the availability of water for irrigation. This is why location is important. Ethnicity is important because each ethnic group in the study area has an occupational specialization and inclination (although this does not preclude other activities). The Somono are fishers who also farm. The Bamana are farmers who sometimes fish. The Peul are livestock raisers who also farm but who are not inclined to farming. Another reason for the Peul disinterest in gardening is unfamiliarity with gardening techniques. A further reason is that there was relatively little pressure on them to adopt gardening because they were little affected by drought in either 1973 or 1984.

The difference between the River and Outer Valley Zones on this drought-coping strategy is that access to water in the Outer Valley Zone is difficult. There is no surface water and the water table is over 30 meters deep. Clearly, there are serious labor constraints to gardening in the Outer Valley.

The relatively high costs of entry into vegetable gardening may have been the reason for the difference in adoption between the wealth classes. This difference may also reflect trade-offs between food and cash crops and labor bottlenecks experienced by poor people as a consequence of the small family size of poor families. Poor families have, on average, 10 members, while average income and rich families have 15 and 25 members on average, respectively. Today, as during the precolonial period, the command of labor is a critical factor in the provision of subsistence and the adoption of innovation. However, there was an increase in the percentage of the poor that adopted gardening. It may be that this was the result of extension work by Opération Riz to increase vegetable production in their zone of operations, particularly for poor people. In the mid-1970s this extension program was designed to develop and diffuse good family gardening practice throughout the study area. Free seeds were distributed to all those interested and three extension agents were involved in this project.

Agricultural Strategies: Food Crops

Reduction in Cash Crop Cultivation

In 1973, 59% of the sample reported reducing the area devoted to cash crops. In 1984, this figure remained more relatively unchanged at 53% of the sample. There were, however, differences between the ethnic groups, ecozones, and wealth classes. The issue of the inappropriateness of cash crops under reduced rainfall regime is obscured by the fact that short-cycle varieties of cash crops have been introduced and are replacing the longer-maturing old varieties in the same way that short-cycle millets and sorghums replaced the slow varieties. It may be that now that the subsistence crisis has been addressed by the almost universal adoption of short-cycle varieties of food crops, the cash crop agriculture that was de-emphasized after the drought in the early 1970s will reassume its importance using short- rather than long-cycle varieties.

The Bamana in 1973 reported significantly greater than expected reduction in cash cropping. In 1984, this figure was not different from what was expected. The reduction in cash cropping for the Bamana in 1973 was probably related as much to the need to address a subsistence crisis caused by drought intolerant food crops as it was to cut losses from drought-intolerant cash crops. The Bamana, as the group most heavily involved in agriculture, felt the greatest impacts of drought and courted the greatest risk of failure.

Respondents in the River Zone in 1973 and 1984 reported significantly less than expected reduction in cash cropping. This may have been related to moisture availability since some cash crops in the River Zone are practically immune to drought, for example vegetables grown on islands or mangos in flooded areas.

The respondents in the Middle Valley Zone reported a significantly greater than expected reduction in the use of cash crops. In 1984, the difference was not significantly different from the expected value. The respondents in the Outer Valley in 1984 reported significantly greater reduction in cash cropping than expected. The Middle and Outer Valleys possess the principal dryland farming areas in the study area. These areas are the riskiest for cash crops - at least until quick-maturing varieties were introduced in the early 1980s.

The respondents of average wealth reported in both 1973 and 1984 greater than expected reduction in the use of cash crops. Average reduction in area devoted to cash crops for the rich was 25%, for those of average means, 53%, and for poor people, 69% between 1973 and 1984 (author's study 1985). Cultivation of food crops rose 18% for the rich, 16% for the average, and declined 8% for the poor from 1973 to 1984. Uncultivated land was put into fallow until conditions for cultivation got better. It seems that poor people prefer to withdraw from risky cash crop agriculture with its high water requirements and risk of loss more than

the average and rich respondents, although both latter groups reduced their cash crops significantly. That the poor decreased the area under cultivation of food crops is at first sight distressing, however, the poor are probably so risk averse that the potential loss posed to investment in risky agriculture is too great to warrant but cautious involvement. It may be that the poor engaged in other activities: of less risk and of surer return than agriculture are mutual aid institutions, seasonal migration for employment, and local wage labor.

Cultivation of Short-cycle Varieties of Millet and Sorghum

In 1973, 1% of the sample reported growing short-cycle varieties of millet or sorghum as a drought-coping strategy. In 1984, use of these varieties rose to 87% of the sample. Among the Bamana and Peul the use of these varieties rose to greater than 90% of the respondents. The lowest were the Somono with 59% of the respondents. The change between 1973 and 1984 was so extreme that it amounts to an agricultural transformation and went far to resolve the subsistence crises that began with the 1973 drought. Short-cycle varieties of millet and maize have always been grown in the study area as hungry season crops. During the predrought period, small enclosures of these varieties were planted near the house or in a field enclosure devoted to specialty crops. Planting near the house was far more common than the

use of field enclosures. In the hungry season prior to the harvest of the late-maturing sorghum and millet crops, these short-cycle (60-70 days) varieties were consumed. Yields are reported to be greater than with the long-cycle varieties (Toulmin 1986). According to respondents, in the ensuing low-rainfall years after the drought of 1973, particularly after 1980, farmers used the seed stocks of the short-cycle millets cultivated near the house to replace the long-cycle varieties formerly planted on the infields and outfields. Seed stock for some long-cycle varieties can no longer be found in the study area. Somono still plant the old varieties on seasonally-inundated islands in the Niger River and 50 or 100 km to the south of the study area, where the rainfall regime is higher, the old varieties are still used. In the study area, the area under maize was not expanded from 1973 to 1984 as was the area under short-cycle millets and sorghums because maize requires more moisture and heavier manuring than millets and sorghums. It is for this reason that maize is still grown in specialty enclosures in favored areas where inputs can be controlled. It was reported by respondents in the Outer Valley that during the 1950s, a more humid period, short-cycle maize was grown in the infields around the village outside of specialty enclosures.

Short-cycle varieties of millet and sorghum, typically from 60 to 70 days from germination to maturity, although more drought-resistant than the formerly cultivated late-

maturing varieties, are risky to the early adopter. Considerably less risk is posed when everyone in an area adopts at the same time. Because the maturity of the short-cycle varieties coincides with the seasonal maximum density of the millet/sorghum pest, the quelea bird, early and lone adopters have high crop loss because the Quelea birds focus on a small area. The risk of crop loss is less after everyone adopts and losses are spread among more people.

Of all the drought-coping strategies adopted after the drought of 1973, the spread in the use of short-cycle varieties of millet and sorghum is perhaps the most interesting and richest in implications. The short-cycle varieties formerly grown around the house in the study area functioned as hungry-season crops and seed stocks in case of drought.

There were no significant differences in 1973 in the use of this strategy by ethnic group, ecozone or wealth, indeed, almost no one used these varieties except as a hungry season crop cultivated on small areas around the house. By 1984, these varieties were being planted in infield and outfield alike and dominated production to such an extent that it was becoming difficult to find seeds for the late-maturing varieties that were formerly cultivated.

The Bamana and Peul respondents reported significantly greater than expected use of short-cycle varieties of millet or sorghum and the Somono, in contrast, reported significantly less than expected. The Somono grow the old

varieties in low spots along the Niger River and on seasonally-inundated islands (guun) in the Niger River. The respondents in the River Zone where the old varieties are grown on islands, reported significantly less adoption of short-cycle varieties than expected in 1984. The respondents in the Middle and Outer Valleys reported use of short-cycle varieties of millet or sorghum greater than expected. There were no differences based on wealth.

Cultivation of Short-cycle Beans

There were no respondents who reported growing short-cycle beans as a drought-coping strategy in 1973. In 1984, 8% of the sample reported using short-cycle beans. The increase in the use of short-cycle beans, although by no means great, is part of the agricultural transformation that is taking place in the study area. The increase in the use of short-cycle beans, like the increase in the use of all short-cycle varieties of crops, will undoubtedly increase unless precipitation becomes as high as it was in, for example, the 1950s.

In 1984, the number of Bamana respondents who reported using short-cycle beans was significantly greater than expected. There were no other differences based on ethnicity. The respondents in the Middle Valley who reported adopting short-cycle beans in 1984 was significantly greater than expected. The respondents in the Outer Valley who reported adopting short-cycle beans in 1984

was significantly less than expected. There were no significant differences by wealth class.

It seems that environmental conditions in the Middle Valley, particularly along the rice polders and in the seasonally inundated streams which flow through the Middle Valley to the polders, are favorable for the cultivation of short-cycle varieties of beans, the well-known shoblenni. Unlike the short-cycle varieties of millet and sorhgum, short-cycle beans are not more drought resistant than the late-maturing varieties (shojéba); their importance lies in the fact that they mature much earlier than the former varieties and address the subsistence problem of the people in the study area. The moisture requirements of the short-cycle bean are greater than those of the late bean; the short-cycle bean is planted in seasonally inundated areas. Although both the River and Middle Valley Zones have many inundated areas, it is the population of the Middle Valley which is preponderantly farmers. Like fonio, which is discussed below, short-cycle beans are a hungry season crop. The hungry season is that period from the beginning of the agricultural season to the harvest when labor requirements are greatest and food availability is least. Fonio, grown in outfields, and short-cycle varieties of millet (sunna), grown around the village, were used before the 1973 drought during the hungry season. Although both fonio and sunna millet are still grown (sunna and other short-cycle varieties now dominate cereal production) the adoption of

short-cycle beans may be seen as an insurance mechanism for food security.

Cultivation of Fonio

Fonio, a traditional hungry season crop in central and northern Mali, was reported to have been grown in 1973 as a drought-coping strategy by 8% of the sample. In 1984, 6% of the sample reported growing fonio. The only ethnic group that differed significantly from the expected value was the Bamana in 1973; their response was significantly greater than expected. The respondents of the Outer Valley Zone reported growing fonio significantly greater than expected in 1973. There were no differences in 1984. In 1984, the rich reported a significantly greater cultivation of fonio than expected. As the Bamana are principally farmers, the adoption of fonio during the food crisis associated with the drought of 1973 seems logical. That respondents in the Outer Valley in 1973, relatively limited in opportunity compared to the respondents in other ecozones, should adopt fonio makes sense as well. The results on the use of this strategy by the wealthy are difficult to interpret. In 1984, the rich reported a significantly greater adoption of fonio than the other groups. Under even the most difficult of circumstances, wealthy people are considered to be relatively free from subsistence crises. This is probably the case, and the interesting response of the rich in 1984 can perhaps be explained in part by the concern held by

Opération Riz in the early 1980s at the decreasing cultivation of fonio throughout their operational area. According to the Chef de Zone of Opération Riz, the Opération adopted a policy to encourage fonio cultivation as a hungry season crop. This policy was brought to the farmers' attention by the many extension agents of the Opération; however, the extension agents do not work with farmers who do not grow rice. It may be that Opération Riz's extension program is oriented toward large and rich rice farmers.

Labor and Migration Strategies

Wage labor and wage labor migration are extremely important economic activities in the study area. Young unmarried men form the bulk of the labor force. It is the contribution of the wage labor migrant to the familial economy that is ignored in the moral economy hypothesis. Richards (1986) would view wage labor migration as one tool of many that is used to steer the household economy through changing circumstances. It is interesting to compare wage labor migration with the common dry-season activity of young men during the precolonial period. During the precolonial period, young men would go off to war with the armies of the Segovians during the dry season. Both wage laboring and pillaging bring a return but wage labor migration is so much more socially productive.

Today, during normal times, most families have at least one member of the family working outside the study area. During drought more, and perhaps all, able-bodied people, including the head of household if he is able-bodied, seasonally migrate in the worst crises. In any year migrants leave their families just after the harvest and remain working up to the beginning of field preparation the following year. Some villages in the study area have a celebration for returning migrants a few weeks before field preparations begin. The contribution of migrants to the local economy is great. The ideal use of migrant-earned income is to buy livestock (reproducible capital) but in reality the money is used for many things. Generally, every member of the family receives a gift (usually clothes) from the successful migrant, and the cash remainder is given to the head of the household to use as he sees fit for the benefit of the entire household.

Head of Household Migrated

Thirty-seven percent of the respondents reported that they themselves migrated to seek employment during the drought of 1973. In 1984, only 18% of the respondents reported migrating to seek work. There were no significant differences by ethnicity in either 1973 or 1984. The number of respondents in the Middle Valley who reported that the head of household migrated to seek work was significantly less than expected. The number of respondents in the Outer

Valley who reported that the heads of household in 1984 migrated to look for work was significantly greater than the expected number. There was only one difference between the wealth classes in either 1973 or 1984: the number of rich respondents who reported that the head of household migrated to seek employment was significantly less than expected in both years.

The adoption of other drought-coping strategies, particularly those addressing the subsistence crisis (food crop strategies), probably were responsible for the decline in the number of heads of household who migrated to seek employment from 1973 to 1984. Perhaps the difference between the zones reflects the limited opportunity of the Outer Valley.

Migration of Family Members

In 1973, 49% of the sample reported that family members, most often sons but sometimes daughters, were sent out of the home area to seek employment. In 1984 that figure had risen to 68% of the sample. In 1973, the roads linking the study area with the outside world were not well developed and in need of repair. In 1978, the roads from Bamako to Ségu and from Ségu to Mopti were completed. The trip from Ségu to Bamako, a trip that previously required six to eight hours to make, now could be done in as little as two hours. The building of this road had an important impact on human movement into and out of the Ségu Region and

it may have had an impact on the seasonal migration of family members in the study area.

The number of Bamana respondents who reported that they had sent their children elsewhere to seek work in 1973 was significantly greater than expected, however; there was no difference in 1984. The number of Peul respondents who sent their children elsewhere for work in 1973 and 1984 was significantly less than expected. The only significant departure from that expected by ecozone was the Outer Valley in 1984, where the number of respondents who sent their children out of the area to look for work was significantly less than expected. There were no other differences. Interestingly, the children of families of average wealth migrated significantly more than the rich or poor in 1973 but in 1984 the poor migrated significantly less than the Average. The small average size of the poor family may explain these results.

The outmigration of people to seek employment during a crisis seems to be a good indicator of the severity of the crisis at least along ethnic or ecozone lines. The use of this strategy by the Bamana reflects the high risk of agriculture while the lack of use by the Peul reflects the advantages of stockrearing. The mobility of livestock makes them virtually a drought-proof investment. During the dry season the herders take their stock to the forests south and southwest of the study area. During drought the animals are

taken south of the Bani river for pasturing (author's study 1985).

Determining the severity of a drought based on migration by wealth class is a bit more problematic than based on ethnicity or ecozone in that wealth in the study area is related to the size of a family's labor force. People with small families may not be able to send family members away to earn money elsewhere. The average number of people in rich families in the sample were 25, in average families the number was 15 and poor families 10 persons.

The response of the people in the Outer Valley is, at first impression, puzzling. Coupled with the 1984 response of the Outer Valley on migration the head of household (significantly higher) and wage labor in the home area (significantly higher), their significantly lower response to migration of family members becomes clearer. Because of the limitations to agriculture in the Outer Valley Zone other strategies must be used for survival; the head of household in the Outer Valley migrated more than his counterparts in the other ecozones in 1984, family members did more local wage labor in 1984. This suggests that in the Outer Valley, family members stayed home and worked while their heads of households migrated to look for employment.

Wage Labor in Home Area

In 1973, 57% of the sample reported that family members engaged in wage labor at home. In 1984, 52% of the sample reported doing so. The Somono respondents reported significantly more use of this strategy than expected in 1973. This was principally fishing for wages by young men without boats, although, some agricultural wage labor was involved. There were no other differences based on ethnicity.

All three ecozones differed significantly from expected. The respondents in the River and Middle Valley Zones reported the use of wage labor in the home area significantly more than expected while those in the Outer Valley Zone reported significantly less than expected in 1973. In 1984, only respondents in the Outer Valley Zone reported significantly more use of wage labor than expected reversing their previous response on this strategy. It is unclear why this was so.

The response of the average wealth class was significantly more than the expected in 1984. Perhaps people of average means feel the economic necessity and dispose of sufficient familial labor (compared to the poor, for example, who tend to have the smallest families) to engage in outside wage labor.

Divestment of Livestock

Divestment strategies are most often used over the long term to acquire assets during good times and shed assets during bad times. The intention is to buffer the ups and downs related to environmental variation. Livestock are the most important investment opportunity in the study area. Cattle reproduce once a year and sheep and goats twice a year (twinnings are common in good years). The importance of livestock stems from their reproduction: the progeny can be used to buffer shortfalls in production. For a relatively small investment, a family can have the means, for example, to pay taxes each year or to buy several extra sacks of sorghum. In the event of drought and low harvest, livestock sales (although the price of livestock depreciates during drought) provide a means to maintain income and consumption levels. Livestock divestment is used in conjunction with other drought-coping strategies in a manner that best suits the abilities of the household. In some large households where there are several young men to migrate seasonally, most of the families livestock may be sold during drought to pay for food. The actual mix of divestment and other strategies depends on the resource endowments of a family as well as the family's ethnic group and location.

Sold Cattle

Thirty-two percent of the sample reported that in 1973 they had sold cattle as a drought-coping strategy. In 1984, this figure had dropped to 15%. The Bamana and Somono response differed significantly from the expected response for both years. For the Bamana this difference was positive but for the Somono negative. The Bamana, particularly those in the Middle Valley, have been the principal beneficiaries of the rice production scheme that was put into operation in the late 1950s. Although the first plow was used in the study area in the mid-1940s, it was during the 1950s and 1960s that animal traction became almost universal there, subsidized by cheap credit and diffused by ambitious extension programs aimed at developing modern rice-production techniques. Cattle, formerly the domain of Peul and Forobafla, had assumed a principal role in the Bamana agricultural system. Successful agriculture without captive labor, the principal foundation of agriculture during the precolonial period, depends on the use of animal traction to increase the productivity of labor. With the profits from rice production the Bamana expanded both their draught and milk herds. The Bamana do not have the tradition of livestock raising as do the Peul and the Bamana are considered to be inept cattle raisers in comparison to the Peul. They do not know pasture and do not practice mobility as do the Peul. From March to the end of May, 1985, when the Bamana herds were dying of starvation or being

slaughtered for sale before they could starve to death during the dry season in 1984-85, the Peul and Forobafla herds survived. These herds were south of the Bani River where drought impacts were slight.

The number of the respondents in the River Zone who reported that they sold cattle was significantly less than expected in 1973 and 1984. Although most people with cattle send them to the river every other day, there is neither space nor pasture to raise cattle permanently there; they are usually kept on fallows in the Middle Valley, the Outer Valley, or in the forests to the south. The numbers of respondents in the Middle Valley who reported the sale of cattle was significantly less than expected for 1973 and,. for 1973, the numbers of respondents in the Outer Valley who reported cattle sales was significantly greater than expected. The reason for this is unclear. In 1973, rich people sold significantly less cattle than the average and poor classes. There were no differences in 1984. Perhaps the economic stress was less in 1984 in comparison with the 1973 period. This suggests that average and poor families in the sample (those with less cattle) tend to divest their cattle during times of stress more than the rich. Ideally, cattle are kept for investment purposes and sheep and goats are used as cash. Rich people can afford to treat cattle as a reproducible investment while poor people cannot; the rich have the labor power to manage large herds of cattle and they have other assets to fall back on in the event of

economically stressful times. Poor people prefer to keep small ruminants because they are more drought tolerant than cattle (less risky), cheaper, require a much smaller investment of labor, and they reproduce quicker. During environmental stress, when labor constraints may be at their highest and the need for cash great, the poor and average are quick to sell their few cattle before they die.

Sold Sheep or Goats

In 1973, 69% of the respondents reported that they sold sheep or goats to cope with drought. In 1984, this figure was 68%. There were significant differences for all variables on this drought-coping strategy. The number of Bamana respondents who reported selling sheep or goats was significantly less than expected in 1973. The number of Somono respondents reporting this strategy in 1973 was significantly greater than expected and the number of Peul in 1984 was significantly greater than expected. All three ecozones differed significantly from expected in 1973: the difference being greater for the River and Middle Valley Zones and smaller for the Outer Valley Zone. The reasons for these differences are unclear. There were no differences in 1984. The number of poor respondents who reported selling sheep or goats in 1973 and 1984 was significantly less than expected while that for the rich in 1973 was greater than expected. Except among the Bamana, selling sheep or goats was preferable to the sale of cattle.

Sheep, and especially goats are used as cash in the study area.

Divestment of Other Assets

Sold Agricultural or Other Equipment

In 1973, 13% of the sample reported the sale of agricultural or other equipment. In 1984, this figure had dropped to 6% of the sample. There were few differences between the variables on this drought-coping strategy. The number of respondents in the Middle Valley Zone was significantly greater than expected in 1973. There were no differences according to wealth.

The sale of agricultural equipment is a dangerous strategy that undermines productivity and subsistence. That people in the Middle Valley, principal agricultural zone and where Opération Riz has concentrated its credit and extension efforts, sold more than other groups in 1973 may be more support for the hypothesis that farmers were hardest hit by drought in the early 1970s.

Stigmatized Strategies

Stigmatized strategies are those drought-coping strategies held to be demeaning by most people in the study area. The use of wild foods, begging, and the pawning of assets or members of the family are three stigmatized strategies mentioned by the respondents. It is significant that these strategies, used only by those pushed to the wall

by adversity, are declining in use in the study area. The use of these strategies declined from 1973 to 1984 and, as Chapter Four and Five show, from the precolonial period to the present. The moral economy approach hypothesizes that the use of stigmatized strategies should increase over time; as market relations are established and spread, vulnerability to the impacts of drought increases as a consequence and people are impoverished and forced to engage in unpleasant activities in order to survive. The model of Boserup and Richards, in contrast, is based on the premise that there is a wide range of evolving adaptive strategies used by people in environments that experience periodic drought. Use of any mix of strategies depends on the intensity of drought, the length of the drought, how unexpected the drought is and the political, economic, locational, and social contexts in which the drought occurs. Evidence from the present study indicates that people in the study area are not being forced to engage in stigmatized activities.

Wild Foods

In 1973, 10% of the sample reported using wild foods to cope with drought. In 1984, this figure had dropped to 1% of the sample. This may have been due to the adoption of short-cycle cereals which minimized the drought-related subsistence crisis. The number of Bamana who reported the use of wild foods in 1973 was significantly greater than

expected. The number of Somono who reported the use of wild foods in 1973 was significantly less than expected. There were no significant differences in 1984 by ethnicity.

The fact that the Bamana differed significantly in the use of wild foods from the other groups lends support to the hypothesis that farmers were hardest hit by drought in the early 1970s. A list of the wild foods used by people in the study area is presented in Appendix I. The foods presented in Appendix I are those actually used by respondents during drought-induced stress periods not a list of edible plants.

Other Strategies

Fished

Many Somono respondents reported that in order to make ends meet during the drought in the early 1970s and in 1984 they fished. In 1973, 5% of the respondents reported that they had fished in order to cope with drought. In 1984, the percentage of the sample that fished was 3%. The number of Peul in 1973 who reported fishing was significantly less than expected. The number of Somono who reported fishing was significantly greater than expected in 1973 and in 1984. The number of respondents in the River Zone who reported fishing was significantly greater than expected for both 1973 and 1984. The response in the Middle Valley Zone was significantly less than expected in 1973. Fishing, like

selling the family boat or boats, is a Somono strategy and a strategy that occurs in the River Zone.

Summary

Results of the present study were examined in this chapter. It was found that drought-responses were diverse and creative in both 1973 and 1984. While 1973 may be described in general as a period of mutual aid, divestment of a variety of assets including livestock, and wage labor, 1984 was characterized by agricultural innovation to address food security issues and the need for cash, the divestment of livestock, and wage labor. The use of drought-coping strategies that were stigmatized by the general population (begging, pledging assets or a family member, and eating certain wild foods), although never used by a majority of respondents, declined from 1973 to 1984. Most non-agricultural strategies declined in general importance, with the exception of labor migration of family members other than the head of household.

CHAPTER SIX: CONCLUSIONS AND POLICY IMPLICATIONS

Conclusions

It was hypothesized in this study that the adoption of drought-coping strategies is influenced by a person's ethnicity, location, and wealth. Of particular importance to theoretical issues under investigation in the present study are the issues of mutual aid, divestment of assets, employment and outmigration, technological change (changes in crop varieties, for example), and the use of stigmatized strategies.

Two theoretical approaches to understanding the impacts of drought on human society were presented in Chapter Two. The first interpretation, from Boserup (1983, 1981, 1965) and Richards (1986) posits that drought may function to temporarily alter the human-environment relationship such that population pressure on resources seems to increase. This interpretation postulates that drought may induce technological change or improvement that enables people to produce more for the increased population. Stemming from this interpretation is the view that political, social, economic, and environmental changes that have occurred since the colonial period may provide opportunity for new response during periods of environmental stress.

The second interpretation of drought discussed in Chapter Two is the moral economy view. Proponents of this interpretation (Campbell 1977 1990, Raynault 1977 1975,

Watts 1983a) hold that the political, social, and economic changes that have occurred since the colonial period and which are associated with the market economy and capitalism have undermined and destroyed the traditional social and technical bases of production and created new mutually hostile social classes. It is held that these changes have so marginalized rural people that the impact of even small environmental variations causes social disintegration, sale of land and other assets, and permanent outmigration to urban areas.

Findings of this study do not support the moral economy hypothesis. The degree of social disintegration predicted by the moral economy hypothesis is not apparent in the study area. Mutual aid networks, for example, may have increased in importance and in area instead of disintegrating. In the twentieth century, mutual aid networks probably grew compared to the 19th century because of political stability. In the turbulent 19th century when movement outside one's home area was an invitation to robbery or enslavement, mutual aid networks must necessarily have been small. Today, in contrast, these networks are extensive, spanning the national space. Land sales never happened in the study area; not once did a respondent report that a land sale had taken place. Indeed, land sale is forbidden by customary law in Mali (although land sales are permitted in the north of Mali where Islamic law is more pronounced than in the rest of the country). The findings of the study suggest

that response to drought is a more complex phenomenon than that suggested by the moral economy hypothesis; a phenomenon influenced by a person's ethnicity, location, and wealth. The adoption of drought-coping strategies involves choice of strategies from a diverse "toolkit" of strategies that changes over time as circumstances warrant. In some cases drought can serve in the Boserupian sense of population growth as a spur to technological change which ultimately mitigates the impact of drought. The change in crop varieties from long-cycle to short-cycle is a good example of this change.

Drought responses of people in the study area were diverse and creative in both 1973, a bad drought year after an unprecedented series of wet years, and 1984, a drought year even worse than 1973. While 1973 may be described in general as a period of mutual aid, divestment, and wage labor drought-coping strategies, 1984, eleven years after the shock of 1973, was characterized by divestment, wage labor and, most importantly, agricultural innovation in cash as well as food crops that mitigated the subsistence crisis. Stigmatized strategies (such as begging, the use of wild foods, and pledging an asset or family member), although never used by a majority of respondents, declined from 1973 to 1984. Most strategies other than agricultural strategies declined in general importance, with the exception of labor migration of family members other than the head of household. Assets from seasonal migration were used to

purchase livestock and agricultural equipment for the family.

The findings suggest that in the area under study an agricultural transformation influenced by drought is taking place. There has been an almost wholesale replacement of late-maturing varieties of millet, sorghum, peanuts, chickpeas, maize, and beans by early-maturing varieties. Some of these varieties were grown as hungry season crops on small patches during humid times. Two of these short-cycle varieties (short-cycle peanuts and short-cycle sorghum) were introduced by the Malian government in the mid-1970s to address declining yields in the traditionally cultivated varieties. Other varieties were brought from outside the region by local young men returning from seasonal labor migration. Today, with the exception of the Somono who plant the old varieties on islands in the Niger River, seed for the old varieties cannot be found. These technological changes are significant because they have changed the terms of the human-environment relation from 1973 to 1984. The possibility of such a change is not dealt with in the moral economy hypothesis and is unanticipated in most behavioral models of drought response.

Another activity that changed the dimension of the human-environment relation was the cultivation of new crops. New crops such as watermelon, tomatoes and other vegetables have been adopted to maintain production and income streams under the reduced rainfall regime of the 1970s and 1980s.

The former crop was introduced as a replacement for the late-maturing variety of peanuts grown on the sandy soils of the Outer Valley. The latter crop is increasingly being adopted where ecological conditions permit (principally in the River Zone where water is abundant or on the northern periphery of the Middle Valley Zone).

While it is true that economic stress associated with drought impoverishes, this impoverishment need not be absolute nor immutable. Evidence from the present study suggests that the divestment of assets is a strategy that is part of a wider mix of strategies designed to cushion stress. Taken over time it becomes clear that a period of drought-induced economic stress and a relative decline in assets may not constitute marginalization. Individuals hypothesized to be marginalized at an observed point in time must be studied over a period of years to determine the actual changes in food security, economic activities, income streams, and the replenishment of assets rather than assuming an outcome based on a synchronic view.

In many marginal areas of Africa where the range of existing and potential drought-coping strategies is small, drought has been the cause of great human suffering. Can it be said, then, that compared to the precolonial period people are more vulnerable to the impacts of drought today? On balance, when the present period is examined against the turmoil of the precolonial period when the range of drought-coping strategies available to a family was effectively

constrained, the present period must be viewed as a period in which people are less vulnerable to drought. There are more opportunities available and there is less political instability than during the precolonial period.

Finding of this study support the view that behavioral models that incorporate a time dimension (and qualitative as well as quantitative data) are more useful aids to understanding human response to drought than macro-economic models of a putative moral economy. The moral economy hypothesis shifts attention from the real micro-level issues of decision making and adaptation to changing circumstances to an abstract, non-empirical level where verification is by agreement rather than by the observation of fact and empirical regularity. The important point is that the moral economy hypothesis does not increase our understanding of drought and human change. It should be stated that behavioral models that do not incorporate the temporal dimension are able to describe form but are inevitably unable to account for process. The use of the diachronic approach would improve behavioral models and increase our understanding of the process of change.

But who are the vulnerable today? Evidence from this study suggests that of the three ethnic groups studied (farmers, fishers, and herders), farmers are the most vulnerable to the impacts of drought, particularly farm families of small size that do not have the labor power to diversify the family economy. These families are

necessarily poor in a chronically labor scarce environment. The most vulnerable families in the study area have three characteristics: farming as the principal activity, relative poverty of assets, and small family size. The returns from farming are more variable and subject to drought impacts than the other two major activities that take place in the study area, herding and fishing. The least vulnerable to the impacts of drought are those who possess reproducible capital, livestock owners. Livestock owning is a relatively new activity for farmers in the study area; farm households which possess livestock, however, are less vulnerable than more traditional farm households. They are less vulnerable for two reasons: they possess the asset value of the livestock and livestock produce manure to enrich the farm fields. In conclusion, it must be emphasized that vulnerability to drought is something which individuals are not born with; it is something which people are prepared to change.

Implications for Policy

What implications for policy may be derived from the findings of this study?

1. Policy should be formulated not on the assumption that rural people are passive players on the economic stage. This study shows that, on the contrary, the rural households in the study area are innovative and responsive to changing

circumstances and that, to a large degree, people have a large measure of control of their vulnerability to the impacts of drought. Policy should be based on the premise that rural households are prepared for the vicissitudes of the environment and are responsible for their own well-being. Behavioral models that incorporate a time dimension and qualitative as well as quantitative data are most appropriate in understanding human response to drought. This is not to say, however, that national or international price policy issues, for just one example, are not important.

2. The impacts of drought are conditioned by a person's ethnicity, location, and wealth status. Governmental and non-governmental interventions must be sensitive to all three of these important factors and interventions must be planned, implemented and evaluated on an appropriate scale to accommodate variation in these factors. As demonstrated in this study change over time (change in status) is possible and policy makers must be aware of past conditions and possible future conditions to formulate effective and appropriate interventions today.
3. The findings of this study also call into question the appropriateness of long-term outside

assistance to people in drought-stricken areas. Although outside assistance may help households cope during "unexpected" droughts like that of the early 1970s, its usefulness during drought in the early 1980s when people were conceptually prepared for drought is questionable. In the intervening years between the two exceptional droughts in 1973 and 1984, people took steps to address the subsistence crisis posed by acute drought in 1973 and an average annual rainfall deficit of 200 millimeters since the early 1970s. There are obvious places where such an approach to assistance does not apply, for example, in northern Ethiopia where decades of war have weakened or destroyed the ability of people to cope with environmental variation.

4. Development policy oriented toward strengthening local ability to respond to drought and economic stress should focus on cash as well as food crops, particularly where the cash crop is a food crop as well. Programs encouraging local farmers to experiment with food and cash crop varieties from different parts of West Africa should be undertaken. This type of program would help increase our understanding of agriculture in semi-arid West Africa and also make available

information from local farmers who conduct their own agricultural experiments.

5. Particular attention should be placed on developing a support structure for the poor, who tend to be people with small families headed by older men or single women. Although the Mosque plays an important role in assisting such people, the role of the Mosque (through zakaat) could be enhanced (Cole 1989a). Local groups such as teachers or religious leaders could be used to identify vulnerable people in the population. Such an advocacy role could also be taken by Opération Riz and may improve its public image.
6. Governments should not encourage the sale of village land to outsiders. If the Malians want to preserve their village way of life, they must not permit powerful urban interests to gain control of the rural areas. This is a policy issue.
7. Early warning or drought-monitoring programs should be aware that in central Mali the social and environmental landscapes are diverse and generalization about drought, drought-response and vulnerable groups must be based on micro-level studies that reflect local diversity.
8. The precolonial period was one of great upheaval for local people in the study area and that political instability undermined the ability to

respond to drought. A last recommendation is that the past should no longer be raised as a ideal state against which the problems of the present are contrasted unless detailed empirical studies are undertaken that show that such is the case.

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APPENDICES

Appendix A. The Questionnaire Used in the Survey

QUESTIONNAIRE

LAND USE AND DROUGHT SURVEY

Name of Respondant _____
Number of Respondent _____
Village _____
Ethnicity _____
Ecozone _____

Name of Enumerator _____
Date _____
Time Begun _____
Time Finished _____

.....

REMARKS

1. Age of Head of Household (HOH)? _____

2. Where were you born? _____

3. (IF BORN ELSEWHERE) When did you come here? _____

4. Where is your father from? _____

5. Where is your grandfather from? _____

6. Do you live somewhere else during the year? _____

7. How many people do you support?

wives	_____
children (<10)	_____
men	_____
women	_____

8. How many of your children have gone or are going to school? (IF QUR'ANIC SCHOOL PUT THE NUMBER OF YEARS)

Age	Sex	Level Achieved	Reason for Leaving (if left)

9. What is your level of education? (SAME AS QUR'ANIC)

_____

10. Do you have children who are not with you now or who go away for part of the year?

Relation	Place	Reason	Time	Returns?

11. What is your principal occupation?

_____

12. What other work do you do?

farm	_____	commerce	_____
fish	_____	sew (hand)	_____
herd	_____	hunt	_____
own livestock	_____	laborer	_____
weave	_____	farm wage laborer	_____
build houses	_____	village chief	_____
leather work	_____	imam	_____
blacksmithing	_____	advisor to chief	_____
		other _____	_____

13. What was your father's principal occupation?

_____

14. What other work did your father do?

farm	_____	commerce	_____
fish	_____	sew (hand)	_____
herd	_____	hunt	_____
own livestock	_____	laborer	_____
weave	_____	farm wage laborer	_____
build houses	_____	village chief	_____
leather work	_____	imam	_____
blacksmithing	_____	advisor to chief	_____
		other _____	_____

14. How many times have you visited the following places?

Place	Times		
	Before Drought	During Drought	After Drought
Ségu	_____		
Konodimini	_____		
Ngara	_____		
Barwélé	_____		
Fana	_____		
Bamako	_____		
Kuchala	_____		
Abidjan	_____		
Dakar	_____		
Accra	_____		
Other (SPECIFY)	_____		

15. During the 1973 drought what did you do to support your family?

prayed ____
reduced our food intake ____
planted sunna in place of sannyo ____
reduced planting of nonfood crops ____
sent children to seek money ____
did wage labor ____
did farm wage labor ____
relatives helped ____
friends helped ____
sold livestock ____
ate stored grain ____
sold farm equipment ____
sold other (SPECIFY) ____
migrated ____
pledged field ____
pledged livestock ____
government aid ____
other (SPECIFY) ____

16. Did you experience drought prior to 1973? YES__ NO __
(IF YES) Which drought and what did you do to support your family?

17. Are you experiencing drought now? YES__ NO __
(IF YES) What are you doing to support your family?

prayed ____
reduced our food intake ____
planted sunna in place of sannyo ____
reduced planting of nonfood crops ____
sent children to seek money ____
did wage labor ____
did farm wage labor ____
relatives helped ____
friends helped ____
sold livestock ____
ate stored grain ____
sold farm equipment ____
sold other (SPECIFY) ____
migrated ____
pledged field ____
pledged livestock ____
government aid ____
other (SPECIFY) ____

18. Who would be able to resist drought best, you or your father? (WHY)

19. What crops have you given up because of drought?

20. When did you stop growing these crops?

21. What crops did you take up because of drought?

22. When did you begin growing these crops?

23. What work do you do now that you did not do before the drought of 1973?

24. During the following periods were you able to support your family?

Period	Response	Reason
Last 5 years		
5 years after drought		
During drought		
Before drought		

25. How many hectares do you or did you have of the following crops?

Crop	Before 1973	Now	Reason
millet/sorghum			
rice			
cotton			
peanuts			
mangos			
manioc			
sweet potatos			
maize			
garden			
fonio			
watermelon			
other (SPECIFY)			

26. Comparing the present to before the drought of 1973, have you been able to obtain more, less, or the same of the following:

Item	Response	Reason
pasture		
manure		
fish		
firewood		
sunna		
keningéba		
rice		
peanuts		
maize		
cotton		
beans		
sweet potato		
karité oil		
vegetables		
mangos		
cattle		
sheep/goats		
other (SPECIFY)		

27. What did your father have in his day that you do not have today?

Item	How Obtained	How Lost

28. What do you have that your father did not have in his day?

Item	How Obtained	Reason

29. How many hectares did you fallow before the drought of 1973 and how many do you fallow now?

	Before 1973	Now
infield		
outfield		

30. What is the reason for this change? _____

31. How long did you keep your land in fallow before 1973 and how long now?

	Before 1973	Now
infield		
outfield		

32. What is the reason for this change? _____

33. Do you manure your outfields? (MANURE TYPE) YES__ NO__

34. Have other persons' livestock entered your fields and damaged your crops? YES__ NO__
(IF YES) How many times? _____

35. Compared to before the drought of 1973, have these incidents increased, decreased, or remained the same?
(WHY)_____

36. Is there land available here for outsiders YES__ NO__
(IF NO) Why? _____

Appendix B. Comparison of the Bamana (n=363), Peul (n=144), and Somono (n=90) ethnic groups on demographic, education, ownership, and agricultural variables.

VARIABLE	ETHNIC GROUP							
	Bamana		Peul		Somono			
	Mean	SD	Mean	SD	Mean	SD	SIG	ETA[a]
Age of head of household	61.22	11.72	59.32	11.87	62.58	12.78		
Family size	16.64	11.39	16.18	11.02	18.21	12.31		
French education (years)	0.06	0.63	0.04	0.37	0.05	0.53	.	
Qur'anic education (years)	1.61	4.87	3.93	7.57	8.22	8.26	0.0000	0.12
Assets (US$)	1629.77	1436.63	2054.69	2068.83	1619.02	1316.65	0.0200	0.01
Cattle	4.35	7.75	12.12	16.60	2.82	3.33	0.0000	0.11
Sheep and goats	7.01	8.83	12.58	15.58	2.00	2.85	0.0000	0.10
Plows	1.66	1.15	1.35	1.08	1.13	1.05	0.0001	0.03
Carts	0.73	0.64	0.53	0.61	0.00	0.54	0.0000	0.04
Harrows	0.42	0.59	0.19	0.38	0.60	0.73	0.0000	0.05
Boats	0.03	0.16	0.0	0.0	0.96	0.83	0.0000	0.48
Food crops 1984 (ha)	8.39	6.17	6.02	5.34	3.14	2.87	0.0000	0.11
Food crops 1973 (ha)	7.09	5.79	5.20	4.57	3.06	2.63	0.0000	0.07
Cash crops 1984 (ha)	4.44	4.49	2.45	3.37	4.50	6.14	0.0000	0.03
Cash crops 1973 (ha)	8.37	7.16	4.59	4.14	5.66	7.11	0.0000	0.06

Appendix C. Comparison of the River (n=145), Middle Valley (n=292), and Outer Valley (n=160) ecozones on demographic, education, ownership, and agricultural variables.

VARIABLE	ZONE							
	River		Middle Valley		Outer Valley			
	Mean	SD	Mean	SD	Mean	SD	SIG	ETA²
Age of Head of Household	61.23	13.10	61.67	11.03	59.41	12.40		
Family size	17.31	11.69	17.35	11.96	15.17	10.32		
French education (years)	0.06	0.53	0.07	0.67	0.04	0.32		
Qur'anic education (years)	6.15	7.74	2.13	5.76	2.40	6.21	0.0000	0.07
Assets (US$)	1752.89	1383.75	1813.48	1716.34	1559.10	1568.26		
Cattle	5.60	9.03	7.10	12.07	4.50	7.91		
Sheep and goats	4.40	7.14	8.30	10.92	9.20	11.94	0.0000	0.03
Plows	1.20	0.97	1.60	1.15	1.50	1.21		
Carts	0.40	0.53	0.70	0.63	0.70	0.61	0.0000	0.04
Harrows	0.06	0.65	0.04	0.60	0.26	0.65		
Boats	0.70	0.65	0.01	0.01	0.0	0.0	0.0000	0.33
Food crops 1984	4.55	4.96	7.75	5.62	7.96	6.57	0.0000	0.06
Food crops 1973	4.87	4.64	6.53	5.10	6.37	6.07		
Cash crops 1984	3.70	5.06	3.87	4.58	4.35	4.25		
Cash crops 1973	5.76	6.30	8.32	7.65	5.76	5.21	0.0000	0.04

Appendix D. Comparison of poor (n=148), average (n=293), and rich (n=156) respondents on demographic, education, ownership, and agricultural variables.

VARIABLE	WEALTH CLASS							
	Poor		Average		Rich			
	Mean	SD	Mean	SD	Mean	SD	SIG	ETA²
Age of head of household	60.20	10.85	60.88	12.39	61.85	12.18		
Family size	10.39	7.37	15.47	7.93	25.34	14.79	0.0000	0.23
French education (years)	0.13	0.94	0.04	0.39	0.02	0.32		
Qur'anic education (years)	2.87	6.35	3.09	6.55	3.60	7.05		
Assets	696.77	190.64	1332.63	349.34	3725.68	2025.88	0.0000	0.57
Cattle	0.77	0.94	3.65	2.56	15.78	17.25	0.0000	0.30
Sheep and goats	2.35	4.02	6.12	6.06	15.43	15.36	0.0000	0.21
Plows	0.64	0.61	1.61	0.68	2.52	1.61	0.0000	0.36
Carts	0.16	0.36	0.66	0.50	1.03	0.68	0.0000	0.26
Harrows	0.04	0.21	0.37	0.49	0.77	0.74	0.0000	0.20
Boats	0.07	0.26	0.14	0.39	0.28	0.77	0.0005	0.03
Food crops 1984 (ha)	3.55	2.00	6.67	3.97	11.05	8.52	0.0000	0.21
Food crops 1973 (ha)	3.90	2.71	5.62	4.14	9.05	7.06	0.0000	0.13
Cash crops 1984 (ha)	1.12	1.13	3.08	2.06	8.38	6.63	0.0000	0.35
Cash crops 1973 (ha)	3.59	3.04	6.54	4.64	11.23	9.84	0.0000	0.17

Appendix E. Percent and standard deviation of adopters of 29 drought-coping strategies for the Bamana, Peul, and Somono ethnic groups in 1973 and 1984.

STRATEGY	ETHNIC GROUP											
	Bamana				Peul				Somono			
	1973		1984		1973		1984		1973		1984	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
ASSISTANCE												
Aid from family/friends	0.63	0.48	0.49	0.50	0.53	0.5	0.41	0.49	0.71	0.46	0.51	0.50
Government aid	0.30	0.46	0.16	0.37	0.21	0.41	0.03	0.16	0.04	0.21	0.02	0.15
AGRICULTURAL STRATEGIES: CASH CROPS												
Grew cash crops less	0.65	0.48	0.54	0.50	0.49	0.50	0.52	0.50	0.51	0.50	0.48	0.50
Grew cash crops more	0.01	0.10	0.04	0.19	0.01	0.12	0.04	0.19	0.01	0.15	0.04	0.21
Short-cycle groundnuts	0	0	0.09	0.29	0	0	0.06	0.23	0	0	0.02	0.15
Tubers	0	0	0.04	0.20	0	0	0.007	0.08	0	0	0.01	0.11
Gardens	0.01	0.09	0.08	0.27	0	0	0	0	0.04	0.21	0.22	0.42
Watermelon	0	0	0.02	0.13	0	0	0.01	0.11	0	0	0	0
Mangos	0.01	0.07	0.02	0.13	0	0	0	0	0	0	0.03	0.18
AGRICULTURAL STRATEGIES: FOOD CROPS												
Short-cycle millet and sorghum	0.01	0.12	0.91	0.28	0.01	0.12	0.95	0.21	0	0	0.59	0.49
Short-cycle beans	0	0	0.10	0.30	0	0	0.04	0.19	0	0	0.04	0.21
fonio	0.12	0.33	0.05	0.22	0.007	0.08	0.05	0.21	0	0	0.08	0.27
LABOR AND MIGRATION												
Household head migrated	0.39	0.49	0.18	0.39	0.31	0.46	0.16	0.37	0.37	0.48	0.17	0.37
Family members migrated	0.58	0.49	0.71	0.45	0.26	0.44	0.57	0.49	0.51	0.50	0.74	0.44
Wage labor at home	0.55	0.50	0.55	0.50	0.54	0.50	0.45	0.49	0.68	0.47	0.52	0.50
Caste occupations	0.04	0.21	0.04	0.19	0.007	0.08	0	0	0	0	0	0
Artisanal production	0.08	0.27	0.06	0.24	0.04	0.19	0.03	0.16	0.03	0.18	0.03	0.18
DIVESTMENT OF LIVESTOCK												
Sold cattle	0.00	0.49	0.17	0.38	0.19	0.39	0.16	0.37	0.17	0.37	0.04	0.21
Sold sheep or goats	0.61	0.49	0.66	0.48	0.82	0.39	0.76	0.43	0.83	0.37	0.64	0.48
DIVESTMENT OF OTHER ASSETS												
Sold farm equipment	0.16	0.37	0.06	0.24	0.09	0.29	0.06	0.23	0.18	0.38	0.07	0.25
Sold boat	0.01	0.09	0	0	0	0	0	0	0.07	0.25	0.02	0.15
Sold jewelry	0.07	0.25	0.01	0.09	0.04	0.19	0.007	0.08	0.01	0.11	0.02	0.15
Sold other	0.03	0.18	0.02	0.14	0.07	0.25	0.01	0.12	0.08	0.27	0.06	0.23
STIGMATIZED STRATEGIES												
Wild foods	0.11	0.32	0.02	0.19	0.10	0.30	0	0	0.02	0.15	0	0
Begged	0	0	0	0	0.007	0.08	0	0	0	0	0	0
Pledged asset/family mem.	0.04	0.19	0.01	0.10	0.08	0.26	0.01	0.12	0.01	0.11	0	0
OTHER												
Fished	0.01	0.09	0.01	0.09	0	0	0	0	0.31	0.47	0.18	0.38
Livestock trade	0	0	0	0	0.007	0.08	0.007	0.08	0	0	0	0
Petty trade	0.01	0.12	0.01	0.10	0	0	0	0	0.01	0.11	0	0

Appendix F. Percent and standard deviation for adopters of 29 drought-coping strategies by ecozone in 1973 and 1984.

STRATEGY	ECOZONE											
	River Zone				Middle Valley Zone				Outer Valley Zone			
	1973		1984		1973		1984		1973		1984	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
ASSISTANCE												
Aid from family/friends	0.64	0.48	0.46	0.49	0.61	0.49	0.48	0.50	0.61	0.49	0.48	0.50
Government aid	0.19	0.39	0.03	0.16	0.25	0.43	0.10	0.30	0.27	0.44	0.19	0.39
AGRICULTURAL STRATEGIES: CASH CROPS												
Grew cash crops less	0.46	0.50	0.44	0.49	0.63	0.48	0.54	0.49	0.63	0.48	0.59	0.49
Grew cash crops more	0.01	0.12	0.06	0.24	0.01	0.12	0.02	0.15	0.01	0.12	0.05	0.22
Short-cycle groundnuts	0	0	0.02	0.14	0.003	0.06	0.09	0.29	0	0	0.09	0.28
Tubers	0	0	0.08	0.08	0.003	0.58	0.05	0.21	0.006	0.08	0.01	0.11
Cardens	0.03	0.16	0.21	0.41	0.01	0.10	0.06	0.23	0		0	00
Watermelon	0	0	0	0	0	0	0.02	0.14	0	0	0.01	0.11
Mangos	0.007	0.08	0.02	0.14	0	0	0.02	0.13	0.006	0.08	0.006	0.08
AGRICULTURAL STRATEGIES: FOOD CROPS												
Short-cycle millet and sorghum	0	0	0.7	0.06	0.01	0.11	0.93	0.25	0.02	0.14	0.93	0.26
Short-cycle beans	0	0	0.06	0.23	0	0	0.12	0.33	0	0	0.01	0.11
fonio	0	0	0.06	0.23	0.003	0.06	0.02	0.26	0.03	0.45	0.03	0.16
LABOR AND MIGRATION												
Household head migrated	0.36	0.48	0.18	0.38	0.38	0.49	0.14	0.35	0.36	0.48	0.24	0.43
Family members migrated	0.50	0.50	0.71	0.46	0.46	0.49	0.70	0.46	0.55	0.49	0.62	0.49
Wage labor at home	0.62	0.49	0.46	0.50	0.67	0.47	0.50	0.50	0.34	0.47	0.60	0.49
Caste occupations	0	0	0.007	0.08	0.04	0.19	0.03	0.17	0.03	0.17	0.02	0.14
Artisanal production	0.07	0.25	0.06	0.23	0.06	0.23	0.07	0.25	0.07	0.25	0.01	0.11
DIVESTMENT OF LIVESTOCK												
Sold cattle	0.19	0.39	0.08	0.28	0.24	0.43	0.17	0.38	0.56	0.49	0.18	0.38
Sold sheep or goats	0.84	0.37	0.70	0.46	0.77	0.42	0.68	0.47	0.41	0.49	0.66	0.47
DIVESTMENT OF OTHER ASSETS												
Sold farm equipment	0.08	0.28	0.06	0.23	0.18	0.39	0.05	0.23	0.09	0.28	0.08	0.27
Sold boat	0.04	0.19	0.01	0.12	0	0	0	0	0.02	0.14	0	0
Sold jewelry	0.01	0.12	0.02	0.14	0.07	0.25	0.01	0.1	0.06	0.23	0	0
Sold other	0.07	0.25	0.03	0.18	0.04	0.19	0.02	0.13	0.05	0.22	0.03	0.16
STIGMATIZED STRATEGIES												
Wild foods	0.01	0.12	0	0	0.11	0.32	0.02	0.14	0.14	0.35	0.01	0.11
Begged	0	0	0	0	0.003	0.06	0	0	0	0	0	0
Pledged asset/family mem.	0.007	0.08	0.007	0.08	0.06	0.23	0.01	0.1	0.04	0.2	0.01	0.11
OTHER												
Fished	0.19	0.39	0.12	0.32	0.007	0.08	0.007	0.08	0	0.08	0	0
Livestock trade	0.007	0.08	0	0	0.003	0.06	0.007	0.08	0	0	0	0
Petty trade	0.007	0.08	0	0	0.02	0.13	0.01	0.12	0	0	0	0

Appendix G. Percent and standard deviation for adopters of 29 drought-coping strategies by wealth class in 1973 and 1984.

STRATEGY	WEALTH CLASS											
	Poor				Average				Rich			
	1973		1984		1973		1984		1973		1984	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
ASSISTANCE												
Aid from family/friends	0.66	0.48	0.54	0.50	0.64	0.48	0.48	0.50	0.53	0.50	0.38	0.49
Government aid	0.30	0.46	0.14	0.35	0.24	0.43	0.10	0.29	0.19	0.40	0.10	0.30
AGRICULTURAL STRATEGIES: CASH CROPS												
Grew cash crops less	0.65	0.48	0.53	0.50	0.60	0.49	0.57	0.50	0.51	0.50	0.46	0.50
Grew cash crops more	0.01	0.12	0.02	0.14	0.01	0.10	0.03	0.17	0.02	0.14	0.08	0.27
Short-cycle groundnuts	0	0	0.04	0.20	0	0	0.07	0.26	0	0	0.11	0.31
Tubers	0	0	0.02	0.14	0.01	0.08	0.03	0.16	0	0	0.04	0.19
Cardeas	0.08	0.11	0.03	0.16	0.02	0.13	0.10	0.30	0.01	0.08	0.10	0.30
Watermelon	0	0	0.01	0.08	0	0	0.02	0.14	0	0	0.01	0.08
Mangos	0	0	0	0	0	0	0.01	0.12	0.01	0.08	0.03	0.18
AGRICULTURAL STRATEGIES: FOOD CROPS												
Short-cycle millet and sorghum	0.01	0.08	0.89	0.32	0.01	0.08	0.88	0.32	0.03	0.16	0.84	0.37
Short-cycle beans	0	0	0.05	0.23	0	0	0.08	0.26	0	0	0.10	0.30
fonio	0.08	0.27	0.03	0.16	0.09	0.28	0.05	0.21	0.04	0.21	0.10	0.30
LABOR AND MIGRATION												
Household head migrated	0.41	0.49	0.22	0.42	0.39	0.49	0.15	0.36	0.27	0.44	0.17	0.38
Family members migrated	0.45	0.50	0.60	0.49	0.55	0.50	0.73	0.44	0.62	0.49	0.68	0.47
Wage labor at home	0.60	0.49	0.57	0.50	0.58	0.49	0.53	0.50	0.52	0.50	0.45	0.50
Caste occupations	0.05	0.23	0.03	0.18	0.025	0.19	0.03	0.16	0.01	0.11	0	0
Artisanal production	0.08	0.27	0.03	0.18	0.07	0.26	0.06	0.25	0.03	0.18	0.03	0.18
DIVESTMENT OF LIVESTOCK												
Sold cattle	0.35	0.48	0.16	0.37	0.34	0.48	0.16	0.37	0.22	0.42	0.12	0.33
Sold sheep or goats	0.63	0.48	0.59	0.44	0.69	0.46	0.72	0.45	0.76	0.43	0.70	0.46
DIVESTMENT OF OTHER ASSETS												
Sold farm equipment	0.13	0.34	0.08	0.27	0.13	0.33	0.04	0.21	0.15	0.36	0.08	0.27
Sold boat	0.03	0.16	0	0	0.01	0.08	0.01	0.08	0.02	0.14	0	0
Sold jewelry	0.05	0.23	0	0	0.06	0.23	0.01	0.12	0.04	0.19	0.01	0.11
Sold other	0.05	0.23	0.03	0.16	0.03	0.18	0.01	0.12	0.07	0.26	0.04	0.19
STIGMATIZED STRATEGIES												
Wild foods	0.11	0.31	0.02	0.14	0.09	0.29	0.02	0.13	0.10	0.30	0	0
Begged	0.01	0.08	0	0	0	0	0	0	0	0	0	0
Pledged asset/family mem.	0.05	0.23	0.01	0.08	0.04	0.19	0.01	0.08	0.03	0.18	0.02	0.14
OTHER												
Fished	0.05	0.23	0.03	0.06	0.06	0.25	0.04	0.19	0.03	0.16	0.03	0.16
Livestock trade	0	0	0	0	0	0	0.01	0.08	0.01	0.11	0	0
Petty trade	0.01	0.01	0.01	0.08	0.01	0.10	0.01	0.08	0.01	0.11	0.01	0.08

Appendix H. Lambdas, standard errors, z-scores, and 95% confidence intervals for 29 drought-coping strategies by ethnic group, location, and wealth, 1973 and 1984.

Table H1. Lamda, standard error, z-score, and 95% confidence intervals for aid from family or friends, by ethnic group, location and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	0.003	0.039	0.054	-0.113	0.119	0.036	0.057	0.63	-0.076	0.147
Peal	-0.189	0.069	-2.730	-0.326	-0.054	-0.118	0.068	-1.73	-0.252	0.015
Semone	0.187	0.084	2.230	0.023	0.351	0.082	0.077	1.07	-0.069	0.034
River	0.043	0.067	0.648	-0.087	0.173	-0.031	0.064	-0.486	-0.157	0.095
Middle Valley	-0.025	0.056	-0.447	-0.135	0.085	0.011	0.054	0.193	-0.096	0.117
Outer Valley	-0.018	0.064	-0.281	-0.144	0.107	0.021	0.063	0.332	-0.102	0.143
Poor	0.094	0.066	1.420	-0.036	0.225	0.145	0.064	2.257	0.019	0.272
Average	0.057	0.056	1.010	-0.053	0.167	0.024	0.056	0.446	-0.083	0.132
Rich	-0.152	0.065	-2.350	-0.278	-0.025	-0.169	0.065	-2.617	-0.297	-0.043

Table H2. Lamda, standard error, z-score, and 95% confidence intervals for reception of government aid, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	0.428	0.095	4.49	0.241	0.615	0.626	0.142	4.420	0.349	0.903
Peal	0.200	0.107	1.88	-0.009	0.049	-0.285	0.194	-1.470	-0.664	0.094
Semone	-0.628	0.166	-3.79	-0.953	-0.303	-0.341	0.229	-1.490	-0.791	0.109
River	-0.180	0.079	-1.76	-0.297	0.016	-0.554	0.166	-3.330	-0.879	-0.228
Middle Valley	0.047	0.064	0.738	-0.078	0.173	0.09	0.107	0.841	-0.120	0.301
Outer Valley	0.093	0.072	1.29	-0.045	0.235	0.463	0.108	4.270	0.251	0.676
Poor	0.149	0.073	2.063	0.007	0.292	0.133	0.095	1.397	-0.053	0.319
Average	0.007	0.064	0.108	-0.119	0.133	-0.103	0.088	-1.167	-0.275	0.069
Rich	-0.157	0.079	-1.990	-0.311	-0.002	-0.030	0.101	-0.299	-0.228	0.167

Table H3. Lamda, standard error, z-score, and 95% confidence intervals for increased the cultivation of cash crops, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	-0.189	0.218	-0.868	-0.618	0.239	-0.056	0.138	-0.406	-0.326	0.214
Peul	-0.028	0.251	-0.111	-0.519	0.464	-0.001	0.162	-0.009	-0.319	0.317
Somono	0.217	0.252	0.864	-0.276	0.710	0.057	0.180	0.318	-0.296	-0.410
River	0.036	0.251	0.144	-0.455	0.527	0.201	0.141	1.430	-0.074	0.476
Middle Valley	-0.023	0.218	-0.103	-0.451	0.405	-0.290	0.148	-1.970	-0.579	-0.001
Outer Valley	-0.014	0.250	-0.054	-0.504	0.477	0.089	0.144	0.622	-0.193	0.372
Poor	0.007	0.248	-0.028	-0.478	0.493	-0.273	0.195	-1.404	-0.654	0.108
Average	-0.176	0.227	-0.773	-0.621	0.269	-0.066	0.107	-0.648	-0.355	0.223
Rich	0.168	0.228	0.740	-0.278	0.615	0.339	0.146	2.323	0.053	0.625

Cell frequencies in 1973 for Ethnic group, Zone, and Wealth were 50% <5.

Table H4. Lamda, standard error, z-score, and 95% confidence intervals for cultivation of short-cycle groundnuts, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	-0.016	0.431	-0.037	-0.861	0.829	0.307	0.136	2.260	0.041	0.574
Peul	-0.112	0.565	-0.206	-1.180	0.975	0.04	0.162	0.249	-0.277	0.357
Somono	0.128	0.500	0.235	-0.941	1.190	-0.368	0.220	-1.550	-0.786	0.091
River	-0.049	0.545	-0.091	-1.120	1.020	-0.471	0.189	-2.490	-0.841	-0.100
Middle Valley	0.169	0.431	0.365	-0.696	0.994	0.245	0.121	2.020	0.007	0.483
Outer Valley	-0.098	0.545	-0.181	-0.696	0.994	0.226	0.133	1.700	-0.035	0.486
Poor	-0.060	0.565	-0.117	-1.133	1.005	-0.263	0.145	-1.812	-0.547	0.021
Average	0.138	0.431	0.319	-0.707	0.983	0.002	0.109	0.017	-0.211	0.215
Rich	-0.074	0.565	-0.136	-1.183	0.995	0.261	0.114	2.287	0.037	0.485

Cell frequencies in 1973 for Ethnic group, Zone, and Wealth were 50% <5.

Table H5. Lamda, standard error, z-score, and 95% confidence intervals for cultivation of tubers, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	0.155	0.395	0.392	-0.619	0.930	0.406	0.212	1.910	-0.009	0.822
Peul	-0.198	0.539	-0.368	-1.25	0.858	-0.325	0.309	-1.050	-0.930	0.281
Somono	0.043	0.539	0.079	-1.01	1.09	-0.082	0.309	-0.264	-0.689	0.525
River	-0.230	0.510	-0.459	-1.23	0.766	-0.337	0.297	-1.140	-0.919	0.245
Middle Valley	-0.035	0.386	-0.092	-0.792	0.721	0.465*	0.195	2.390	0.083	0.848
Outer Valley	0.269	0.386	0.698	-0.487	1.03	-0.128	0.257	-0.499	-0.631	0.375
Poor	-0.149	0.538	-0.278	-1.205	0.906	-0.136	0.201	-0.676	-0.529	0.258
Average	0.309	0.395	0.782	-0.466	1.084	-0.038	0.161	-0.234	-0.354	0.278
Rich	-0.159	0.538	-0.297	-1.215	0.896	0.174	0.171	1.014	-0.162	0.509

Cell frequencies in 1973 for Ethnic group, Zone, and Wealth were 50% <5.
Cell frequencies in 1984 for Zone were 33% <5.

Table H6. Lamda, standard error, z-score, and 95% confidence intervals for vegetable gardening, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	-0.106	0.307	-0.344	-0.707	0.496	0.331	0.248	1.330	-0.156	0.818
Peul	-0.628	0.487	-1.290	-1.580	0.327	-1.280	0.475	-2.690	-2.210	-0.345
Somono	0.734	0.299	2.450	0.145	1.320	0.946	0.253	3.740	0.451	1.440
River	0.569	0.299	1.840	-0.036	1.140	0.992	0.249	3.990	0.505	1.480
Middle Valley	0.063	0.307	0.204	-0.539	0.664	0.256	0.252	1.010	-0.239	0.750
Outer Valley	-0.612	0.487	-1.260	-1.570	0.343	-1.250	0.475	-2.630	-2.180	-0.317
Poor	-0.099	0.314	-0.314	-0.714	0.517	-0.425	0.169	-2.518	-0.756	-0.094
Average	0.207	0.241	0.860	-0.269	0.679	0.203	0.112	1.816	-0.016	0.423
Rich	-0.108	0.314	-0.346	-0.724	0.507	0.222	0.126	1.787	-0.021	0.465

Cell frequencies in 1973 for Zone and Wealth were 50% and 33% <5 respectively.

Table H7. Lamda, standard error, z-score, and 95% confidence intervals for cultivation of watermelon, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	-0.383	0.578	-0.663	-1.520	0.749	0.207	0.291	0.711	-0.363	0.777
Peul	0.071	0.578	0.123	-1.060	1.200	0.182	0.325	0.560	-0.454	0.818
Soninke	0.312	0.579	0.539	-0.822	1.450	-0.389	0.489	-0.750	-1.350	0.569
River	0.134	0.578	0.232	-0.999	1.270	-0.567	0.489	-1.160	-1.520	0.390
Middle Valley	-0.219	0.578	-0.378	-1.350	0.914	0.373	0.291	1.280	-0.197	0.943
Outer Valley	0.085	0.578	0.147	-1.050	1.220	0.195	0.324	0.599	-0.441	0.830
Poor	0.119	0.578	0.207	-1.013	1.253	-0.126	0.313	-0.406	-0.740	0.486
Average	-0.229	0.578	-0.397	-1.362	0.903	0.264	0.234	1.137	-0.195	0.723
Rich	0.109	0.578	0.189	-1.024	1.243	-0.137	0.313	-0.438	-0.750	0.476

Cell frequencies in 1973 for all variables were <5.
Cell frequencies in 1984 for Zone and Wealth were 33% <5.

Table H8. Lamda, standard error, z-score, and 95% confidence intervals for cultivation of mangos, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	0.155	0.395	0.392	-0.619	0.930	0.147	0.285	0.517	-0.412	0.707
Peul	-0.198	0.539	-0.368	-1.250	0.858	-0.689	0.485	-1.420	-1.640	0.262
Soninke	0.043	0.539	0.079	-1.010	1.090	0.542	0.305	1.770	-0.056	1.140
River	0.318	0.386	0.824	-0.439	1.080	0.203	0.237	0.854	-0.263	0.668
Middle Valley	-0.587	0.509	-1.150	-1.590	0.412	0.074	0.218	0.342	-0.352	0.501
Outer Valley	0.269	0.389	0.696	-0.488	1.030	-0.277	0.297	-0.934	-0.859	0.304
Poor	-0.248	0.510	-0.486	-1.248	0.752	-0.658	0.484	-1.351	-1.603	0.295
Average	-0.046	0.386	-0.119	-0.803	-0.710	0.102	0.293	0.349	-0.473	0.677
Rich	0.290	0.386	0.762	-0.463	1.051	0.552	0.288	1.915	-0.013	1.116

Cell frequencies in 1973 for all variables were 50% <5.
Cell frequencies in 1984 for Ethnic group, Zone and Wealth were 33%, 33%, and 50% <5 respectively.

Table H9. Lamda, standard error, z-score, and 95% confidence intervals for reduction in cash crop cultivation, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	0.199	0.058	3.460	0.086	0.312	0.069	0.057	1.220	-0.042	0.180
Peul	-0.117	0.068	-1.730	-0.250	0.015	0.008	0.068	0.117	-0.124	0.140
Somono	-0.082	0.077	-1.060	-0.233	0.069	-0.077	0.077	-0.997	-0.228	0.074
River	-0.225	0.065	-3.470	-0.352	-0.098	-0.168	0.065	-2.600	-0.295	-0.042
Middle Valley	0.121	0.056	2.170	0.012	0.231	0.044	0.055	0.800	-0.064	0.151
Outer Valley	0.100	0.064	1.620	-0.022	0.229	0.124	0.063	1.970	0.001	0.248
Poor	0.131	0.066	1.971	0.001	0.260	0.026	0.064	0.412	-0.099	0.152
Average	0.037	0.056	0.658	-0.073	0.146	0.087	0.055	1.589	-0.020	0.194
Rich	-0.167	0.064	-2.602	-0.293	-0.041	-0.113	0.064	-1.777	-0.238	0.012

Table H10. Lamda, standard error, z-score, and 95% confidence intervals for cultivation of short-cycle varieties of millet and sorghum, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	0.150	0.296	0.507	-0.430	0.731	0.247	0.095	2.600	0.061	0.433
Peul	0.210	0.326	0.645	-0.428	0.849	0.529	0.134	3.970	0.268	0.792
Somono	-0.360	0.489	-0.736	-1.320	0.599	-0.777	0.099	-7.820	-0.971	-0.582
River	-0.562	0.487	-1.150	-1.520	0.393	-0.570	0.864	-6.600	-0.739	-0.401
Middle Valley	0.191	0.298	0.639	-0.394	0.775	0.315	0.096	3.290	0.128	0.502
Outer Valley	0.371	0.307	1.210	-0.231	0.974	0.255	0.109	2.330	0.040	0.469
Poor	-0.152	0.304	-0.499	-0.748	0.444	0.066	0.097	0.679	-0.124	0.256
Average	-0.246	0.264	-0.928	-0.764	0.273	0.076	0.082	0.924	-0.085	0.237
Rich	0.397	0.235	1.689	-0.064	0.859	-0.162	0.089	-1.590	-0.316	0.033

Cell frequencies in 1973 for Ethnic group, Zone, and Wealth were 33%, 50%, and 33% <5 respectively.

Table H11. Lamda, standard error, z-score, and 95% confidence intervals for cultivation of short-cycle beans, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	-0.383	0.578	-0.663	-1.520	0.749	0.274	0.119	2.280	0.039	0.508
Peul	0.071	0.578	0.123	-1.060	1.200	-0.166	0.159	-1.050	-0.477	0.145
Sonono	0.312	0.579	0.539	-0.822	1.450	-0.107	0.177	-0.601	-0.454	0.239
River	0.134	0.578	0.232	-0.999	1.270	0.089	0.161	0.558	-0.226	0.406
Middle Valley	-0.219	0.578	0.378	-1.350	0.914	0.503	0.135	3.730	0.238	0.768
Outer Valley	0.085	0.578	0.145	-1.050	1.220	-0.593	0.222	-2.670	-1.030	-0.157
Poor	0.119	0.578	0.207	-1.014	1.253	-0.156	0.131	-1.177	-0.411	0.103
Average	-0.229	0.578	-0.397	-1.362	0.903	-0.006	0.104	-0.059	-0.209	0.198
Rich	0.109	0.578	0.189	-1.024	1.243	0.160	0.113	1.419	-0.061	0.382

Cell frequencies in 1973 for all variables were 50% <5.

Table H12. Lamda, standard error, z-score, and 95% confidence intervals for cultivation of fonio, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	0.972	0.278	3.490	0.426	1.520	-0.068	0.118	-0.579	-0.299	0.163
Peul	-0.329	0.363	-0.910	-1.040	0.381	-0.096	0.145	-0.667	-0.379	0.191
Sonono	-0.642	0.493	-1.300	-1.610	0.324	0.162	0.147	1.110	-0.125	0.450
River	-0.851	0.492	-1.730	-1.820	0.114	0.088	0.147	0.595	-0.201	0.376
Middle Valley	-0.653	0.362	-1.800	-1.360	0.057	0.208	0.124	0.167	-0.036	0.451
Outer Valley	1.500	0.279	5.390	0.957	2.05	-0.295	0.174	-1.690	-0.636	0.046
Poor	0.085	0.121	0.697	-0.153	0.323	-0.297	0.172	-1.731	-0.634	0.039
Average	0.115	0.104	1.097	-0.090	0.319	-0.016	0.127	-0.124	-0.264	0.233
Rich	-0.199	0.138	-1.439	-0.471	0.072	0.313	0.129	2.418	0.059	0.566

Cell frequencies in 1973 for Ethnic group and Zone were 33% <5.

Table H13. Lamda, standard error, z-score, and 95% confidence intervals for head of household migrated for work, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	0.073	0.059	1.240	-0.043	0.189	0.047	0.075	0.630	-0.099	0.194
Peul	-0.102	0.072	-1.420	-0.243	0.039	-0.043	0.091	-0.467	-0.221	0.136
Somono	0.029	0.080	0.362	-0.128	0.187	0.005	0.102	-0.045	-0.206	0.197
River	-0.036	0.067	-0.534	-0.168	0.096	-0.008	0.083	-0.091	-0.169	0.155
Middle Valley	0.034	0.056	0.595	-0.077	0.144	-0.159	0.073	-2.180	-0.303	-0.016
Outer Valley	0.002	0.065	0.035	-0.125	0.129	-0.167	0.077	2.180	0.017	0.317
Poor	0.126	0.066	1.900	-0.004	0.256	0.136	0.079	1.718	-0.019	0.292
Average	0.078	0.057	1.364	-0.034	0.189	-0.091	0.072	-1.258	-0.232	0.051
Rich	-0.203	0.070	-2.914	-0.341	-0.067	-0.046	0.088	-0.544	-0.209	0.119

Table H14. Lamda, standard error, z-score, and 95% confidence intervals for migration of family members for work, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	0.271	0.059	4.610	0.155	0.386	0.082	0.062	1.320	-0.039	0.203
Peul	-0.405	0.074	-5.490	-0.549	-0.261	-0.236	0.071	-3.320	-0.375	-0.097
Somono	0.135	0.079	1.710	-0.019	0.289	0.154	0.086	1.780	-0.015	0.324
River	-0.008	0.068	-0.130	-0.134	0.117	0.073	0.069	1.060	-0.064	0.209
Middle Valley	-0.089	0.055	-1.650	-0.197	0.017	0.059	0.059	1.010	-0.056	0.175
Outer Valley	0.098	0.063	1.570	-0.025	0.221	-0.132	0.066	-2.010	-0.260	-0.003
Poor	-0.052	0.064	-0.813	-0.178	0.074	-0.154	0.066	-2.314	-0.284	-0.024
Average	0.149	0.055	2.726	-0.002	0.257	0.133	0.059	2.247	-0.017	0.249
Rich	-0.097	0.068	-1.511	-0.223	0.029	0.021	0.068	0.309	-0.112	0.154

Table H15. Lamda, standard error, z-score, and 95% confidence intervals for wage labor in home area, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	-0.078	0.058	-1.340	-0.192	0.036	0.086	0.057	1.520	-0.025	0.197
Peul	-0.104	0.069	-1.510	-0.239	0.031	-0.119	0.068	-1.770	-0.252	0.013
Sonono	0.182	0.082	2.230	0.022	0.352	0.033	0.077	0.435	-0.118	0.185
River	0.157	0.067	2.360	0.027	0.287	-0.122	0.064	-1.890	-0.248	0.005
Middle Valley	0.265	0.057	4.640	0.153	0.378	-0.046	0.055	-0.846	-0.154	0.061
Outer Valley	-0.422	0.066	-6.430	-0.551	0.294	0.168	0.163	2.650	0.048	0.293
Poor	0.071	0.065	1.092	-0.056	0.198	0.103	0.064	1.598	-0.023	0.229
Average	0.043	0.055	0.771	-0.066	0.151	0.028	0.055	0.515	-0.079	0.135
Rich	-0.113	0.064	-1.775	-0.239	0.012	-0.131	0.064	-2.051	-0.256	0.006

Table H16. Lamda, standard error, z-score, and 95% confidence intervals for caste occupations, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	0.613	0.286	2.150	0.053	1.170	0.728	0.367	2.090	0.048	1.410
Peul	-0.151	0.368	-0.414	-0.868	0.563	-0.486	0.530	-0.913	-1.520	0.555
Sonono	-0.462	0.493	-0.936	-1.430	0.506	-0.263	0.530	-0.459	-1.280	0.796
River	-0.814	0.480	-1.690	-1.760	0.127	-0.321	0.293	-1.090	-0.896	0.254
Middle Valley	0.463	0.265	1.750	-0.056	0.983	0.261	0.197	1.330	-0.125	0.648
Outer Valley	0.351	0.281	1.250	-0.199	0.902	0.059	0.233	0.256	-0.397	0.516
Poor	0.356	0.170	2.097	-0.023	0.690	0.458	0.283	1.603	-0.101	0.101
Average	-0.071	0.173	-0.408	-0.409	0.269	0.319	0.273	1.168	-0.216	0.854
Rich	-0.286	0.229	-1.249	-0.735	0.163	-0.772	0.481	-1.605	-1.716	0.171

Cell frequencies in 1973 for Ethnic group and Wealth were 33% <5.
Cell frequencies in 1984 for all variables were 33% <5.

Table H17. Lamda, standard error, z-score, and 95% confidence intervals for artisanal production, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	0.239	0.129	1.860	-0.015	0.494	0.206	0.141	1.460	-0.071	0.482
Peul	-0.083	0.164	-0.505	-0.406	0.239	-0.162	0.187	-0.865	-0.529	0.205
Somono	-0.156	0.196	-0.795	-0.541	0.229	-0.044	0.202	-0.217	-0.439	0.352
River	0.036	0.125	0.284	-0.209	0.281	0.205	0.163	1.260	-0.115	0.525
Middle Valley	-0.067	0.110	-0.611	-0.284	0.149	0.273	0.144	1.890	-0.010	0.556
Outer Valley	0.032	0.122	0.261	-0.201	0.271	-0.478	0.224	-2.130	-0.917	-0.039
Poor	0.176	0.128	1.381	-0.074	0.427	-0.096	0.167	-0.579	-0.423	0.230
Average	0.093	0.115	0.807	-0.133	0.318	0.203	0.129	1.577	-0.049	0.455
Rich	-0.269	0.157	-1.711	-0.578	0.039	-0.106	0.167	-0.641	-0.433	0.219

Cell frequencies in 1984 for ethnic group were 33% <5.

Table H18. Lamda, standard error, z-score, and 95% confidence intervals for sold cattle, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	0.381	0.068	5.570	0.247	0.515	0.251	0.100	2.510	0.055	0.447
Peul	-0.162	0.086	-1.880	-0.331	0.007	0.199	0.112	1.770	-0.022	0.419
Somono	-0.219	0.101	-2.170	-0.417	-0.021	-0.469	0.167	-2.690	-0.777	-0.122
River	-0.324	0.078	-4.160	-0.476	-0.171	-0.270	0.108	-2.510	-0.481	-0.059
Middle Valley	-0.185	0.063	-2.950	-0.309	-0.062	0.125	0.079	1.580	-0.030	0.280
Outer Valley	0.509	0.067	7.570	0.377	0.641	0.165	0.088	1.680	-0.025	0.319
Poor	0.106	0.069	1.547	-0.028	0.241	0.061	0.088	0.692	-0.112	0.234
Average	0.078	0.059	1.313	-0.038	0.194	0.053	0.076	0.696	-0.096	0.202
Rich	-0.184	0.073	-2.520	-0.327	0.041	-0.114	0.094	-1.212	-0.299	0.071

Table H19. Lamda, standard error, z-score, and 95% confidence intervals for sold sheep or goats, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	-0.366	0.068	-5.380	-0.499	-0.231	-0.075	0.061	-1.230	-0.194	0.045
Peal	0.154	0.086	1.790	-0.015	0.323	0.177	0.076	2.320	0.027	0.326
Semeo	0.211	0.101	2.090	0.013	0.409	-0.102	0.082	-1.250	-0.262	0.058
River	0.011	0.083	0.950	0.248	0.573	0.038	0.069	0.546	-0.098	0.174
Middle Valley	0.193	0.065	2.950	0.064	0.321	0.002	0.058	0.028	-0.113	0.116
Outer Valley	-0.603	0.069	-8.710	-0.739	-0.468	-0.039	0.066	-0.594	-0.169	0.091
Poor	-0.107	0.068	-2.159	-0.280	0.014	-0.177	0.066	-2.663	-0.307	-0.047
Average	-0.022	0.059	-0.364	-0.138	0.095	0.105	0.059	1.777	0.011	0.219
Rich	0.168	0.072	2.328	-0.027	0.310	0.072	0.069	1.052	-0.062	0.207

Table H20. Lamda, standard error, z-score, and 95% confidence intervals for sold agricultural or other equipment, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	0.189	0.088	2.140	0.016	0.362	0.001	0.115	0.013	-0.223	0.226
Peal	-0.130	0.114	-1.150	-0.353	0.092	-0.057	0.101	-0.407	-0.333	0.218
Semeo	-0.059	0.126	-0.468	-0.306	0.188	0.056	0.152	0.366	-0.242	0.354
River	-0.157	0.112	-1.400	-0.375	0.062	-0.058	0.138	-0.436	-0.321	0.204
Middle Valley	0.285	0.084	3.400	0.121	0.449	-0.079	0.113	-0.702	-0.302	0.143
Outer Valley	-0.129	0.107	-1.200	-0.339	0.081	0.138	0.119	1.160	-0.096	0.372
Poor	-0.032	0.094	-0.347	-0.216	0.151	0.114	0.119	0.952	-0.120	0.348
Average	-0.057	0.079	-0.713	-0.213	0.099	-0.217	0.116	-1.867	-0.444	0.011
Rich	0.089	0.089	1.006	-0.085	0.264	0.103	0.119	0.862	-0.312	0.337

Table H21. Lamda, standard error, z-score, and 95% confidence intervals for sold boat, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	-0.170	0.034	-0.562	-0.767	0.425	-0.655	0.538	-1.220	-1.710	0.399
Peul	-0.693	0.485	-1.430	-1.640	0.258	-0.201	0.539	-0.373	-1.260	0.855
Somono	0.864	0.287	3.010	0.302	1.430	0.856	0.396	2.160	0.079	1.630
River	0.675	0.286	2.360	0.115	1.240	0.675	0.396	1.710	-0.101	1.450
Middle Valley	-0.981	0.485	-2.020	-1.930	-0.030	-0.489	0.538	-0.909	-1.540	0.566
Outer Valley	0.305	0.304	1.000	-0.291	0.902	-0.186	0.538	-0.345	-1.240	0.869
Poor	0.264	0.212	1.248	0.151	0.679	-0.149	0.538	-0.278	-1.205	0.906
Average	-0.389	0.244	-1.597	-0.866	0.088	0.309	0.395	0.782	-0.466	1.084
Rich	-0.125	0.224	-0.558	-0.314	0.563	-0.159	0.538	-0.297	-1.214	0.896

Cell frequencies in 1973 for Ethnic group and Wealth were 33% and 50% <5.
Cell frequencies in 1984 for Zone and Wealth were 50% <5.

Table H22. Lamda, standard error, z-score, and 95% confidence intervals for sold jewelry, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	0.317	0.168	0.189	-0.011	0.646	-0.188	0.249	-0.754	-0.677	0.301
Peul	0.095	0.195	0.488	-0.287	0.477	-0.158	0.307	-0.515	-0.759	0.444
Somono	-0.413	0.285	-1.450	-0.970	0.145	0.346	0.269	1.290	-0.181	0.873
River	-0.456	0.223	-2.040	-0.893	-0.019	0.463	0.310	1.490	-0.145	1.070
Middle Valley	0.272	0.142	1.910	-0.007	0.550	0.106	0.309	0.341	-0.502	0.713
Outer Valley	0.184	0.159	1.160	-0.127	0.495	-0.569	0.489	-1.160	-1.530	0.389
Poor	0.046	0.141	0.325	-0.231	0.323	-0.519	0.490	-1.059	-1.480	0.442
Average	0.059	0.121	0.492	-0.178	0.297	0.237	0.303	0.781	-0.358	0.831
Rich	-0.106	0.152	-0.696	-0.403	0.192	0.282	0.327	0.862	-0.359	0.924

Cell frequencies in 1984 for Zone and Wealth were 50% <5.

Table H23. Lamda, standard error, z-score, and 95% confidence intervals for sold other asset, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	-0.283	0.127	-2.230	-0.532	-0.034	-0.154	0.178	-0.862	-0.503	0.196
Peel	0.103	0.133	0.772	-0.158	0.364	-0.251	0.233	-1.080	-0.708	0.206
Sonono	0.180	0.146	1.240	-0.106	0.466	0.485	0.191	2.120	0.030	0.780
River	0.163	0.132	1.240	-0.095	0.421	0.172	0.180	0.954	-0.181	0.525
Middle Valley	-0.161	0.128	-1.260	-0.411	0.089	-0.189	0.179	-1.060	-0.541	0.162
Outer Valley	-0.002	0.138	-0.014	-0.273	0.269	0.018	0.189	0.093	-0.353	0.388
Poor	0.034	0.139	0.248	-0.237	0.306	0.059	0.190	0.308	-0.314	0.431
Average	-0.219	0.131	-1.683	-0.476	0.036	-0.297	0.189	-1.570	-0.669	0.074
Rich	0.185	0.129	1.437	-0.068	0.438	0.239	0.175	1.368	-0.103	0.581

Cell frequencies in 1984 for Wealth were 33% <5.

Table H24. Lamda, standard error, z-score, and 95% confidence intervals for the use of wild foods, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	0.267	0.128	2.080	0.016	0.519	0.569	0.353	1.610	-0.124	1.260
Peel	0.223	0.142	1.570	-0.055	0.502	-0.405	0.531	-0.762	-1.450	0.636
Sonono	-0.491	0.220	-2.230	-0.922	-0.059	-0.164	0.532	-0.308	-1.210	0.878
River	-0.713	0.218	-3.270	-1.140	-0.286	-0.567	0.489	-1.160	-1.520	0.390
Middle Valley	0.284	0.128	2.200	0.033	0.536	0.373	0.290	1.280	-0.197	0.943
Outer Valley	0.429	0.133	3.210	0.167	0.689	0.195	0.324	0.599	-0.441	0.830
Poor	0.056	0.104	0.535	-0.148	0.259	0.373	0.306	1.219	-0.226	0.972
Average	-0.028	0.091	-0.307	-0.207	0.151	0.248	0.291	0.853	-0.322	0.817
Rich	-0.028	0.107	-0.258	-0.237	0.182	-0.620	0.486	-1.277	-1.573	0.332

Cell frequencies in 1984 for Ethnic group, Zone, and Wealth were 33% <5.

Table H25. Lamda, standard error, z-score, and 95% confidence intervals for begged, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	-0.567	0.545	-1.040	-1.640	0.501	-0.383	0.578	-0.663	-1.520	0.749
Peul	0.439	0.432	1.020	-0.406	1.290	0.071	0.578	0.123	-1.060	1.200
Somono	0.128	0.546	0.234	-0.942	1.190	0.312	0.579	0.539	-0.822	1.450
River	-0.049	0.545	-0.091	-1.120	1.020	0.134	0.578	0.232	-0.999	1.270
Middle Valley	0.169	0.431	0.385	-0.696	0.994	-0.219	0.578	-0.378	-1.350	0.914
Outer Valley	-0.099	0.545	-0.181	-1.170	0.969	0.085	0.578	0.147	-1.050	1.220
Poor	0.488	0.432	1.131	-0.358	1.334	0.119	0.578	0.207	-1.018	1.253
Average	-0.414	0.545	-0.759	-1.482	0.655	-0.229	0.578	-0.397	-1.362	0.903
Rich	-0.075	0.545	-0.137	-1.143	0.994	0.109	0.578	0.189	-1.024	1.243

Cell frequencies in 1973 and 1984 for all variables were 50% <5.

Table H26. Lamda, standard error, z-score, and 95% confidence intervals for pledged family member or asset, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	0.007	0.173	0.040	-0.332	0.346	0.082	0.304	0.271	-0.513	0.677
Peul	0.402	0.178	2.270	0.054	0.749	0.284	0.328	0.765	-0.398	0.886
Somono	-0.409	0.283	-1.440	-0.964	0.146	-0.327	0.491	-0.665	-1.290	0.636
River	-0.559	0.283	-1.970	-1.110	-0.003	-0.094	0.307	-0.306	-0.695	-0.507
Middle Valley	0.343	0.171	2.000	0.007	0.679	-0.021	0.249	-0.085	-0.509	0.467
Outer Valley	0.316	0.189	1.140	-0.156	0.587	0.005	0.268	0.029	-0.810	0.641
Poor	0.148	0.147	1.009	-0.139	0.437	-0.109	0.307	0.355	-0.710	0.493
Average	-0.058	0.137	-0.426	-0.327	0.210	-0.203	0.268	-0.757	-0.727	0.322
Rich	-0.090	0.164	-0.549	-0.412	0.232	0.311	0.249	1.247	-0.178	0.801

Cell frequencies in 1984 for all variables were 50% <5.

Table H27. Lamda, standard error, z-score, and 95% confidence intervals for fished, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	-0.467	0.299	-1.560	-1.050	0.118	-0.347	0.299	-1.160	-0.935	0.241
Peul	-0.990	0.482	-2.050	-1.930	-0.045	-0.869	0.483	-1.800	-1.820	0.077
Somono	1.460	0.264	5.530	0.941	1.970	1.220	0.268	4.530	0.691	1.740
River	1.090	0.186	5.890	0.773	1.460	1.090	0.272	4.010	0.557	1.620
Middle Valley	-0.574	0.254	-2.250	-1.070	-0.075	-0.293	0.319	-0.916	-0.920	0.334
Outer Valley	-0.526	0.295	-1.780	-1.100	0.053	-0.798	0.486	-1.640	-1.750	0.154
Poor	0.090	0.147	0.613	-0.199	0.379	-0.009	0.189	-0.515	-0.381	0.362
Average	0.161	0.126	1.281	-0.086	0.409	0.159	0.154	1.030	-0.143	0.461
Rich	-0.251	0.174	-1.444	-0.594	0.089	-0.149	0.203	-0.735	-0.547	0.249

Cell frequencies in 1973 for Ethnic group, Zone, and Wealth were 33% <5.
Cell frequencies in 1984 for Ethnic group and Zone were 33% <5.

Table H28. Lamda, standard error, z-score, and 95% confidence intervals for traded livestock, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	-0.200	0.386	-0.519	-0.957	0.556	-0.200	0.386	-0.519	-0.157	0.556
Peul	0.256	0.386	0.663	-0.502	1.010	0.256	0.386	0.663	-0.501	1.010
Somono	-0.056	0.511	-0.109	-1.060	0.945	-0.056	0.511	-0.109	-1.060	0.945
River	0.319	0.386	0.825	-0.438	1.080	-0.136	0.538	-0.252	-1.190	0.919
Middle Valley	-0.036	0.386	-0.092	-0.792	0.721	0.320	0.395	0.809	-0.455	1.090
Outer Valley	-0.283	0.510	-0.555	-1.280	0.717	-0.185	0.538	-0.343	-1.240	0.871
Poor	-0.151	0.538	-0.279	-1.206	0.905	-0.149	0.538	-0.278	-1.205	0.906
Average	-0.499	0.538	-0.929	-1.555	0.555	0.309	0.395	0.782	-0.466	1.084
Rich	0.651	0.396	1.644	-0.125	1.426	-0.159	0.538	-0.297	-1.214	0.896

Cell frequencies in 1973 and 1984 for all variables were 50% <5.

Table H29. Lamda, standard error, z-score, and 95% confidence intervals for petty trade, by ethnic group, location, and wealth, 1973 and 1984 periods.

	1973					1984				
Variable	Lamda	SE	Z	Lower 95% CI	Upper 95% CI	Lamda	SE	Z	Lower 95% CI	Upper 95% CI
Banana	0.236	0.308	0.765	-0.369	0.840	0.353	0.369	0.955	-0.372	1.080
Peul	-0.516	0.497	-1.040	-1.490	0.458	-0.297	0.534	-0.556	-1.340	0.749
Somono	0.279	0.369	0.759	-0.443	1.000	-0.056	0.534	-0.105	-1.100	0.991
River	0.099	0.368	0.271	-0.622	0.822	-0.235	0.534	-0.439	-1.280	0.812
Middle Valley	0.402	0.308	1.300	-0.202	1.010	0.518	0.369	1.400	-0.206	1.240
Outer Valley	-0.502	0.497	-1.010	-1.480	0.472	-0.284	0.534	-0.530	-1.330	0.763
Poor	-0.108	0.307	-0.353	-0.709	0.493	0.035	0.324	0.107	-0.599	0.669
Average	-0.032	0.249	-0.129	-0.521	0.456	-0.059	0.287	-0.206	-0.621	0.503
Rich	0.140	0.268	0.523	-0.385	0.666	-0.025	0.324	-0.076	-0.609	0.659

Cell frequencies in 1973 for Ethnic group, Zone, and Wealth were 33%, 33%, and 50% <5.
Cell frequencies in 1984 for all variables were 50% <5.

Appendix I. Wild foods used in the study area.

CROP RESIDUES, NUTS, AND FRUITS	1. Chaff.
	2. Larginaria ciceraria (flen).
	3. Adansonia digitata fruit.
	4. Vitellaria paradoxa nuts (shi).
	5. Cordyla pinnata fruit (duguré).
	6. Boscia senegalensis fruit (béré).
	7. Balanites aegyptiaca fruit (zeginé).
	8. Ntégé fruit (unidentified tree).
	9. Guéré fruit (unidentified shrub).
LEAVES	1. Cassia tora (baninkokatiga)
	2. Cassia occidentalis (mbalanmbalan)
	3. Amaranthus spinosus (buraburaba)
	4. Diascoreaceae spp. (chékurakulusijalan)
	5. Hibiscus cannabinus (dafin)
	6. Gynandropsis gynandra (nansébé)
	7. Adansonia digitata (sira fura)
	8. Leptadenia heterophylla var. hastata (zonnyé)
	9. Moson (unidentified tree)
	10. Corcorus spp. (zonfin)
TUBERS	1. Diascorea prehensilis (nyana)
	2. Nymphaea lotus (ngoku)
	3. Taccia involucrata (bwabayayo) (poisonous unless treated)
	4. Amorphallus abyssinicus (bwa) (poisonous unless treated)
OTHER	1. Termites (nblin, géré)
	2. Grain dug out of anthills.

Appendix J. A Note on Orthography.

The Bamana (also called "Bambara") orthography adopted in the present study is that developed by the Malian Government and used by Opération Riz in the study area (see Bailleul 1981). All Bamana words have been spelled using this method. Place names which are commonly spelled using French orthography have been respelled in Bamana orthography. For example, the town of Ségou is spelled in the present study Ségu, and the proper noun "Ousmane" is spelled "Usmaan". Pronunciation difficulties one would experience using the French spelling of , for example, "Ouagadougou" do not exist in the Malian system which would spell this word as "Wagadugu".

Words in the Bamana language derived from the Arabic language are not dealt with well by either the French or the Malian systems of orthography. Consequently, the system used by modern Arabists has been adopted (see Wehr 1979). A particular problem for the French and Malian alphabets is the lack of a suitable representation of the sounds 'ein, ghayn, and the glottal stop hamza. In instances where these sounds occur in the text a "'" has been used to represent the sound 'ein, "gh" has been used to represent ghayn, and "`" has been used to represent the glottal stop, hamza. An example of each instance is "'Umar" (a man's name), "ghazzal" (gazelle), and "taliba`" (doctors).