This is to certify that the

dissertation entitled

Knowledge, Innovation, and Communication:
Contributions of the formal and informal systems
to agrarian change in the
Office de la Haute Vallee du Niger, Mali

presented by

Brent M. Simpson

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Resource Development

Major professor

Date 7/31/95

KNOWLEDGE, INNOVATION, AND COMMUNICATION: CONTRIBUTIONS OF THE FORMAL AND INFORMAL SYSTEMS TO AGRARIAN CHANGE IN THE *OFFICE DE LA HAUTE VALLEE DU NIGER*, MALI

By

Brent M. Simpson

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Resource Development

1995

ABSTRACT

KNOWLEDGE, INNOVATION, AND COMMUNICATION:
CONTRIBUTIONS OF THE FORMAL AND INFORMAL SYSTEMS
TO AGRARIAN CHANGE IN THE
OFFICE DE LA HAUTE VALLEE DU NIGER, MALI

By

Brent M. Simpson

Conventional models of agricultural development have largely failed to stimulate major improvements in the management systems and general welfare of farmers in the 'complex, diverse, and risk-prone' environments of sub-Saharan Africa. In response, alternative 'Farmer First' approaches advocate making a number of reversals in the basic orientation and specific practices of development initiatives, with a primary focus on farmers' concerns, knowledge, and capacities. These alternatives, however, lack an underlying conceptual framework that could facilitate a more comprehensive and coherent approach to addressing the many difficult problems associated with agricultural research, extension, and local capacity-building. A clearer understanding of the internal dynamics of knowledge formation and communication operating within the 'black box' of local agrarian change will be key to developing such a framework.

In order to advance the current understanding of farmers' knowledge, innovation, and communication, this dissertation uses an inductive, grounded theory approach to explore the central processes involved in the evolution of agricultural practices among farmers in an integrated rural development program, the *Office de la Haute Vallée du Niger*, in Southwestern Mali. The major themes and improvisational nature of farmers' 'linked agricultural performances' characterize their responsiveness to the vagaries of their physical and social environments. At the household level, these performances represent a central feature in the larger set of decisions regarding the

investment of scarce resources in diverse 'portfolios' of economic activities.

A review of the changes that have occurred in local production systems over the past generation reveals that farmers' own knowledge and informal processes of innovation and communication are responsible for the majority. The objectives, orientation, and organization, of the formal governmental research and extension programs are juxtaposed with farmers' practices and concerns, and assessed in terms of the realities of the physical environment.

A proposed conceptual framework is used to interpret the empirical findings in terms of the individual and social patterns of behavior involved. Recommendations are presented on changes specific to the formal system, as well as more general recommendations for enhancing the ability of farmers, extensionists, and researchers to contribute to agricultural development in Southwestern Mali.

Dedicated to Susan, Cameron, and Lillian

ACKNOWLEDGEMENTS

This dissertation could not have been completed without the assistance of many people. The members of my dissertation committee, Frank Fear, Phil Robertson, and Richard Bernsten, all provided invaluable help in preparing me for the field, and in assisting me during the many months of writing. My academic advisor, dissertation director, and research colleague, R. James Bingen, deserves a special note of thanks for his tireless efforts in helping me through the process, and for his thoughtful guidance throughout my doctoral program. His many lessons will continue to serve me for years to come.

To the over 400 men and women farmers in the villages of Balanzan, Banamba, Banankoro, Bassian, Dégula, Falan, Fansébougou, Gouani, Kalé, Kanika, Karan, Missira, Samako, Sikoro, Sougoula, Tenemabougou, Tielé, Tinguelé, and Tomba, with whom I stayed and carried on long conversations, I will be forever in your debt for sharing parts of your lives with me. To the many interpreters, numerous DRSPR/OHV and OHVN Field Agents, and Peace Corps Volunteers of Balanzan, Bancoumana, Oueléssébougou, and Gouani, I owe my gratitude for your many contributions. I am eternally grateful to my driver and friend, Bocar Traoré, for getting us through the long hours of road travel safely, and for helping me to see a side of Malian life that I would not have experienced otherwise.

A number of other individuals also gave generously of their time and knowledge for which I am grateful. My Malian colleague Adama Berthé (AMRAD) helped to open many doors, as well as his own, and in the process provided my introduction to Malian hospitality. Maryjo Arnoldi (Smithsonian Institute) and Juliana Short (Indiana University at Bloomington) helped tremendously during several sticky periods of data collection. Ulli Helberg (DED), Adrian Gnägi (Suisse Development Coop), and Jeff Felton (CLUSA) shared their many insights and experiences with rural development in Mali. Constance McCorkle reviewed major portions of this dissertation and made a number of valued suggestions. William McConnell, William Moseley, and David Midgarden shared freely with me their field observations and findings. And a warm thanks to the Boughton family, who allowed me to spend time with them while I was away from my own family.

A heartfelt thank you is also due to Birama Diarra (Direction Nationale de la Metéorologie), Makan Fofana (DRSPR/OHV), Stephanie Horowitz (Institute for Development Anthropology), Joe Lauer (Michigan State University Africana Library), Gerry McKiernan (CIKARD), Pierre Rosseau (Auburn University), Catherine Weber (Foster Library, University of Michigan), Anthony Yeboah (SECID), and the staff at IIED for providing me with information, helping to locate, and providing access to the many obscure documents and reports that I requested.

A special word of thanks goes to Dennis Bilodeau (USAID/Mali) for his openness, enthusiasm, and continued support of this research.

This dissertation could never have been completed without the tremendous sacrifice and effort put forth by my family. In supporting my own children I will forever strive to follow the example set by my parents. Words alone fail to capture the deep sense of gratitude that I feel for my wife, best friend, and companion, Susan, for her unwavering support and encouragement throughout this entire period. Above all others, she made this work both possible and meaningful.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AFSI	Africa Food Systems Initiative
AV	*Associations Villageoises*
AT	Animal Traction
BDPA	*Bureau de Développement de la Production Agricole*
BECIS	*Bureau d'Études de Conseils et d'Interventions au Sahel*
CAC	*Centres d'Assisance et d'Animation Coopératives*
CARRDS	Community Action Research with Resource Development Students
CCA-ONG	*Comité de Coordination des Actions des Organisations non-Gouvernementales*
CDR	Complex, Diverse, and Risk-Prone
CEC	Cation Exchange Capasity
CEM	*Cellule Essais Multilocaux*
CFAR	*Centre Féminin d'Animation Rurale*
CFDT	*Compagnie Française pour le Développement des Fibres Textiles*
CIKARD	Center for Indigenous Knowledge for Agricultural and Rural Development
CILSS	*Comité Inter-états pour la Lutte contre la Sécheresse au Sahel*
CIRAD	*Centre de Coopération Internationale en Recherche Agronomique pour le Développement*
CLUSA	Cooperative League of the USA
CMDT	*Compagnie Malienne pour le Développement des Textiles*
CRED	Center for Research on Economic Development
CS	*Chef Secteur*
CSS	*Chef Sous-Secteur*
DAI	Development Alternatives Inc.
DED	*Deutscher Entwichlungsdienst*
DHV	Development of the *Haute Vallée*
DNM	*Direction Nationale de la Météorologie*
DRA	*Division de Recherche Agronomique*
DRSPR	*Département de Recherche sur les Systèmes de Production Rurale*
DRSPR/OHV	*Département de Recherche sur les Systèmes de Production Rurale/Volet OHV*
FAC	*Fonds d'Aide et de Coopération*
FED	*Fonds Européen de Développement*
FF	Farmer First
FPR	Farmer Participatory Research
FSR	Farming Systems Research
FAO	Food and Agriculture Organziation of the United Nations
GERDAT	*Groupement d'Etudes et de Recherches pour le Developpement de l'Agronomie Tropicale*
GIS	Geographic Information Systems

GO	Governmental Organization
GOM	Government of Mali
GRAAP	*Groupe de Recherche d'Action et d'Appui à l'Auto-Promotion*
GTZ	*Deutsche Gesellschaft für Technische Zusammernarbeit*
GV	*Groupements de Vulgarisation*
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IARC	International Agricultural Research Center
IER	*Institut d'Economie Rurale*
IFAC	*Institut Français de Recherches Fruitières Outre-Mer*
IGN	*l'Institut Géographique National*
ILO	International Labor Organization
IPM	Integrated Pest Management
IRAT	*Institut de Recherches Agronomiques Topicales et des Cultures Vivrières*
IRCT	*Institut de Recherches du Coton et des Textiles Exotiques*
IRHO	*Institut de Recherches pour les Huiles et Oléagineux*
ISNAR	International Service for National Agricultural Research
ITCZ	Intertropical Convergence Zone
IER	*Institut d'Economie Rurale*
MSU	Michigan State University
NARP	National Agricultural Research Project
NARS	National Agricultural Research System
NGO	Non-Governmental Organization
OACV	*Opération Arachide et Cultures Vivrières*
ODIPAC	*Opération de Développement Intégré pour la Production Arachidière et Cerealière*
ODR	*Opération de Développement Rural*
OHV	*Opération Haute Vallée*
OHVN	*Office de la Haute Vallée Du Niger*
ON	*Office du Niger*
OPAM	*Office des Produits Agricoles du Mali*
PAE	*Projet Agro-Ecologie*
PAR	Participatory Action Research
PNT	*Phosphate Naturel de Tilemsi*
PRA	Participatory Rural Appraisal
PSPGRN	*Programme Système de Production et Gestion des Ressources Naturelles*
R&D	Research and Development
RD	Resource Development (Department of)
RRA	Rapid Rural Appraisal
SAFGRAD	Semi-Arid Food Grain Research and Development
SATEC	*Société d'Aide Technique et de Coopération*
SCAER	*Société de Crédit Agricole et d'Equipment Rural*
SECID	Southeast Consortium for International Development
SMS	Subject Matter Specialists
SNPV	*Service National de la Protection des Végétaux*
SOCOMA	*Société des Conserveries du Mali*
SOMIEX	*Société Malienne d'Import Export*
SPAAR	Special Program for African Agricultural Research
SPARC	Strengthening Research Planning and Research on Commodities Project
SRCVO	*Section de Recherche sur les Cultures Vivrière et Oléagineuses*

SRCFJ	*Section de Recherche Coton. Fibre et Jutieres*
TA	Technical Assistance
T&V	Training and Visit
TOR	Terms of Reference
UBT	*Unité Bétail Tropical*
USAID	United States Agency for International Development
USRDA	*Union Soudanaise Rassemblement Démocratique Africain*
WMO	World Meteorological Organization
ZER	*Zone d'Expansion Rurale*

Chapter I. Introduction: Towards a Better Understanding of the Local Processes of Agrarian Change

Innate human creativity and the capacity to innovate is a central factor in agrarian change. The impact of this intrinsic force on the processes of local technical and social change is clearly evident in the evolution of specific practices and entire production systems during the course of agricultural development. As central players in this evolutionary drama, farmers derive much of their motivation to undertake various changes from sheer necessity, as well as from both the desire to achieve specific gains and a general curiosity about the potential benefits of alternative practices. As a result, the state-of-the-art in local agricultural production is continually undergoing modification, as old practices are abandoned or adapted and new ones are adopted in order to better fit the evolving set of perceived social and physical conditions.

While these informal processes of adaptation have been responsible for both the genesis of and much of the development occurring in local agrarian systems, a whole new range of formal actors--public, private, and non-profit--have emerged during the last century who are explicitly dedicated to influencing agricultural transformation. Ostensibly, the common goal of these additional actors is to enable and assist farmers in their pursuits. Yet in practice, they tend to be motivated by different sets of objectives, and approach problems from radically different perspectives than those of the farmers they are attempting to serve. As a result, the rate, orientation, and scope of change taking place within any location at any point in time becomes a product of not one, but several sets of informal and formal influences.

It is against this backdrop--the fusion of farmers' own innate creativity and the input from the various formal technical and social support services--that this dissertation investigates the transformation in agricultural practices over the past generation among farmers in a large, integrated rural development project, the *Office de la Haute Vallée du Niger* (OHVN), in Southwestern Mali (see Figure 1). This dissertation specifically focuses upon improving our understanding of how the knowledge, innovation, and communication systems of both the formal governmental research and extension services, and farmers' more informal development activities, have contributed to the generation and spread of new agricultural practices. This improved understanding is then used as the basis for making recommendations on how the complementarity of these two sets of resources can be strengthened.

Figure 1. Mali and the Location of the *Office de la Haute Vallée du Niger*.

Background to the Research Problem

Since the decade of independence in the 1960's, much of sub-Saharan Africa has become locked in a protracted struggle to meet the basic nutritional and economic needs of its growing population. National policy disincentives, debt burdens, fluctuations in world commodity markets, periods of civil strife, regional climatic change, and inadequate agricultural technical packages and approaches are among those factors credited with inhibiting a more rapid rate of growth within the agricultural sector (e.g., Conable, 1991; Diouf, 1990; Eicher, 1989; Wheeler, 1984; World Bank, 1989). Since agriculture productivity is both the primary provider of food and the potential 'engine' of economic transformation, the continued stagnation in production levels raises serious concerns over the future prospects of food security and economic development throughout sub-Saharan Africa. The increasingly ominous specter of natural resource degradation that hangs over much of the region makes these concerns all the more pressing (Harrison, 1987; NRC, 1983; World Bank, 1989).

For Mali, and the OHVN zone in particular, the litany of events that has transpired since independence differs little from that of many other nations within this same period. The national rate of population growth has averaged nearly two and a half percent over the past decade (World Bank, 1993), with the OHVN zone experiencing the country's highest rate of growth at over three percent annually. Although Mali is still a country with land surpluses, the open frontier of arable lands is fast closing, and many communities, such as those in the more fertile and better watered southern areas, are beginning to experience shortfalls of suitable land types. The result of increasing land pressure, coupled with major changes in agricultural production practices (related in some areas to increased cash crop production), has led to excessive levels of soil erosion and a depletion of the natural soil nutrient stores (e.g., Bishop and Allen, 1989; Day, 1989; van de Pol, 1992). Forest resources have suffered similarly, declining at a steady aggregate rate of one percent per year, with the highest rates of loss concentrated around centers of human habitation (WRI, 1994). The major reductions in annual rainfall levels, which have plagued much of West Africa since the late 1960's, have severely limited farmers' abilities to increase production. Nationally, per capita cereal production levels in Mali have dropped below 1979/81 levels (World Bank, 1993), while the crash of the world peanut market in the late 1970's, and a decline in world cotton prices through the 1980's and early 1990's (cotton and peanuts are the principle cash crops in the OHVN zone), have weakened farmers' abilities to maintain their former levels of income through agriculture alone. Lacking employment opportunities in other sectors of the economy, rural poverty levels have continued to rise (IFAD, 1993).

For Mali, as well as much of Africa, the failure of external investments in rural development to have an appreciable impact on the welfare of the rural poor has been one of the most troubling trends. Particularly disheartening has been the failure of the major investments in the national and international agricultural research centers (NARS and IARCs) to achieve widespread or sustained successes in alleviating farmers' constraints and in generating significant new production opportunities. Although collectively African NARS have had the lowest budgets for agricultural research of any region in the world, the Consultative Group on International Agricultural Research has spent more on agricultural research in Africa than in any other region (Ravnborg, 1992). In the case of Mali, past national investments and significant donor support have contributed to the development of one of the largest national agricultural research systems in West Africa (ISNAR, 1990). Despite these investments, farmers in areas such as the OHVN zone have benefited little.

Since 1978, the United States Agency for International Development (USAID) alone has spent nearly 70 million $US in the OHVN zone to stimulate agricultural development (USAID, 1978; 1984; 1988; 1993). These investments, which run the gamut of mainstream development approaches--from integrated rural development to farming systems research, and training and visit extension--have produced few positive results (see Bingen et al., 1994; Kingsbury et al., 1994). The adoption rates of improved varieties and the use of external inputs in food crop production within the OHVN zone remain low. Although overall production levels for the major cereal crops have risen, the increases have been achieved almost entirely through the expansion of cropland under production. Millet is the only cereal crop that has shown a significant increase in annual per hectare yield levels in recent years (averaging 3.5 percent per annum)(OHVN, 1992a)[1]. However, these increases cannot be attributed to the efforts of the formal research and extension system.

Despite the poor results of investments in what can be labeled as the conventional, centralist approach to agricultural development (Biggs, 1989a), Mali's national planners, and the major donors supporting much of the country's research and development activities, have yet to seriously question the basic assumptions and underlying objectives of the current development approaches. Underscoring this point, efforts presently being undertaken in Mali by the World Bank, USAID, and ISNAR, among others, are focused upon yet another round of reorganizations and adjustments within the formal research institution, both nationally and across eco-regional lines (e.g., IER, 1992; TAC, 1993; USAID, 1992; Weijenberg et al., 1992). However, there is little reason to believe that the current efforts to improve the operational efficiency

---

[1] This figure has been adjusted to eliminate the influence of the disastrous 1990 harvest; the 1991 harvest surpassed that of 1990 by 140 percent.

of the centralist model of development will be capable of redressing the numerous shortcomings. The lessons learned over the past several decades suggest that a more fundamental reassessment of the overall orientation of agricultural and rural development will be needed.

As an alternative to the conventional approaches to agricultural development, the 'Farmer First' (FF) movement (Chambers et al., 1989) was born out of dissatisfaction with the widespread failures of previous efforts to improve farmers' welfare. Inspired by positive experiences with farmer participation in the on-farm research programs of early farming systems research initiatives (e.g., Chambers and Ghildyal, 1985; Rhoades and Booth, 1982), the FF paradigm is oriented towards bringing about a number of 'reversals' in the established approaches to agricultural development. Proponents of the FF movement argue that, in order for the formal system to address the problems of farmers in 'complex, diverse, risk-prone' (CDR) environments (Chambers el al., 1989), such as the OHVN zone, researchers must start with where farmers are--their problems, their priorities--and increasingly involve them in the entire development process. The 'complementary methods' advanced by this 'populist' perspective include making greater use of farmers' knowledge within the formal research programs, engaging in various forms of farmer-researcher collaboration, as well as promoting the development of farmers' own experimental capacities.

Although success of the FF perspective is predicated on engaging farmers' knowledge and capacities, the internal dynamics of local agricultural change remain largely a 'black box' (e.g., de Boef, 1993; Chambers et al., 1989; Richards, 1989a). In recent years the FF movement has stimulated a virtual flood of books, journal articles and special issues, monographs, professional conferences and workshops on indigenous peoples and their knowledge systems (see for example the following bibliographies and collected works, e.g., Agriculture and Human Values, 1989; 1991; Brokensha et al., 1980; de Boef et al., 1993; Gupta, 1990; Inglis, 1993; Johannes, 1989; McCall, 1988; Mundy, 1991; Narby and Davis, 1983; Warren et al., 1995). While much of the early research focused upon describing local knowledge systems within different cultural contexts, more recently researchers have begun to shed light upon the structure of local agricultural knowledge (e.g., Bentley, 1992), methods of farmers' experimentation (e.g., Fujisaka, et al., forthcoming; Potts et al., 1992; Stolzenbach, 1993), and the patterns of different types of information exchange (e.g., Indigenous Knowledge and Development Monitor, 1994; Mundy and Compton, 1991). These and other studies have advanced considerably the level of understanding on specific aspects of the structure of local knowledge systems, as well as the inner-workings of the informal R&D process. However, taken by themselves, these studies are partial and fragmented, and have not led to a coalescence in our understanding of the overall process of local agrarian change. In order to improve the ability of FF approaches to effectively bring farmers, and their skills and knowledge, into the development process, a more holistic understanding is needed of how these internal processes of knowledge generation and exchange function (cf. Okali et al., 1995; Scoones and Thompson, 1994).

The Problem Statement

The accumulated evidence of stalled agricultural production (OHVN, 1992a), growing environmental degradation (NRC, 1983; van de Pol, 1992), and rising rural poverty (IFAD, 1993) indicates that in complex, diverse, risk-prone environments, such as the OHVN zone in Southwestern Mali, the conventional, centralist approach to agricultural development has largely failed to improve the welfare of rural producers. A growing body of evidence also indicates that farmers possess both a wealth of information and a great deal of innovative capacity (e.g., Chambers, et al., 1989; Warren et al., 1995), yet this knowledge and capacity has neither been accounted for, nor utilized by, the traditional development approaches. Despite these findings, and the promotion of a major alternative paradigm (Farmer First) for increasing farmer participation in the development process, the present level of understanding and conceptualization of the internal dynamics of local agrarian change limits the extent to which these new approaches can be utilized effectively in local development initiatives.

In response to the recognized shortfalls of traditional approaches to agricultural development, as well as the noted gaps in the knowledge base and conceptual framework that underlie the alternative FF perspective, this dissertation attempts to consolidate and expand our understanding of the internal processes of local agrarian change. Using a detailed case study on the evolution of agricultural practices among farmers in Southwestern Mali, this research examines the processes by which the formal and informal systems of knowledge, innovation, and communication have jointly and separately contributed to the recent transformations in local production systems.

Research Objective and Major Research Questions

This dissertation, first and foremost, explores the poorly understood process of local agrarian change. In order to operationalize this primary objective, as well as to gain insight into the specific details of the processes of knowledge formation and dissemination, including the structure of knowledge-based relationships within the context of the case study, this research addresses four general areas of inquiry. First, what specific changes in agricultural practices have occurred during the lifetime of the present agricultural managers, and why? What additional changes are these individuals currently attempting to make, and how? Second, what are the origins--formal or informal--of the information and materials that have contributed to the identified changes? Third, how have these ideas, information, and materials been acquired and disseminated within the informal system? Finally, what changes in the formal system's approach can be made that would help improve the overall effectiveness of agricultural development efforts undertaken by both the formal and informal systems?

While this dissertation is explicitly concerned with agricultural change within the context of the OHVN, the lessons drawn from this case study are applicable to the similar situations found among other national research and extension systems within the region. In this regard, the OHVN is particularly well-suited as a case study because of its long history of attempts to stimulate agricultural and rural development through various mainstream development approaches. In light of the growing number of local farmer groups that are independently becoming involved in their own research and information exchange activities, including those in non-CDR environments (such as in the United States), research on the patterns and processes of local agrarian change provides a basis for drawing generalizations on the nature of agricultural and rural development efforts that are more broadly relevant.

Theoretical Orientation of the Study

The theoretical orientation of this study and the framing of the primary research questions for this case study emerged from several sources. The value of using a historical case study perspective in examining local agricultural change was highlighted

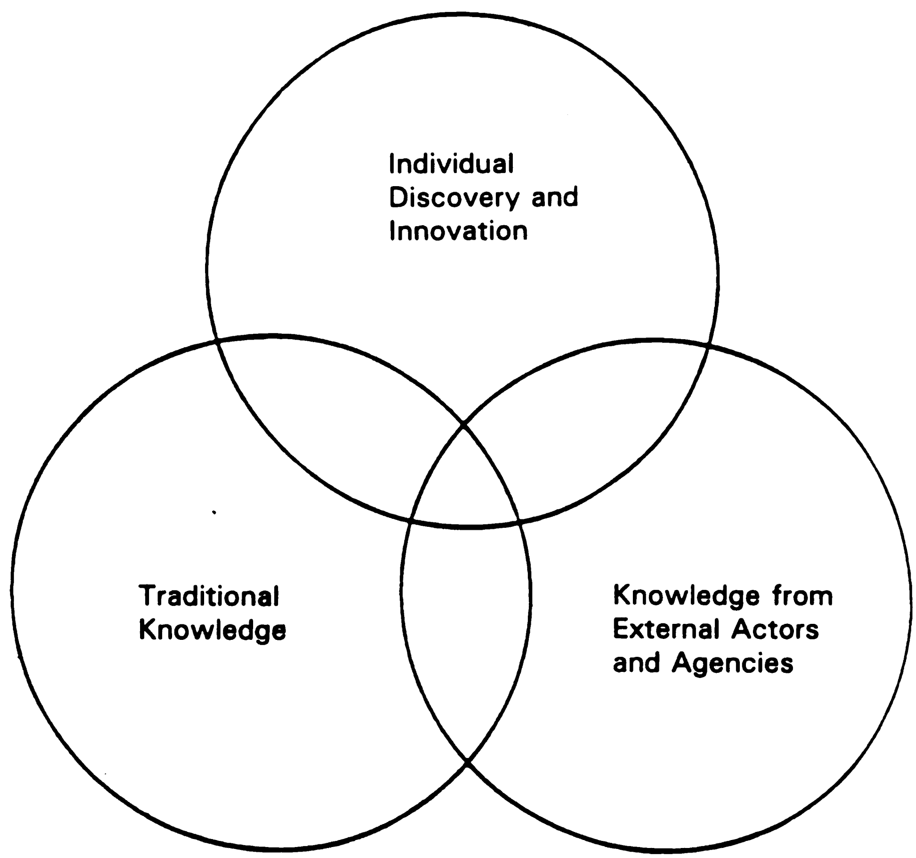
by the exemplary research of Richards (1985) and Knight (1974) on the evolution of agricultural systems in West and East Africa, respectively. These studies, in addition to the findings of a number of field anthropologists and others (e.g., McCorkle et al., 1988; Niamir, 1990; Sharland, 1989), underscore the observation that the process of local change should not be viewed as a closed system, i.e., wholly indigenous, but rather as an open system involving contributions from many sources (cf. Biggs' (1989a) multiple-source of innovation model).

The literature on local agrarian change also can be used to help describe the basic structure and evolution of agricultural practices in terms of the relationships among three overlapping sources of influence: the intergenerational, social reproduction of traditional knowledge; the generation of new knowledge through individual discovery, innovation, and validation; and the acquisition of new ideas, information, and materials from external actors and agencies, including farmers from other areas, merchants, and contacts with research and extension personnel, non-governmental representatives, among others (see Figure 2). Conceptually, the dynamic interplay among these three sources can be used to characterize the evolution of local knowledge systems, where the successful elements of individually-generated innovations and the verification of useful information and materials emanating from external sources are, over time, incorporated into the larger pool of orally-reproduced cultural traditions that are passed on from one generation to the next. This perspective provides the general orientation for investigating the internal dynamics of local change, and for identifying the relative contributions of the formal and informal systems in the OHVN case study.

by the exemplary research of Richards (1985) and Knight (1974) on the evolution of agricultural systems in West and East Africa, respectively. These studies, in addition to the findings of a number of field anthropologists and others (e.g., McCorkle et al., 1988; Niamir, 1990; Sharland, 1989), underscore the observation that the process of local change should not be viewed as a closed system, i.e., wholly indigenous, but rather as an open system involving contributions from many sources (cf. Biggs' (1989a) multiple-source of innovation model).

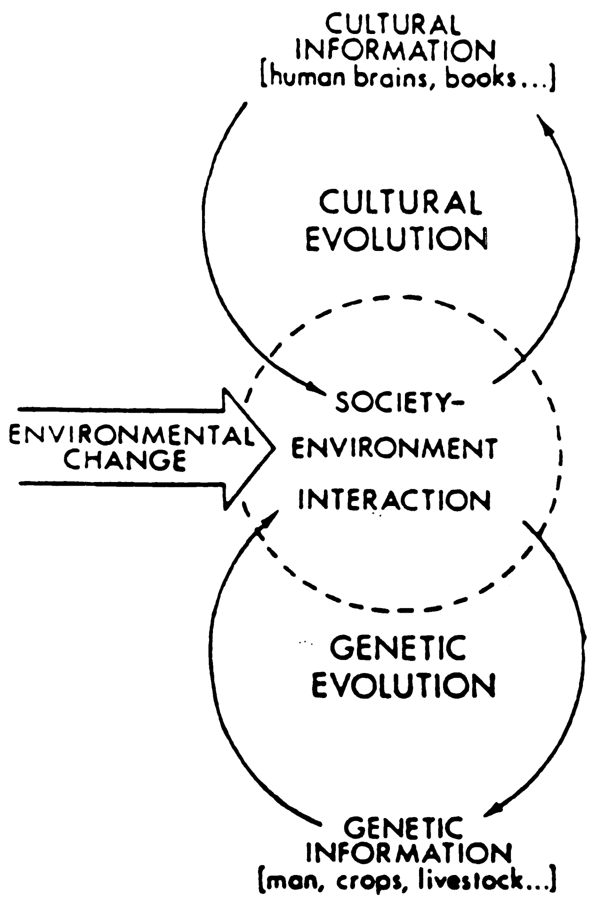
The literature on local agrarian change also can be used to help describe the basic structure and evolution of agricultural practices in terms of the relationships among three overlapping sources of influence: the intergenerational, social reproduction of traditional knowledge; the generation of new knowledge through individual discovery, innovation, and validation; and the acquisition of new ideas, information, and materials from external actors and agencies, including farmers from other areas, merchants, and contacts with research and extension personnel, non-governmental representatives, among others (see Figure 2). Conceptually, the dynamic interplay among these three sources can be used to characterize the evolution of local knowledge systems, where the successful elements of individually-generated innovations and the verification of useful information and materials emanating from external sources are, over time, incorporated into the larger pool of orally-reproduced cultural traditions that are passed on from one generation to the next. This perspective provides the general orientation for investigating the internal dynamics of local change, and for identifying the relative contributions of the formal and informal systems in the OHVN case study.

Figure 2. Sources of Influence in the Formation and Evolution of Local Knowledge Systems.



Additional observations drawn from personal experience and the human ecology and development literature (e.g., Biggs and Clay, 1981; Brokensha and Riley, 1986; Falconer, 1990; Fleuret, 1986; Johnson, 1972; Knight, 1980; NRC, 1995; NRC, Forthcoming; Western, 1982)(see Figure 3) led to an examination of the patterns of diversification in household production activities and the major economic and nutritional contribution of so-called 'minor,' or 'secondary,' crops and products. This examination, as part of a broader interest in rural people's detailed environmental knowledge and adaptive capacity, emphasizes the importance of the physical environment on human welfare. In response, this dissertation reviews and synthesizes the literature on the major natural resource systems in the OHVN zone (soils, rainfall, genetic diversity). These resources provide not only the major parameters within which the formal and informal systems must operate, but in a historical sense, define the *milieu* in which local knowledge and farmers' skills have developed. A detailed understanding of the physical environment also provides a basis for more accurately interpreting the observed patterns of farmers' adaptive behaviors, and for assessing the relevancy and viability of the assistance offered through the formal system.

Figure 3. The Co-evolution of Human and Natural Systems.[2]



[2] Source: Knight, 1980.

The growing body of literature on indigenous, or local, knowledge systems and the informal processes of innovation and communication indicates that the distribution of knowledge among individuals in specific locations is not homogeneous. It also suggests that local communities are not composed of individuals with equal interests and capacities to innovate (e.g., Box, 1988; Johnson, 1972; McCorkle, et al., 1988; Swift, 1979). Several authors indicate the existence of local communication channels, or pathways, which influence the acquisition and local spread of information (e.g., Coughenour and Nazhet, 1985; McCorkle et al., 1988; Nazhet and Coughenour, 1987). These observations on the nature of local knowledge systems had direct bearing on how the data were collected, as well as in the identification of areas which warranted further probing during field work.

The Research Context

The field research upon which this dissertation is based was conducted as part of a contractual agreement between the Department of Resource Development at Michigan State University and the United States Agency for International Development (USAID) Mission in Mali.[3] This agreement was reached in response to USAID's request for an institutional analysis of the service delivery systems of one of its major projects, the Development of the *Haute Vallée* (DHV), located in the *Office de la Haute Vallée du Niger* (OHVN). With the DHV project nearing completion, USAID was interested in determining what steps could be taken to strengthen the project's impact before

[3] The terms of this contract were negotiated as part of the Department of Resource Development's Community Action Research with Resource Development Students (CARRDS) program. This program was established to allow graduate students, under faculty guidance, to gain experience in responding to the outreach needs of the department's clientele

committing additional funds. During the negotiation over the Terms of Reference (TOR) for the study, the original scope was broadened to include a detailed technology assessment of the importance and impact of both the indigenous and introduced practices, crops, and processes of innovation and communication on changes in the agricultural systems of the area. These issues were added to concerns over future technical service needs of farmers and village associations in the area; the identification and assessment of the contributions to rural development by other actors; the organizational dynamics of the village associations and their ability to act as 'engines' for local development; the political context within which development efforts are taking place; and the identification of organizational constraints on further development efforts (see Appendix A). In order to accommodate the expanded TOR, the time frame for the field research was increased from a fairly standard short-term consultancy to one that eventually involved three and-one-half person-months of independent field work.

The contractual nature of the research, as well as the philosophical commitment of the researchers involved, led to a primary concern for producing results that would improve the OHVN's ability to stimulate agricultural change through an improved delivery of relevant services to farmers and village associations. To facilitate this objective, the use of a participatory action research (PAR) approach (e.g., Whyte, 1991) was proposed as a way to establish a collaborative working relationship between the research team and the OHVN administration. In support of this suggestion, a separate agreement was reached with the USAID Mission to hold a final planning workshop following the completion of the study. The workshop was intended to facilitate the direct translation of the research findings into pragmatic changes within the OHVN. In the end, however, a number of factors blocked this attempt to engage the PAR approach. As a result, the collection of data for this dissertation was completed primarily as an individual effort.

Methodological Orientation of the Study

The conceptual foundation of the data collection and analytic methods used in this dissertation is based upon the seminal work of Glaser and Strauss on the 'discovery' of grounded theory (Glaser and Strauss 1967; Strauss and Corbin, 1990). The grounded theory approach is an inductive, qualitative methodology developed for the study of complex social phenomena. As with other research approaches, grounded theory assumes that there is order in the universe, and that data, once properly categorized and integrated, will allow this order to become discernable within the complex web of individual behaviors and social interactions (Glaser and Strauss, 1967; Corbin and Strauss, 1990). In the grounded theory approach, the social science researcher becomes the primary research instrument, where the acts of data collection, analysis, categorization, integration and hypothesis-testing are carried out in an iterative fashion. The validity and reliability of conclusions reached under this approach depend largely upon the quality of the data collected, and the skill, theoretical sensitivity, and creativity of the researcher in organizing and integrating this information into accurate representations of reality.

Although in many respects the grounded theory approach is indistinguishable from other exploratory research approaches, its ultimate focus on the construction of theory, the "plausible relationships...among concepts" (Strauss and Corbin, 1994:278), clearly sets it apart from other approaches. Conceptually, theory developed through the grounded theory approach is said to evolve out of "the continuous interplay between analysis and data collection" (1994:273), where the emerging theory is shaped by the theoretical sensitivity of the researcher, and his or her "interplay [with] the actors studied," as well as prior knowledge and investigations into the issues under study (1994:280; Strauss and Corbin, 1990). Pragmatically, theory development is based upon the use of what Glaser and Strauss (1967) term the 'constant comparative method,' where new data are analyzed and placed into newly-created or pre-existing 'conceptual categories' (defined as distinct, self-standing, conceptual abstractions that serve to group and organize the data collected). Categories are developed by using principles of 'minimum' and 'maximum' differences, where in the early stages of research, the researcher seeks data that are fairly homogenous in nature, or which exhibit 'minimum' amounts of variation. This enables the conceptual properties of the categories, and their theoretical relationships, to emerge more quickly. Once categories are sufficiently developed, the researcher turns to seeking out data for their 'maximum' degree of diversity. The examination and comparison of contrasting or negative cases helps to strengthen and enrich the emerging theoretical connections between the categories. The continuing comparison of new data with the existing evidence and categories occurs simultaneously with the generation and testing of hypotheses that explain the relationships between the categories. The use of multiple slices of data, obtained from different sources and through different means, helps to develop the theoretical richness of the categories and their relationships with each other. Glaser and Strauss (1967) suggest that core categories continue to be explored until they become sufficiently 'saturated,' or until additional data no longer contribute to their theoretical development. The practical constraints of time and access to additional data frequently limit this process.

Although proponents of the grounded theory approach argue strongly for adherence to the full set of methods as described above, most research situations require adjustments and adaptations to the grounded theory approach in order to fit a broader range of research conditions (Strauss and Corbin, 1990; 1994). In the OHVN case study, the time limitations under which the study took place, as well as the large size and diverse nature of the study area, required the fusion of grounded theory methodologies with various Rapid Rural Appraisal (RRA) data collection techniques. In addition, because logistical limitations precluded multiple visits to each study site, secondary sources of information were used extensively in order to enrich the categories established through the analysis and organization of primary field data. In some instances, conceptual categories, developed by other authors in their analysis of empirical evidence, were adapted to this study, a practice which, when done with the necessary caution, is consistent with the grounded theory approach (Strauss and Corbin, 1990; 1994).

The grounded theory approach was selected as the methodological basis for this dissertation because of its compatibility with the main research questions, data needs, and research conditions confronted in Mali. The approach proved capable of producing the type, quantity and quality of information needed for exploring the issues under investigation within the existing time limitations and field conditions (Strauss and Corbin, 1990). The primary concern for investigating how the 'black box' of local change operates--how local knowledge is generated, maintained and exchanged--as well as how the formal and informal systems within the OHVN have interacted with one another in contributing to local change, required the use of an exploratory research technique. Due to the poor level of understanding concerning the local processes of agrarian change, it was important to avoid producing research results that were "more a product of the methodology than of the phenomenon being studied" (Lawler, 1985:3). It was felt that approaches such as standard survey methods would be inappropriate, since they require a great deal of knowledge about the research subject at the outset in order to design relevant and revealing questions. In contrast, the research approach needed to be capable of allowing the lines of inquiry to evolve and reflect the acquisition of new information as the research progressed. Secondly, because local producers themselves held the bulk of knowledge concerning their practices, the research method needed to be capable of giving 'voice' to local producers, allowing them to fully explain their experiences, perceptions and activities, rather than simply serving as a collection tool for obtaining responses to validate the researcher's own hypotheses (Strauss and Corbin, 1990; Marshall and Rossman, 1989).

Third, the research conducted needed to be capable of producing results that could be used as guides for action in making management and policy decisions (Strauss and Corbin, 1994). Although less action-driven than other types of research, proponents of the grounded theory approach are deeply concerned with the ability of research results to benefit the research subjects; researchers have "an obligation towards society," which carries with it the "responsibilities to develop or use theory that will have at least some practical applications" (Strauss and Corbin, 1994:281). The ability of grounded theory to make such contributions is based on the belief that theory, "carefully induced from diverse data," will have a high degree of "fit" regarding its explainative power over the phenomena which it claims to address (Strauss and Corbin, 1990:23).

Finally, the selection of research methods needed to be consistent with the skills and convictions of the researcher who would be conducting the research (Strauss and Corbin, 1990).

In consideration of these factors, a 'grounded,' or inductively-oriented, research strategy was felt to meet best the demands of the specific research objectives and context. This approach not only provided the flexibility needed to pursue evolving lines of inquiry into poorly understood areas, but also provided an analytic framework for identifying major variables and relationships within complex patterns of social phenomenon. In addition, because this approach relies upon interpretations built directly from the empirical data, it is capable of giving voice to the actors involved in the study. By blending the use of the grounded theory approach with various RRA data collection techniques, information could be obtained on a number of sensitive areas (such as those regarding individuals' personal agricultural practices, including their successes and failures), among individuals located across the wide range of physical and social conditions found in the project area under the time limitations stipulated. Although no record could be found that the grounded theory approach had previously been used for investigating issues related to agricultural development, or had ever been combined with RRA data collection techniques, its methodological orientation towards use in situations where the social or behavioral phenomenon under study is poorly understood made it appropriate choice.

Organization of the Dissertation

The dissertation is organized as follows: Chapter II discusses the specific methods used in the collection and analysis of the primary and secondary data in this dissertation. Chapter III provides a detailed description of the major natural resource streams which present both farmers and researchers with their basic physical parameters for developing new opportunities and addressing existing production constraints. Chapter IV reviews the highly adaptive nature of farmers' agricultural performances, and provides an overview on the organization of household resource allocation and the diversification of household economic activities. This is followed by a characterization of the OHVN zone into different household economic portfolio areas. Chapter V explores farmers' environmental knowledge, patterns of information exchange, and processes of innovation. Chapter VI presents a summary of farmers' observations on the changes that have occurred in their farming systems since the time of their 'fathers' and 'mothers.' Chapter VII reviews the emergence and current operations of the formal system of research and extension within the OHVN project area, and reviews areas of compatibility and discord among these efforts, farmers' practices and concerns, and the realities of the physical environment. Chapter VIII uses a synthesis of postulates and theories on social and individual behavior to explain and link the observations and findings of the case study to the larger knowledge base on human behavior. Chapter IX provides a brief summary of the major research findings, offers some recommendations for strengthening the abilities of the formal system to contribute to agricultural growth within the OHVN zone, as well as for additional research, and concludes with some comments on the usefulness and limitations of the research, with special reference to the methodologies used.

Chapter II. The Research Methods

The research upon which this dissertation is based was part of a much larger research effort, the conditions of which significantly influenced the choice of data collection and analytic methods. This chapter describes the overall research design and organization of the study, and the methodological approaches used in the collection and analysis of field data.[4]

Data Collection and Analytic Techniques

The combined constraints of limited time and personnel, the large size and highly diverse nature of the project area, as well as the explorative nature of the research questions, required the use of highly flexible and adaptive data collection techniques. In this research, the strategies of the grounded theory research approach were blended with various Rapid Rural Appraisal (RRA) data collection techniques to meet the existing challenges. Structurally, the study was organized around a multi-stage research design that allowed a progressive immersion in the social and physical context of the study environment. These stages included: a period of pre-departure data collection and reflection; a rapid reconnaissance of the project area consisting of

---

[4] While this research was carried out as part of a larger team project, only those issues that are concerned with the approach and methodologies used in the collection and analysis of data presented in this dissertation are discussed here. For a review of the larger team effort see Bingen et al., 1994.

interviews with various individuals associated with public, private, non-profit, and volunteer organizations active in the project area, and forays into the field; the main field work of data collection and preliminary analysis; and successive rounds of increasingly intensive post-field data analysis and integration with additional secondary sources.

Pre-Departure Preparations

A number of information sources were consulted prior to departure for the field. A two-day visit was made to the Center for Indigenous Knowledge and Agricultural and Rural Development (CIKARD) at Iowa State University, in order to review their comprehensive collection of documentation on indigenous knowledge and local processes of experimentation and communication. This was followed by local interviews with former Peace Corps Volunteers familiar with the study area, and a three-day visit to Michigan State University by a member of the OHVN staff who was in the United States for advanced technical training. In addition, project documents, the latest OHVN annual reports, and some additional consultant reports were received from the USAID/DHV project officer and technical support staff in Mali. Based upon a review of information gained from these sources, a strategic plan was devised that outlined a two-phase research approach: a preliminary three-week reconnaissance phase, where the main research questions, assumptions, and proposed data collection techniques could be verified, tested and refined; and the main field research phase of data collection and primary data analysis.

Drawing upon the approach to rapid data collection outlined by Bernsten et al. (1980) and others (e.g., Holtzman, 1986), a three-step process was used. First, the major areas of inquiry were broken down into individual questions, and linked with the potential sources of information identified through the interviews and review of secondary literature. Each data need was matched with at least two sources, a primary and secondary source, and with at least one verifying source. Second, once linked, the various data requirements and potential sources of information were paired with specific data collection methodologies deemed appropriate for the particular source and the type of information required, and which were manageable under the time limitations. The selection of different sources of information and data collection methods was guided by the principle of 'triangulation,' a central feature of the grounded research approach (Glaser and Strauss, 1967).[5] Based upon the linking of information needs, source(s), and the use of different methodologies, a series of information collection sheets were created to assist with data collection and recording. These sheets outlined the primary and secondary questions, or information needs, for each source, as well as any additional questions that needed verification, and the proposed method(s) for obtaining the information (see example, Appendix B). Lastly, a tentative schedule was drawn up that provided an opportunity to interview or, in the case of secondary information, access each of the sources identified.

---

[5] Originally a navigational expression, triangulation refers to the process of using multiple sources for, as well as methods of, obtaining data, in order to verify the accuracy of the information. Using the navigational analogy, the observer first locates him or herself on an approximative line drawn between two points. Because there are no additional points of reference, the exact position along this single line cannot be determined. The construction of a second line locates the observer at an intersection, yet infers a higher degree of certainty than the approximative methods of line placement actually warrant. A third line (or more) is then used to determine an area, triangle, within which the observer is located. The skill of the navigator, or in this case the researcher, in constructing the boundary lines determines the resulting size, and degree of certainty, that the truth or reality is contained within the triangle. Triangulations can be constructed with regard to several dimensions of data (Denzin, 1978). In this research, triangulations were applied to both different data sources and methods of data collection.

To facilitate the *in situ* modification of the research approach, a 'toolbox' of additional RRA methodologies (articles, papers and case examples) was assembled and taken to the field.[6] These methodological tools (including the use of various ranking procedures, transect walks, and mapping exercises) were in addition to those selected for use in the rapid reconnaissance, and served as an important resource in the evolution and refinement of data collection methods used for the main phase of field research.

The Rapid Reconnaissance Phase

As a member of a larger research team, the researcher was involved in a number of important joint activities prior to the main phase of field research. Following an initial round of meetings and introductions at the OHVN, USAID and Development Alternative Inc. (DAI) offices, scheduled interviews and meetings were held with various governmental, non-governmental, private-sector, and project officials in the Bamako area to gather information on the state of rural development activities in the OHVN zone. These interviews were interspersed with discussions with USAID representatives and OHVN staff over the implementation of the rapid reconnaissance and the organization and selection of research sites for the main phase of field research.

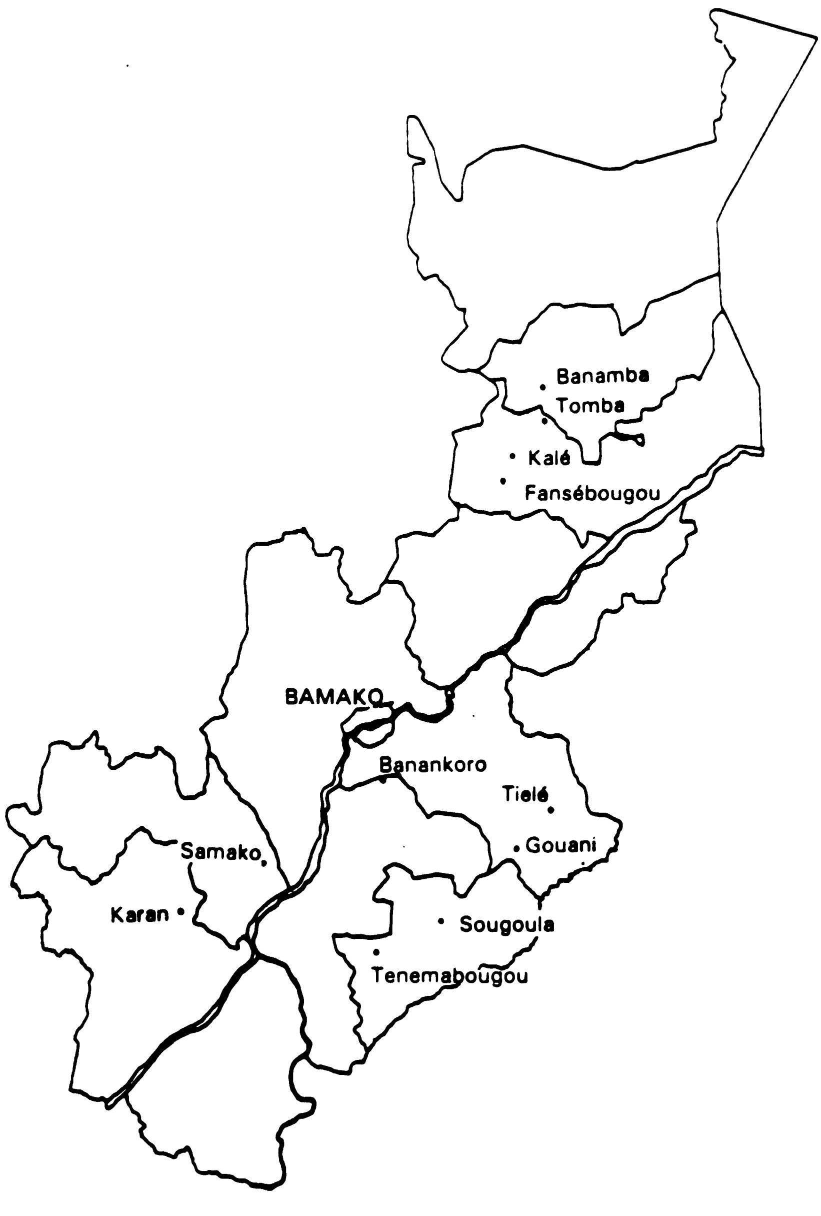
Because of the emphasis placed on establishing and supporting the *associations villageoises* (AV) as the new 'engines' for local development, it was decided that in

---

[6] A large share of this material was drawn and adapted from the *RRA Notes* and additional manuals published by the International Institute for Environment and Development, in London (e.g., RRA Notes Volumes 13-15; Gueye and Schoonmaker-Freudenberger, 1991), as well as other sources (e.g., Forest, Trees, and Peoples Newsletter, Nos. 13 and 15/16; Barker, 1979; Jiggins and de Zeeuw, 1992).

selecting villages for the rapid reconnaissance, the research team should visit both villages with perceived 'strong' AVs, and those with no, or at best very 'weak,' AVs, in order to assess their impact on local development. Examples of these two types of villages were selected with the assistance of OHVN personnel, and a revised program of visits was drafted that allowed the research team, and a senior member of the OHVN administration, to visit 11 different sites over an 11 day period (see Figure 4).

Figure 4. Location of Rapid Rural Reconnaissance Sites.



During the village visits group and individual interviews, observation, and Venn diagramming techniques were used to gain a sense of the local development dynamics and to test the relevance of the main research questions as framed by the TOR (see Appendix A). The information gained in this way led to a number of significant changes in the proposed main-phase research plan. Originally, use of a village-based questionnaire had been proposed as one of the primary data collection instruments (based upon the pre-departure review of information, a 'dummy' questionnaire had been prepared). However, comments made by farmers during the rapid reconnaissance and discussions with OHVN officials and representatives of other development organizations working in the zone, indicated that use of a survey would run the risk of encountering respondent fatigue and learned response patterns, and overall would be ill-suited to obtaining the type of data required for addressing many of the major research questions.[7] Drawing upon the strengths of the most successful methods used during the reconnaissance visits, and selecting other promising techniques from the 'toolbox,' a combination of group and individual interviews, resource and activity mapping exercises, and guided field visits were proposed as the primary research techniques for the main phase of data collection. This revised schedule of activities was then field-tested and further refined during an all-day visit to a village 20 km. outside of the capital (see Appendix B for examples of the interview and activity guides developed).

[7] The use of large questionnaire surveys was one of the favorite tools employed by the OHVN and other governmental agencies. In many cases villagers had been subjected to several surveys each year for the past several years. In reference to these questionnaires, one farmer observed "they ask us the same questions every time, but never do anything."

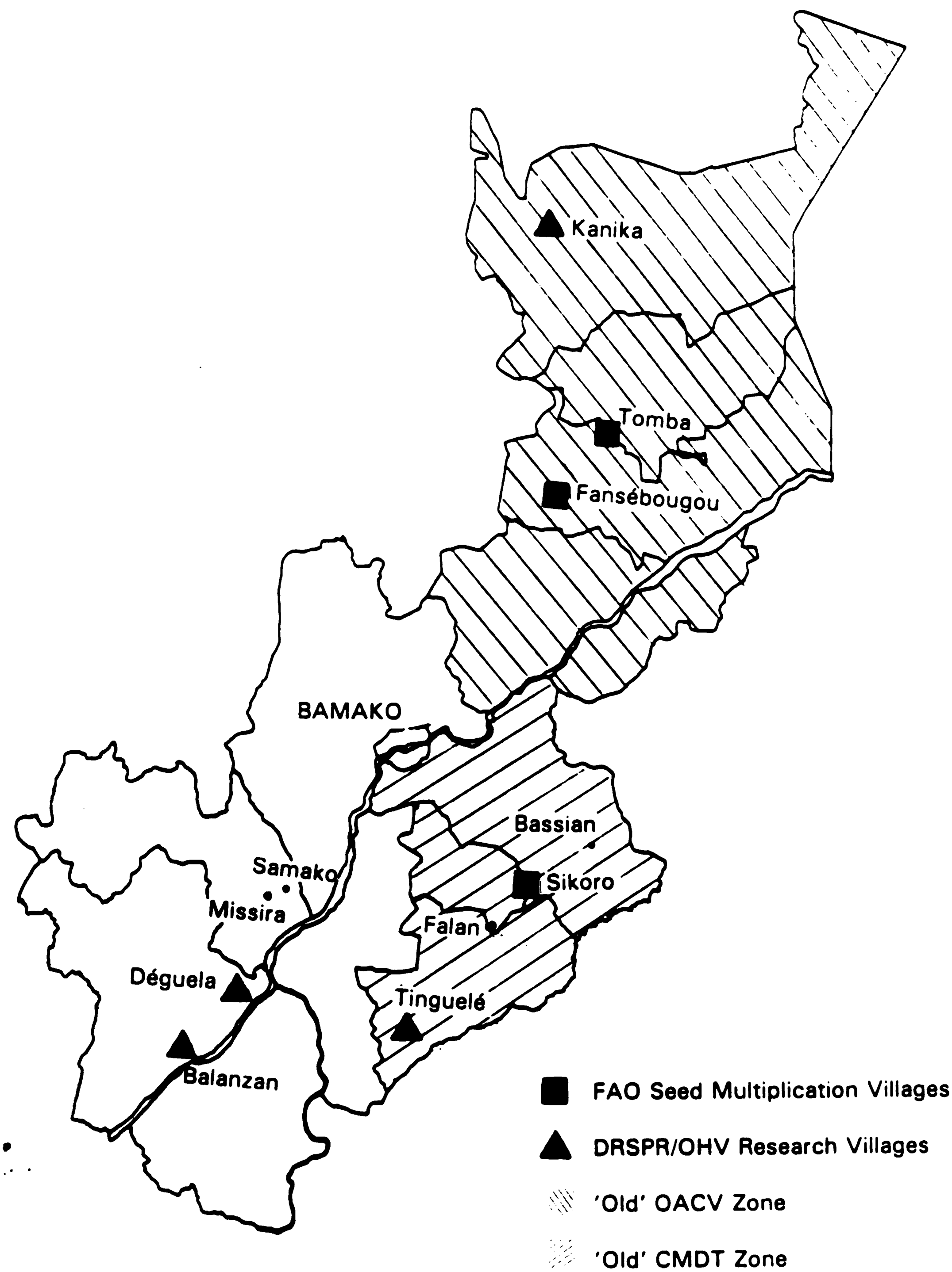
Based upon the information gained during the rapid reconnaissance field visits and formal interviews, two related changes in the research design were also made. The first involved abandoning the 'strong-village,' 'weak-village' typology. Because the village associations were a creation of the USAID-funded project, and were engaged in a relatively small number of standardized activities under the project's domain, the measurement of 'weakness' or 'strength' of village associations was almost wholly dependent upon the length of time that the association had been functioning. As a result, this line of inquiry by itself held little potential for producing particularly illuminating information, and because of the time constraints, it was dropped. Secondly, it became fairly obvious to the research team that in terms of extending agricultural technologies to farmers across the entire zone, the OHVN extension service was virtually 'the only game in town.' It was also apparent that the services being provided by the OHVN and other assistance organizations were quite limited, and in most cases literally stopped at the village edge, i.e., there was little outward spread in their impact. In contrast, the more dynamic process of indigenous, or local, development seemed to permeate the entire area. Thus, in terms of sampling, the decision was made to concentrate on examining in greater detail some of the OHVN's 'best case' villages, in order to gain a clearer picture of the OHVN's potential for stimulating local agricultural development throughout the project zone using its current approaches. At the same time, comparative observations could be made on the local processes of innovation and communication, and how they might possibly be incorporated into the formal attempts to stimulate rural development. Adopting this approach eliminated the need for sampling villages 'with' and 'without' project support; time limitations and the broad range of environmental and social conditions in the zone, which needed to be accounted for, also made use of such a comparative sampling frame impractical.

The rapid reconnaissance visits and field-testing of the revised data collection methodologies helped to confirm a number of important issues vital to carrying out the main research phase. The preliminary field visits confirmed the suspicion that separate meetings for men and women would be necessary. Women simply were unable to consistently voice their opinions in the presence of large numbers of men. Similarly, the reconnaissance visits confirmed the suspicion that local OHVN personnel could not be present during the meetings if open discussions were to be held and reliable information obtained. In the instances where OHVN personnel had been present, villagers tended to 'tow the party line,' even when these responses obviously contradicted the conditions in their area. The village visits also verified the value of and farmers' willingness to engage in exercises of pictorially representing various aspects of their social and physical landscapes. Finally, these visits confirmed the existence of major geographic differences between conditions and farming systems in the northern and southern, as well as between the southeastern and southwestern, portions of the zone.

The Main Field Work Phase

Site Selection. The research sites for the main phase of data collection were selected on the basis of three criteria: agro-ecological conditions (based primarily upon annual rainfall levels and soil types); the intensity of development activity by the formal institutions of research and extension; and the institutional history of each area in terms of past relationships with governmental development programs. The northern half of the OHVN zone averages less than 800 mm. of rainfall a year, and well under 600 mm. annually in the northernmost areas. In the southern areas, villages receive between 900 mm. and 1100 mm. annually. A rough North-South division in soil types divides the areas as well. Each of the study sites selected were said to have an established village extension group. In addition, the *Département de Recherche sur les Systèmes de Production Rurale* (DRSPR) conducted field research in several of the villages, and the FAO seed multiplication program was active in several other villages. Institutionally, the northern areas of the zone had been part of the *Opération Arachide et Cultures Vivrières* (OACV), and were transferred to the OHVN in the early 1980's. Areas of the Southeast had formerly been part of the *Compagnie Malienne pour le Développement des Textiles* (CMDT), and were also transferred to the OHVN in the late 1970's. Development efforts in the *Haute Vallée* area begun in the mid-1960's, in the southwest portion of the zone and focused on tobacco and vegetable crop production. Based upon these features of agro-ecological conditions, institutional history, and development intensity, three villages (Kanika; Tomba; Fansebougou) were selected in the North, one each in the *secteurs* of Boron, Banamba, and Sirakorola. In the Southeast, four villages were selected (Bassian, Sikoro; Falan, Tinguelé), two each in the *secteurs* of Gouani and Oueléssébougou, and in the Southwest four villages were also selected (Samako, Missira; Déguela, Balanzan), two each in the *secteurs* of Kangaba and Bancoumana (see Figure 5).

Figure 5. Location of Main Phase Research Sites



One of the assumptions behind village selection was that looking at the villages best served by the formal system of research and extension would provide a basis for identifying what had worked, what had not worked, and what the potential would be in further extending these activities across the entire zone. With this in mind, the villages selected were among those receiving the highest level of attention by the governmental research and extension services. They included four out of five of the DRSPR/OHV main field research villages, and three out of six of the FAO seed multiplication centers located in the zone. Furthermore, three of the villages housed OHVN field agents, and another three housed CLUSA agents.[8] All 11 villages were within 30 km. of the *secteur* field offices. The only village included in the study that did not house an OHVN or CLUSA field agent, or host a supplemental development activity (e.g., village research program, or seed multiplication center) had recently hosted one of the annual farmer field days sponsored by the OHVN, and had participated in a major varietal/fertilizer field trial jointly sponsored by a private fertilizer company and several governmental research departments. The villages selected lay in seven of the ten OHVN administrative *secteurs*. Beyond the selection of villages where specific development activities were located within specific agro-ecological zones, the OHVN *Chef Secteurs* (CS) identified all of the remaining study sites, with the only criteria being that these could not be the 'show-case' villages that were visited during the reconnaissance phase.[9] It was assumed that the CS would select

---

[8] Cooperative League of the USA (CLUSA) field agents assist AVs and other village groups in initiating local economic activities as part of the USAID-funded DHV project.

[9] In fact, two of the villages selected for the main research phase had been visited in the reconnaissance visit. However, they were located in critical areas of the North and each served as host to one of the FAO seed multiplication centers, and for those reasons were retained in the sample.

those villages most successful in adopting the program's recommendations.

Village Interviews. The bulk of the primary data analyzed in this dissertation were obtained through two main tracks of data collection: village visits and a questionnaire administered to the entire OHVN field staff (see Appendix B).[10] Once the selection of study sites was complete, a schedule of visits was established allowing 2-3 days at each site, and enough additional time to administer the questionnaire to the OHVN extension agents in each *secteur* field office. Short periods away from the field were designed for use as opportunities to review field notes, reflect on observations, revise questions, and begin preliminary data analysis as recommended by the grounded theory approach (Glaser and Strauss, 1967) and ethnographers (e.g., Hammersley and Atkinson, 1983).

Local secondary school leavers and other local French speakers were hired as interpreters to facilitate the village interviews (the researcher spoke neither *Bamanan*, nor *Malinké*). Suitable individuals were identified by the CS in each *secteur* where village visits were taking place.[11] In order to remove any possible biases related to project influences and inter-personal relationships, it was requested that these individuals not be closely associated with the OHVN, including village *animateurs* (who worked for, and were sometimes paid by, the local *associations villageoise*), and, if

---

[10] In responding to the entire TOR, the research team included the use of four additional data collection efforts: a modified village assessment survey completed by the CLUSA field agents for each of the villages where they worked; a series of in-depth village case studies written by CLUSA field agents; a series of discussions with AVs in CLUSA and non-CLUSA serviced villages, a visit to AVs in the CMDT zone; and a map of NGO activities in the zone (see Bingen et al., 1994).

[11] Interpreters were paid for their services based on OHVN per diem pay rates, and at the end of each visit were given a small gift for their assistance with the study.

possible, should not reside in the village where the interviews were taking place. The condition of not using local *animateurs* was violated in three cases.[12] In two of these three cases, the sessions resulted in interviews of generally poor quality, with numerous instances of the *animateurs* providing 'the' answers for the rest of the group, or 'correcting' the group's responses during translation when they differed significantly from, or were critical of, the OHVN technical recommendations. In the remaining case where an *animateur* was used, this was less of a problem. However, in each of these three instances there was a significant problem with the interpreter's French-speaking capabilities, which led to several other local French speakers becoming involved in the translations. While the inclusion of these additional participants did lead to some moments of initial chaos in the interview sessions, in the long run having more people involved in the translation process helped to improve the overall accuracy of the translations. In only one other case did the local hire of a resident other than an *animateur* result in any kind of problems during the interview sessions. In this instance the individual was employed as an interpreter in two separate villages. In the first, a village some 60 km. from his home, where he was unknown to the local residents, he performed admirably. However, in returning to his home village, his status as a member of the village's founding family, which was embroiled in a major intra-village conflict, and his personal image as a young 'playboy,' led to difficulties both in convening groups with broadbased representation among the men, and in the outright refusal of the village women's association to meet with the researcher.

---

[12] Because of the time constraints and lack of alternative choices, the researcher was forced to rely on the individuals identified by the CS as the primary interpreters, regardless of any local positions they may have held.

In all but this last incidence, where little could be done to improve the researcher's reception, the personal relationship established with the OHVN driver, proved to be invaluable. After familiarizing himself with the research questions during the first several interviews, and with the knowledge that the translated answer should be that of the group responding and not that of the translator, the driver intervened in a number of instances to help, either with the proper translation of the questions, or to make sure that the translated responses were accurate. In addition, this individual provided invaluable guidance on local customs, and shared freely his knowledge of wild fruits and food plants during the long periods of travel.

Although all of the official interpreters were male, this did not noticeably interfere with the interview sessions with the women. Besides those difficulties already noted, the need to train a succession of interpreters in the content and intent of each research question, and the interview style for the group sessions, proved to be an exhausting task. While the interviews would have gone far more smoothly if a single interpreter of excellent quality had been used throughout, the prospects for locating someone in the capital on short notice with suitable qualities was doubtful. Fortuitously, all of the difficulties that were encountered with the interpreters occurred towards the end of the study, when most of the conceptual categories had already been identified. Ironically, these instances proved to be immensely valuable learning experiences in terms of providing glimpses into the fragile nature of the relationship between the village associations and the unpaid *animateurs*, and the type of dissonance that can occur in the local social fabric. These events would have gone completely unnoticed had an external interpreter been used throughout, or had all the interviews gone smoothly.

In general, each of the village visits followed a similar schedule. Shortly after arrival a meeting was held with the *Chef de Village* and other notables, where a gift of Kola nuts[13] was presented, the purpose of the study was described, and permission to conduct meetings with different village groups was sought. After permission was granted, separate meetings were held with representatives of the men's *group de vulgarisation* (GV) and the president of the women's association, whose groups formed the primary sample pool for each visit. During the meetings with the group leaders, the intent and process of the research were explained, and times and locations were set when group discussions could be held. This was typically followed by several hours of waiting for the groups to assemble, which allowed for innumerable glasses of tea and a chance to explore the area and informally talk with a wide range of villagers.

In each village, the first group sessions held were with the men's GV, and typically took place just prior to or following evening prayer, whereas the meetings with the women's groups typically took place during the morning of the second day. Attendance varied from 12 to over 25 members, with participants ranging from their late teens to the very aged. Although meetings were intended to be held only with GV members, in most cases there were a number, even a majority, of individuals from outside of these groups.[14] In contrast, the meetings with the village women's association consisted almost exclusively of current members. After some introductory remarks, the activities and intent of the study were again explained and the interview

[13] Following tradition, ten Kola nuts, a mixture of red and white, were presented out of respect. These were purchased at the Bamako market before each visit.

[14] The very existence of GV was contested in the majority of villages, with the OHVN claiming that such groups did exist and the local residents claiming that they did not, or that they had not seen an extension agent in over a year.

session began, following the questions contained in the interview guidelines (see Appendix B). The questions in the interview guide were divided into a number of sections covering different aspects of the transformation of farmers' agricultural practices. In order to begin identifying the types of changes that had occurred in farmers' production systems, the interview questions were constructed to elicit farmers' responses with respect to three general timeframes: the period since the preceding generation; the recent past (last three to five years); and the present, i.e., what changes farmers were currently making. Each new area of discussion covered during the interviews were introduced with a general, open-ended question, e.g., "Describe the agricultural practices used during the time of your fathers or mothers" (based upon an interview approach used by the World Neighbors, e.g., Gubbels, 1988). Following these entry questions, a series of open-ended and close-ended questions were used to begin specifying information and to further probe into new areas that emerged from the group's responses.

Early in several of the meetings it became evident that a 'spokesperson' had begun to dominate the discussion. In these instances, the individual was thanked for her or his valuable contributions, and those present were reminded that in this 'group' meeting, everyone's opinions and experiences were needed. It was made clear that the groups did not need to come to a consensus over each response, but that it was important to discuss the different points of view. In every case, once the floor had been opened lively debate and widespread discussion followed.

Throughout the village visits, the researcher was careful about the impression he conveyed. An effort was made to wear fairly neutral, clean but not 'expensive' looking, clothing and footwear, and during all of the group sessions the researcher used encouraging (transparent) body language to ease participants' hesitancy in disclosing sensitive information. A detailed written record of each interview session was kept (because of the difficulties of translation, tape recording was not considered a viable option), containing not only farmers' responses, but also other significant details concerning the session itself: individuals' reactions, and the degree of discussion or arguments over particular questions; the coming and goings of participants; the level of attentiveness; any difficulties with the interpreter; a general assessment of how well each question was received; and the need to return to the same question, or to explore related issues. During the interviews, observations on participants' behavior served as triggers for the further probing of and returning to specific issues, and as cues for when to move to a new topic, or close the discussion. In this way each of the group sessions were customized to fit a group's rate of progress.

Resource Mapping Exercises. Based upon individual and group responses, the general level of attentiveness, and how well the session was going, either the entire interview guide would be covered in a single session, or the time would be used to complete mapping activities, with any remaining questions to be covered during a subsequent session. In every case the mapping exercises took place using a chalkboard (differing from the rapid reconnaissance where diagrams were done with 'sticks in the dirt'), borrowed either from the village school or literacy center. In constructing the 'maps,' farmers were asked to indicate the periphery of the village, location of the major roads and pathways, and to use whatever symbols they wanted in representing the location of specific development activities, such as: formal research and informal varietal test plots; community woodlots established by, or with the assistance of, a NGO; fields containing technologies adopted from the extension technical program; fields where

new or unique local varieties had been planted; unique production niches; the fields of noted local experts; or any other item of interest that had come up during the interviews, or which the participants wanted to highlight. In about half of the cases, the researcher had to help with the initial orientation of the map (e.g., locating the village and the main road). Afterwards, the mapping exercises, in all but two cases, generated immediate and widespread involvement.[15]

Field Tours. Following the mapping exercise, a route was planned to visit each of the locations included on the map. The field tours were typically held on the second day of each village visit. Individuals who had been identified in the course of group discussions as being particularly knowledgeable, or who held obviously different views about various production activities, were asked to serve as guides for the field tours. If this was not possible, or proved to be too awkward, these individuals were asked to meet the researcher at a specific time and location during the tour in order to discuss their activities. The field visits were used to validate the group responses through observation of a broad sample of field conditions, and to 'square' the general group remarks with the individual experiences of selected producers. The field tours also provided an opportunity to meet and talk with individuals who had not participated in the group meetings. In sum, these field visits were extremely valuable in obtaining new and more detailed information, as well as in verifying the information obtained in the group discussions. The field visits lasted anywhere from two to four hours, depending on the distances to be covered and the amount of discussion that took place.

[15] With regard to these two exceptions, the meetings had gone on unusually late in the evening and participants were tired and eager to leave.

After the field tours, a second meeting was generally held with each group. This provided the opportunity to ask questions concerning any new discoveries or observations that occurred in the course of the field visits, as well as a chance to explore the nature of any discrepancies between the information obtained during the previous group session and the information gained from individual interviews and discussions with the women's (or men's) group. These final sessions were the last opportunity to collect missing information, and to make a final attempt at covering any questions that had not gone over well during the previous discussions. At the conclusion of these sessions, the groups were thanked for their participation, and the researcher indicated his intention of returning once the study was complete to present the findings and solicit their reactions.[16] [17]

Mid-Course Adjustments. Certain conditions encountered during the course of field visits required that the researcher modify several elements of the research plan *in situ*. Initially, equal time had been planned for replicating the mapping exercises and field tours with each group, men and women. However, because the data collection was

---

[16] In each village a sum of money was given to the women who had hosted the researcher, interpreter and driver. Where these chores had been broadly shared by the members of the village women's association, a donation was publicly given to their joint savings fund.

[17] As mentioned, early in the study an informal agreement had been reached with the USAID project officer to provide the researcher with the opportunity to make a return visit to the study sites, in preparation for the final planning workshop. The intent of these return visits was to allow the researcher a chance to report back to the village groups on the research findings, and to allow these groups an opportunity to critically respond to the findings. These sessions were also intended to solicit additional feedback on farmers' perceived needs, which was then to be used as direct input for the planning sessions of the final workshop. Unfortunately, a heavy load of visitors and a temporary ban on additional USAID-financed in-country travel prevented this phase of the research from being carried out.

carried out during periods of peak labor demands--the height of the planting season in the North, and at approximately the time of the first weeding in the South--it was felt that the additional demands being placed upon the women participants of these meetings were unreasonable. As a result, several adjustments were made in the research plan to ease the burden being placed on women, while still attempting to maintain a high level of quality in the information obtained. The interview sessions, which typically lasted two to three hours in length with the men, were held to a two hour maximum for the women. Although meetings with the men were held at least twice, and occasionally three times, during the course of village visits,[18] the women in most instances met only once or, if twice, for a maximum of one hour the second time. In addition, although the researcher continued to request meetings with the men as soon as it was convenient after his arrival, the women participants were allowed to select a time and place for their meeting that was the most convenient for the majority of their association members.[19] After the first several village visits, women were not asked to construct their own maps (a very time-consuming process, requiring well over an hour to complete), but a representative of the men's group would present and explain their map to the women who, in turn, were given the chance to add, modify, or delete items from the men's map (the researcher kept both a photographic and hand-sketched record of each group's rendition). Although the women were generally hesitant to make many major structural modifications to the men's map, they did typically add several new items that were of particular significance to them, such

[18] In one village the GV demanded that the entire interview guide and mapping exercise be completed in a single meeting. After meeting for several hours, the groups broke for lunch and later finished the discussions.

[19] This was greatly appreciated by the women, and did much to establish a basis of trust for the interview sessions.

as their personal fields, gardens, group fields and various development projects. Finally, in about half of the villages the women were asked to meet the researcher at specified locations in the field, rather than conduct their own separate field tours.

Although on the whole these changes reduced the amount of contact time between the researcher and the women's groups, the quality of the meetings with the women were generally higher than those with the men. The women participants typically answered questions more readily and came to a consensus, or alternative positions, faster than did the men. Women were not the least bit hesitant to voice their criticisms of various aspects of the development organizations with which they were in contact, or of the resource constraints and labor demands that were being placed upon them by their husbands. Information gained from the men's discussion was often used as a foil against which the women could contrast their own experiences. This greatly accelerated the interview process, and also helped in data analysis and category formation, because the information obtained in this manner was already in a form that directly spoke to the influences of gender on resource allocation and agricultural practices.

Beyond the modifications required by the women's extremely heavy work loads, other changes in were made in the approaches used in data collection. After initial difficulties in getting village groups to identify local agricultural 'experts' (something repeatedly mentioned in the literature (e.g., McCorkle et al., 1988; Box, 1988), discussions with other field researchers[20] concerning these difficulties indicated that farmers may have been avoiding such questions because of the risk of arousing local jealousies through emphasizing the differences in individual skill levels. The questions

[20] Mary Jo Arnoldi of the Smithsonian Institute; Juliana Short of the University of Indiana at Bloomington.

were modified to ask individuals from whom they received 'good advice' about producing one or another crop, or who was locally known, or who farmers went to, for 'good advice,' with the assumption being that these individuals possessed superior knowledge or wisdom concerning specific areas of crop production. This revised approach worked far better in eliciting responses during subsequent village visits.

Additional Activities. In addition to the formal schedule of group interviews and field tours, informal market surveys conducted in a number of major market centers (Bamako, Banamba, Bancoumana, Oueléssébougou, and Tiele) within the OHVN zone helped to confirm the availability of equipment parts and inputs, the regional differences in the economic importance of various crops, gathered products, and goods manufactured through on-farm processing. The extensive field travel also provided numerous opportunities for informal discussions with OHVN field staff and those of the DRSPR/OHV research program during chance encounters. In addition, lengthy discussions were held with Peace Corps Volunteers and other NGO and project personnel. These discussions were immensely helpful in gaining additional perspectives on various aspects of local development activities.

Another valuable source of information were the host families in each of the villages visited. During the long periods of free-time between group sessions, the researcher was able to walk about the compound of the host family, observing and talking with the women of the household concerning their various chores and activities. In this way, a wealth of information on women's on-farm processing and income-generating activities was acquired that would have been unavailable otherwise.

Questionnaires. The administration of the questionnaire to the entire OHVN field staff was carried out sequentially, as each *secteur* was visited during the main phase of the data collection. The questionnaire was administered under supervised conditions in eight of the ten *secteurs*. Scheduling difficulties in the remaining two *secteurs* required that agents self-administer their questionnaires. In only one of these cases was there obvious evidence that the agents had conferred with one another (in small groups of two and three) in filling out the response sheets. The questionnaire contained six parts; the data from three of these areas--extension-research, extension-farmer relations, and agents' impressions of the extension program--are included in this dissertation (see Appendix B). Although the response rates for some of the sections were rather low, in only one instance was there blatant refusal to answer a particular series of questions. In this instance a senior field agent instructed the others from his *secteur* not to answer the questions pertaining to extension-researcher relations. All but one of the agents in this session complied.

Data Analysis

Consistent with the grounded theory approach, the collection and initial analysis of data (the comparison of data for patterns of similarities and differences) took place in an interactive fashion throughout the main phase of data collection. These early cycles of data collection and analysis were followed by several successive rounds of more intensive data analysis, carried out well after the main phase of field research was complete. Between periods of intensive data collection during each of the village visits, the researcher was able to review and expand upon interview notes, record additional comments and observations, and begin to look for areas of missing data or issues that would require additional questions or further investigation. Following Glaser and Strauss's (1967) suggestion that researchers should block out regular periods of time to review and begin to organize their field notes away from the field, in order to help direct subsequent sessions of data collection, the researcher used his weekly returns to the capital as an opportunity to review field notes, begin to organize the data, and search for conceptual patterns and similarities when comparing new data to previously collected responses. The results of this initial analysis were then used to help direct the discussions and modify questions in the group and individual interviews in subsequent village visits. It is in this way that several of the conceptual categories developed in this dissertation were first 'discovered.'

Once recognizable patterns could be discerned in the data, for example, certain land use patterns and the similarities in household economic opportunities within different areas of the OHVN zone (presented as 'portfolio areas' in Chapter IV), lines of inquiry were then used to confirm or explore each new area's similarities or differences, in relation to those areas already visited.[21] Although the use of RRA methodologies allowed the researcher to collect data from across the entire OHVN zone, the relatively short time available for data collection, compounded by the lack of opportunity to revisit specific research sites later in the research process, did not permit the researcher to fully formulate and test hypotheses governing the relationships between the different conceptual categories, as called for in the grounded theory approach. As a result, much of the theoretical development of these initial findings took place in subsequent periods of post-data collection analysis and integration of secondary data, and not as an integrated part of the data collection

[21] In the portfolio area example, study sites that were located close together tended to represent areas with 'minimum' difference, whereas the more distant sites represented areas of 'maximum' difference.

process.

In analyzing the field data for this dissertation, the conceptual categories, some of which were only briefly referred to in the consulting reports,[22] were developed in far greater detail. During this process, information from a number of additional sources was integrated into the analysis to provide further details on the informal local, and more formal institutional, influences on agricultural change. Findings from research conducted elsewhere in Mali and neighboring countries in West Africa on the social patterns of agricultural production systems, agricultural change, indigenous knowledge, processes of informal communication and experimentation, among other topics, were also included. The extensive use of this larger store of information was intended not so much as a validating tool, but as a means of further illustrating the basic findings and interpretations drawn from the data of the OHVN case study, and in helping to generalize these interpretations beyond the limits of the OHVN project boundary.

In conducting this expanded analysis, some conceptual interpretations, such as Richards' (1989b) agricultural 'performances,' were taken directly from the literature and expanded upon. The use of such concepts, which themselves were derived from extensive field observations, is based purely upon the goodness-of-fit of their explanative powers over patterns of behavior observed in the OHVN case study, and their use is entirely consistent with the grounded theory approach (Strauss and Corbin,

---

[22] Before departing, the research team was required to draft and present a debriefing paper to USAID and the OHVN administration on the preliminary findings of the research. This initial effort was followed by a second, more complete yet still preliminary, analysis of the data, which was presented at the final planning workshop held eight weeks after the completion of the field portion of the study. A final report of the research findings was then submitted to USAID, OHVN and DAI several months later for comments and revisions (Bingen et al., 1993). During the preparation of the final report for USAID, the researcher was able to create maps for the study using CMAP, a GIS software program, to digitize the 1:200,000 IGN country map sheets, and over-lay various data sets of village and activity locations.

1990). Explicit in the use of all such secondary literature in this dissertation is the direct relationship of the information to the categories generated from the primary data collected during the field portion of this research. Additional sources of data are used to explicitly exemplify, extend, contrast and add further detail to the interpretations of field observations collected in the study. In terms of theoretical development, this is most evident in the material presented in Chapter VIII, which re-interprets the patterns of behavior and relationships identified in the case study through a synthesis of theoretical contributions drawn from a number of behavioral science disciplines.

CHAPTER III. The Production Environment: Climate, Water, Soils, and Vegetation

A detailed examination of the major natural resource systems which support agricultural production within the OHVN zone is critical to understanding farmers' knowledge and behaviors, and is a necessary step in identifying the general parameters within which the formal research and extension system must function. Because the OHVN zone is not a 'green revolution'-type environment, with abundant and stable natural resources, farmers must respond to and exploit innumerable variances in the natural resource systems within, as well as between, seasons, in order to achieve nutritional and economic security. Major differences in the physical conditions found across the OHVN zone shape local production opportunities, influence farmers' management styles, and are reflected in the development of the local knowledge system. In order to generate technologies relevant to farmers' conditions, and contribute to the development of farmers' management capabilities, the formal research and extension system must be capable of accounting for the overall diversity and variability of these natural systems in their programming.

In reviewing the major resource systems (climate, water, soils, vegetation), this chapter focuses upon two levels of analysis. The first concerns the 'overall system' dynamics of each resource stream, e.g., the climatological system responsible for providing the OHVN, as well as the rest of West Africa, with its rainfall. The second level of understanding involves the specifics of how these systems are translated into the actual conditions with which farmers must contend in managing their fields, e.g., the diversity of local soils and variability of local rainfall. Each of the major natural resource systems is discussed in terms of both their general characteristics, important for understanding their immutable qualities and the inherent limitations they pose for the zone as a whole, and the specific attributes and levels of variability that these systems present to farmers and the research and extension system at the local level.

Geophysical Location

The major environmental systems, natural resource endowments and agricultural potential of any region reflects its position on the globe. The OHVN zone, located along both sides of the Niger River in southwestern Mali, lies within Sahelian West Africa. As defined by Hayward and Oguntoyinbo (1987), West Africa is the region roughly bounded by the Atlantic to the South and West, the Sahara to the North, and Lake Chad to the East.[23] While the eastern border is an arbitrary assignment, that to the north reflects the northernmost advance of the intertropical convergence zone, the region's major climatic force that shapes local agricultural calendars, controls long-term soil forming processes, and helps to determine the distribution and composition of vegetative communities.

The Sahel,[24] first used to describe a specific vegetative zone south of the

[23] West Africa generally includes, but is not limited to, the coastal states of: Mauritania, Senegal, The Gambia, Guinea Bissau, Guinea, Sierra Leone, Liberia, Cote d'Ivoire, Ghana, Togo, Benin and Nigeria; and the land-locked countries of: Mali, Burkina Faso, and Niger. The term 'West Africa' is often used in referring to political and linguistic commonalities of these countries as well.

[24] Sahel is an Arabic word meaning literally 'shore' or 'border,' and is used in reference to the Sahara, which is derived from the Arabic *sahra*, meaning 'wilderness.' The Sudan, the area south of the Sahel, is derived from the Arabic word for 'black' and its use originates in reference to the people inhabiting this region (from Franke and

Saharan desert (Chevalier, 1900), has become associated with a larger regional image of a harsh, transitional environment (Doenges, 1988; Franke and Chasin, 1980). Spanning the continent from the Atlantic to Indian Oceans, the Sahelian zone receives between 200-600 mm of rainfall annually and is one of four increasingly moist climatological zones that are encountered as one approaches the equator (including the Saharan, Sahelian, Sudanian, and Guinean zones--see Table 1).[25] Mali contains each of these climatic zones, while the OHVN consists of portions of the southern Sahelian, Sudanian, and northern Guinean zones. Throughout the remainder of this dissertation, the term 'region' will be used in reference to those countries located within West Africa through which the Sahelian zone passes (see Figure 6).[26]

Table 1. Annual Rainfall Levels of the Major Climatic Zones in West Africa.[27]

Climatic Zones	Average Annual Rainfall Levels (mm/yr)
Saharan	< 250 mm
Sahelian	250-600 mm
Sudanian	600-900 mm
Guinean	900-1250 mm

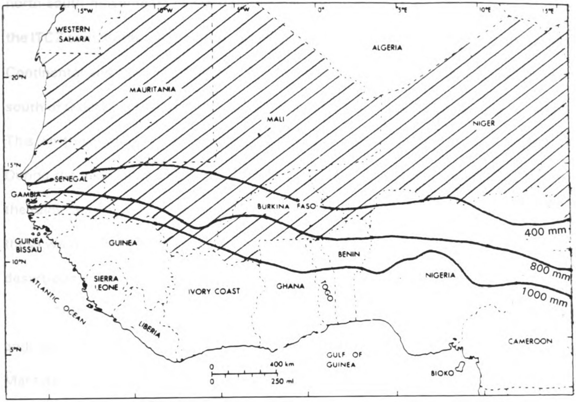
Chasin, 1980).

[25] There is no universally accepted definition for these climatological and vegetative zones (e.g. Davy et al., 1976). The limits adopted here are in general agreement with the original definitions proposed by Chevalier (1900), as described by Lawson (1986).

[26] The following seven countries are generally included in reference to the Sahelian West Africa: Senegal, Gambia, Mauritania, Mali, Burkina Faso, Niger, and Chad (MacDonald, 1986). Except for the omission of Cape Verde Islands, this list corresponds to the CILSS (*Comité Inter-états pour la Lutte Contre la Sècheresse au Sahel*) countries.

[27] Source: Lawson, 1986.

Figure 6. The Location of Sahelian West Africa.[28]



Weather

Regional Climatic Patterns

In describing the climatological conditions of dryland areas (to which livelihoods and development strategies must adapt), long-term averages have little value (Nicholson in NRC, 1984). A few 'wet' years can skew the average well above the mode and medium, and do not reflect the impact of extensive runoff and high evapotranspiration rates. Also obscured is the fact that dry years tend to come in groups (Nicholson, 1982). In reference to the Sahel's climate, variability and periodic drought should be considered as the 'norm' (NRC, 1984).

[28] Source: Adapted from Hayward and Oguntoyinbo, 1987; Pieri, 1989.

The regional weather patterns affecting the OHVN zone are driven by the annual north-south movements of the Intertropical Convergence Zone (ITCZ). Conceptually, the ITCZ constitutes a thermal equator (IUCN, 1989), located between the dry Tropical Continental and the moisture-laden Tropical Maritime air masses that move north and south of 0 degrees latitude in accordance with the earth's position relative to the sun. This north-south movement in the ITCZ is responsible for the change in seasons. During the year, temperatures in the region increase dramatically prior to the onset of the rainy season, with a lesser peak following the rains, and a cool-dry winter. During these warmer periods, the hot, dust-laden *harmattan* winds blowing out of the Saharan desert dominate the landscape.

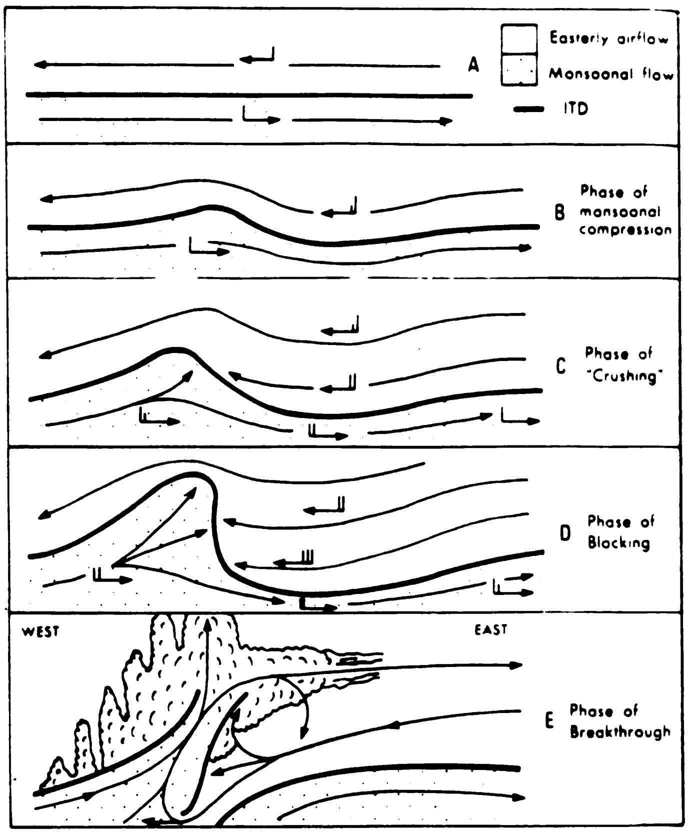
The region's single rainy season, which occurs in the OHVN zone between June and September, results from convective activity initiated by the moist Tropical Maritime air mass being drawn northward off the Gulf of Guinea with the advance of the ITCZ (see Figure 7).[29] The main rainfall zone generally follows 450-500 km, or four to six weeks, behind the ITCZ (Farmer and Wiggly, 1985; Cochemé and Franquin, 1967). As shown by Figure 8, the northward advance of the ITCZ is characterized by major daily advances and retreats in its position.[30] This erratic movement causes the uncertainty in arrival and length of the rainy season for any one location. Irregularity

[29] As the ITCZ moves northward, the moist ground flow is contained beneath the region's dominant dry trade winds coming out of the Northeast. Regular disturbances in these overlying trade winds allow convective activity in the moist surface flow to break through the containing dry air mass, forming cloud clusters (Farmer and Wigley, 1985).

[30] The ITCZ can move as much as 12 degrees of latitude in a single day (Hayward and Oguntoyinbo, 1987).

in the onset and duration of the rains,[31] as well as the variability in the resulting precipitation, increases steadily with latitude. The coefficient of variability for annual rainfall[32] along this south-north gradient is approximately 15-20 percent for the northern Guinean, 20-30 percent for the Sudanian, and 30-50 percent for the Sahelian zone (Nicholson, 1982).

Figure 7. The Profile of Line Squall Formation Along the ITCZ.[33]

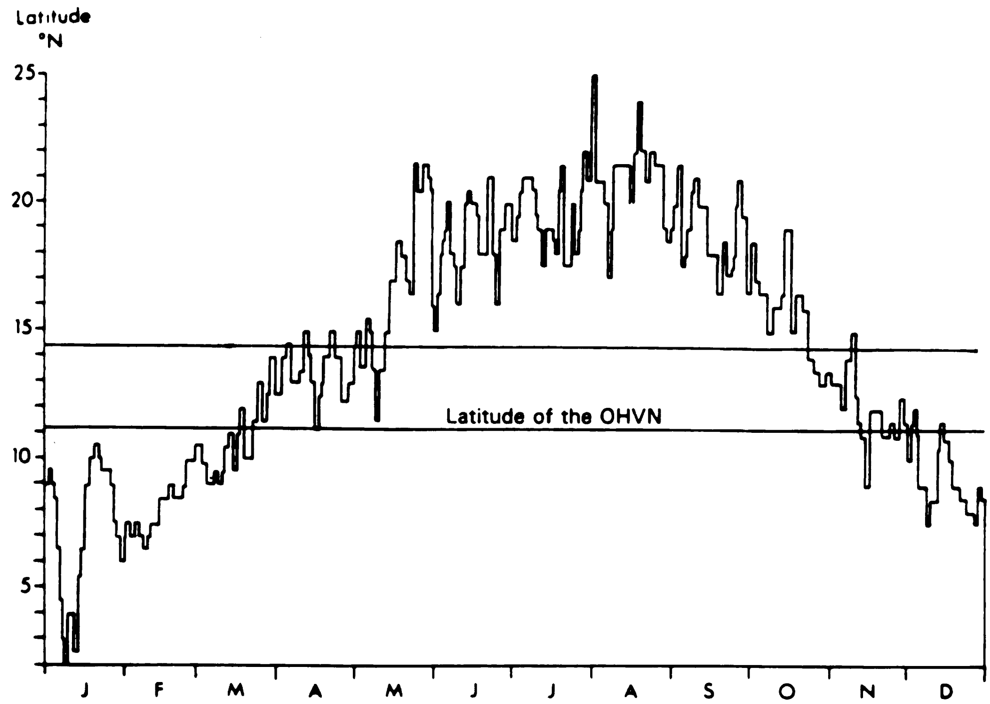


[31] Although 'false starts' in the wet period are said to occur in roughly 50 percent of the years (Cochemé and Franquin, 1967), there is little agreement in defining what constitutes the actual beginning of the rainy season.

[32] The coefficient of variation--defined as the standard deviation of annual totals expressed as a percentage of the annual mean--describes the variation about the mean that is expected two-thirds of the time (Nicholson, 1982). For example, a 50 percent variability means that yearly rainfall will fall within 50 percent of the annual mean two-thirds of the time.

[33] Source: Hayward and Oguntoyinbo, 1987.

Figure 8. Daily Movements in the ITCZ.[34]



Local Climatic Patterns

Over 80% percent of the rainfall occurring in the Sahel is generated by line squalls associated with the ITCZ (Nicholson, 1982).[35] [36] The leading edge of these line squalls typically exhibit intense rates of discharge, with brief periods of rainfall routinely exceeding 100 mm/hr (Jones and Wild, 1975), which can cause a number

[34] Source: Hayward and Oguntoyinbo, 1987.

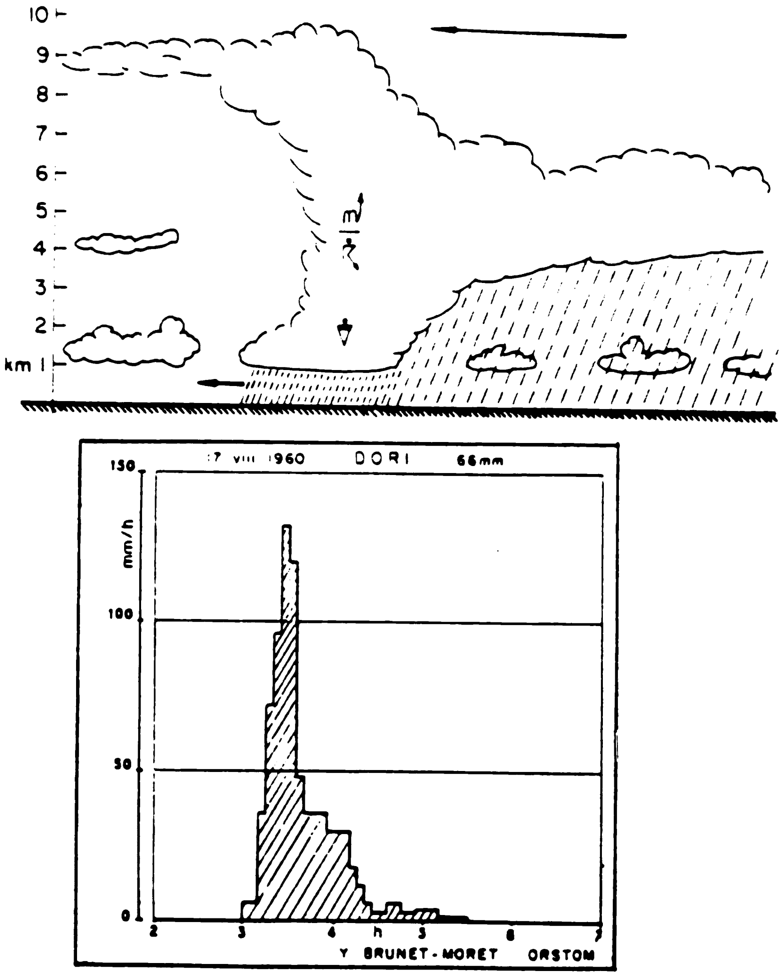
[35] The cloud clusters, which form along the ITCZ, can be over 1000 km. wide. Embedded within these larger cloud bands are narrower line squalls (5-20 km. in width) of actual rainfall. Once formed, these storm events flow over the region from northeast to southwest, pushed by the northeasterly trades (Davy, 1976; Farmer and Wigley, 1985).

[36] Thunderstorms (most strongly associated with the southeastern areas of West Africa) are relatively infrequent in the Sahelian countries, averaging less than 100 per year (Hayward and Oguntoyinbo, 1987).

of management problems for agricultural production (see Figure 9). Particularly violent storm events have been recorded with rainfall rates reaching 360 mm/hr, and even 760 mm/hr, for brief periods (Jones and Wild, 1975; Sivakumar, 1989). Such intensity can result in rates of surface runoff that exceed 60 percent (Rodier, 1982), depending on the soil type and topography. High rates of runoff not only lead to poor infiltration, but serious incidence of soil erosion as well (e.g., Roose, 1977).[37] In summary, Charreau states that "dry tropical climates have 6-10 times more erosive power than temperate climates" (1974: 74).

[37] For soils in Mali, measured rates of infiltration average 10 mm/hr, while precipitation levels exceed 27 mm/hr in nearly 50 percent of the storm events (Sivakumar, 1989). In general, any storm producing more than 20 mm/day results in some sort of runoff (Jones and Wild, 1975; Kowal and Kassam, 1978). Beyond the problem of erosion, surface runoff is critical to the replenishment of certain aquifers and seasonal surface catchments (Gritzner, 1988).

Figure 9. Anatomy of a Line Squall and Discharge Rates.[38]



In addition, line squall movements and discharge rates show strong diurnal variance, contributing to the overall pattern of high spatial variability in precipitation experienced on the ground.[39] On the whole, convective activity may be limited to 1-10% of the total ITCZ at any one time, leaving large gaps between cloud clusters and

---

[38] Source: Cochemé and Franquin, 1967.

[39] The passage of one storm in Niger shifted 100 km. during the first six hour period, 400 km during the second six hours, slowed again, then traveled 600 km. in the final six hours before dissipating entirely (Hayward and Oguntoyinbo, 1987).

individual line squalls (Farmer and Wiggly, 1986). The intensive rates of discharge causes squalls to continually change their shape as they dissipate and expand with the addition of new moisture in their passage over the landscape.[40] The net result of such widely-spaced, constantly evolving storm events is that even contiguous land areas may receive widely disparate levels of precipitation.[41] Village *animateurs*, responsible for monitoring rain gauges used by different development programs within the OHVN zone, report variations in rainfall of as much as 10 mm for single storm events between gauges located within the same village. Viewed in terms of inter-annual variation, the pattern of day to day differences experienced from one year to the next are tremendous (see Table 2).

---

[40] Because of the extensive run-off and evapotranspiration rates that are at their peak during the rainy season, it is estimated that as much as 30-60% of the precipitation in the region is the result of evaporated surface moisture.

[41] In any one year, 50 percent of the rainfall stations in the Sahel report below average rainfall (Nicholson, 1982)

Table 2. Comparison of Daily Rainfall, Oueléssébougou Station, OHVN, Mali (1962-63).[42]

	April 1962 (mm)	April 1963	May 1962	May 1963	June 1962	June 1963
1	-	-	-	32.9	-	-
2	-	-	-	.2	-	-
3	-	-	-	-	-	-
4	-	-	-	-	-	-
5	.4	-	-	-	-	-
6	-	-	-	-	-	-
7	2.4	-	1.7	8.2	-	-
8	-	-	-	-	41.0	-
9	-	-	-	-	-	-
10	-	-	-	-	17.5	1.2
11	-	3.5	1.5	-	1.5	-
12	-	-	-	-	-	-
13	-	.4	8.6	-	-	-
14	-	-	-	-	-	-
15	-	1.9	12.5	-	15.6	-
16	-	-	-	-	13.3	-
17	-	-	-	-	14.1	.3
18	-	-	36.2	-	-	-
19	-	.3	-	-	29.4	-
20	-	-	-	2.3	-	-
21	-	-	31.5	-	1.0	-
22	17.6	-	-	6.6	-	20.0
23	-	-	-	-	-	16.0
24	.7	-	-	-	-	.6
25	-	-	17.6	19.2	20.9	-
26	-	-	2.0	-	-	-
27	.9	6.1	-	-	-	38.8
28	-	52.2	-	-	-	-
29	.2	-	-	-	12.2	-
30	5.3	-	-	.4	-	11.4
31			6.7	20.3		
Monthly Totals	27.5	64.4	118.3	90.1	166.5	88.3
Annual Totals	1358.5	1146.4				

[42] Source: ORSTOM, 1974.

From the perspective of individual household decision-makers, whose fields may be separated by several kilometers, the high degree of variance in precipitation requires that each field be managed on an individual basis. This variance is especially prevalent at the onset of the rainy season, when the spotty rainfall is aggravated by the final ravages of the *harmattan* winds.[43] A situation that is further complicated by the tendency of soil types found in this region to form surface crusts after the first rains, which greatly reduces the infiltration of subsequent rainfall (Charreau, 1974). This is especially so for those soils that have lost most of their organic matter and structural integrity through repeated cultivation.

Recent Trends

Regional trends in annual precipitation levels have shown a significant downturn during the past several decades. Following the relatively 'wet' decade of the 1950's, with many stations recording rainfall 60 percent above their previous average (Nicholson, 1982), the region experienced years of declining rainfall, culminating in the disastrous 1968-73 drought.[44] Since that time, rainfall has yet to return to its pre-drought levels (see Table 3). Regionally, the approximate 200-300 mm per year decline in rainfall levels represents a 20-30% departure from pre-drought levels, corresponding roughly to a 150-250 km. shift southward in the rainfall isohytes (NOAA, 1979)(see

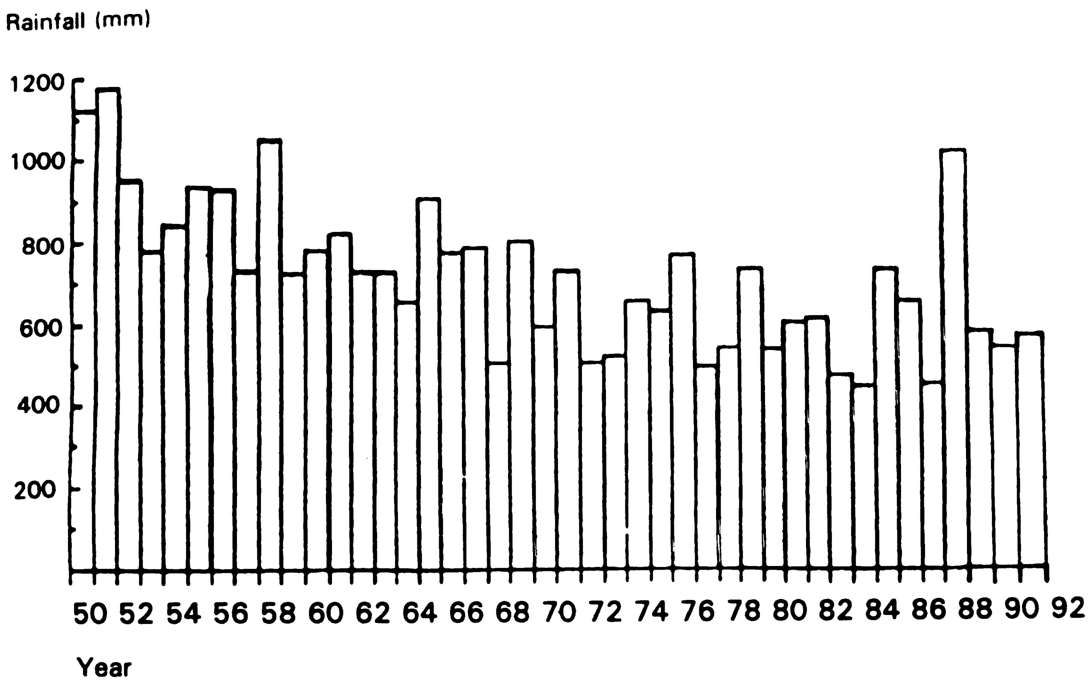
---

[43] These searing, dust-laden winds can raise the already high evapotranspiration rates by eight mm/day (Kowal and Kassam, 1978).

[44] Rainfall in much of the Sahelian and Sudanian zones during the 1968-73 drought was only 50% of the levels of the 1950's (Nicholson, 1982). For an examination and comparison of the extensive social impacts of this period and the severe 1910 drought, see Kates (1981).

Figure 10).[45] [46]

Table 3. Annual Rainfall Levels, Banamba Station, OHVN, Mali (1950-1991).[47]



Not only does reduced rainfall limit the productive opportunities of farmers, effectively reducing the growing season by 25 days, or by as much as 20 percent (IUCN, 1989)[48], but lower rainfall levels are also associated with higher annual

---

[45] Nicholson (1982) notes that, as a rule of thumb, in the Sahel a 100 mm shift in rainfall levels equates to a 100 km. movement along the North-South axis.

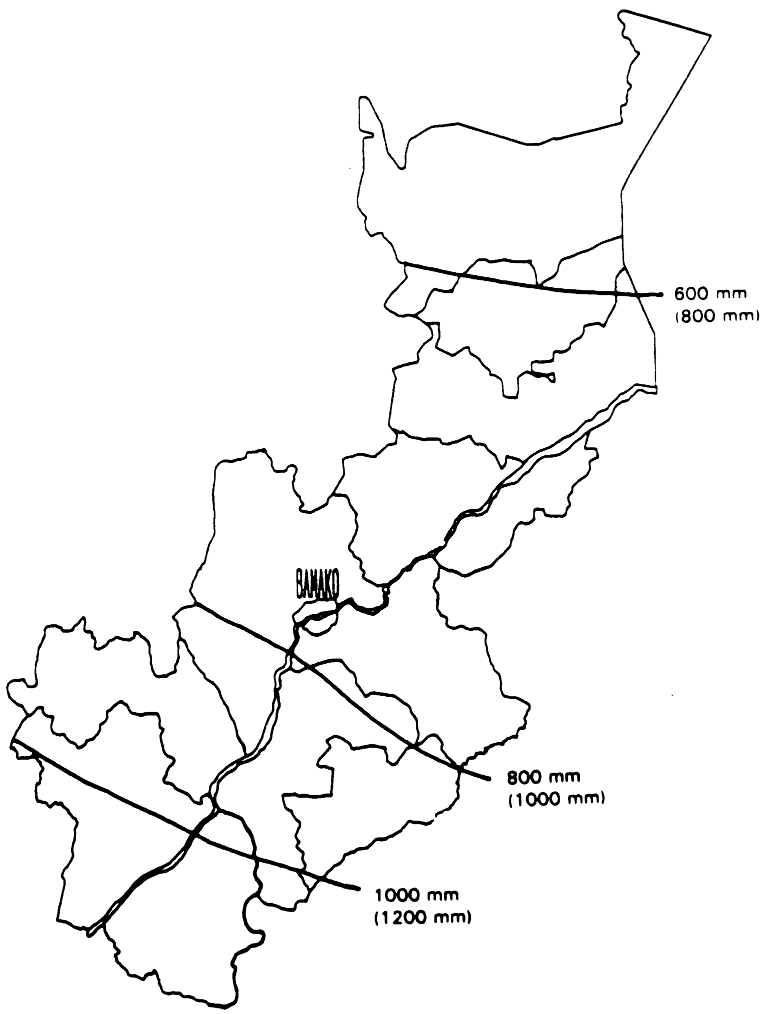
[46] The positioning of the rainfall isohytes is extremely sensitive to the measurement period being used. Although the World Meteorological Organization has recently adopted the period 1960-1991 as its official measurement standard, most maps in use are based upon the earlier WMO standard that covers the period 1930-1961, or contains only a portion of the present drier period.

[47] Source: SRCVO, 1989; OHVN, 1992a.

[48] Each movement northwards of 5.5 km. equates to a decrease in the length of the growing season by one day (in Franke and Chasin, 1980).

variability, especially at the onset and length of the rainy season. This increased variability has imposed even greater uncertainty on the farming systems of affected areas, which is especially evident during the critical period of planting. In the semi-arid zone, the flush of nutrients that are released by the first rains can have a tremendous impact on crop yields.[49] Yet, for newly germinated crops, even a two-week period of drought (which is common during these early rains) can be disastrous.

Figure 10. Southward Shift in the Average Annual Rainfall Isohytes in the OHVN.[50]



[49] A two-week delay in planting can result in yield losses of up to 30 percent for peanuts, and 60 percent for sorghum (Jaeger, 1986).

[50] Source: ORSTOM, 1974; SRCVO, 1989; OHVN, 1992a.

Climatological History

The persistence of the present period of decreased rainfall far exceeds those recorded during the earlier periods of this century,[51] and has led to speculation that the region is undergoing permanent climatic change as a manifestation of global warming, or due to human impact on the region's biota (see Nicholson, 1982; Farmer and Wigley, 1985; Gritzner, 1988). However, a historical view of the region reveals periods of drought lasting 12-15 years during the 1680's, the 1730's-1740's, the 1820's and 1830's (Nicholson, 1982). It is apparent that recurrent periods of intense drought and longer-term fluctuations similar to the present are part of the region's character.

Ground and Surface Water Resources

The region's limited surface and ground water supplies have also been significantly affected by the continued drought. The Niger River and its tributaries constitute nearly all of the permanent surface water in the OHVN zone.[52] Seasonal stream flows, the extent of river flood levels and inundated areas (*bas fonds*) are all dependent upon seasonal rainfall. With the decrease in rainfall, farmers in many areas have had to adopt new production strategies. Those in the southern *secteurs*, practicing recessional (*décrue*) agriculture (Harlan and Pasquereau, 1969) and semi-controlled flooding, have abandoned aquatic rice production on large tracts of land because of reduced flood levels since the late 1960's.

---

[51] Such as the droughts of 1910, the 1920's, the 1940's, and 1950's (Nicholson, 1982).

[52] These tributaries within and bordering the zone include the Sankarani, Banifing, Faya, Fié, Koda and Koro (see IGN 1:200,000 map series). In general, permanent surface water is limited to areas receiving well over 1000 mm of rainfall annually.

Ground water levels for much of the zone have also been negatively affected by the decreases in precipitation. Even during periods of abundant rainfall, neither the extensive aquifer found in most locations at between 2-35 m depth, nor the deeper aquifers located in the faults and deformations of the crystalline bedrock in the southern part of the zone (PIRT, 1989), have enough reserve to support widespread irrigation (PIRT, 1989; Shaikh, A. et al., 1988b). Villagers note that during years of poor rainfall, certain wells in most villages run dry. Many of the shallow wells in the northern areas, used in the past for irrigating dry season gardens and watering livestock, have been abandoned. Widespread, drought-induced mortalities are visible in the tree populations of Boron *secteur*,[53] in part because of ground water levels that have fallen as much as 75 feet in some areas (Shaikh, et al. 1988a).

Soil Resources

Macrovariations in Soils

From the perspective of the soil geographer,[54] a distinct north-south division of major soil 'regions' is immediately evident when considering the OHVN zone as a whole. These distinct soil regions are the product of two major geologic formations (Ahn, 1969; Charreau, 1974). The secondary weathering of these major geological features (illustrated in Figure 11) under the generally stable climate of the past 4,000-

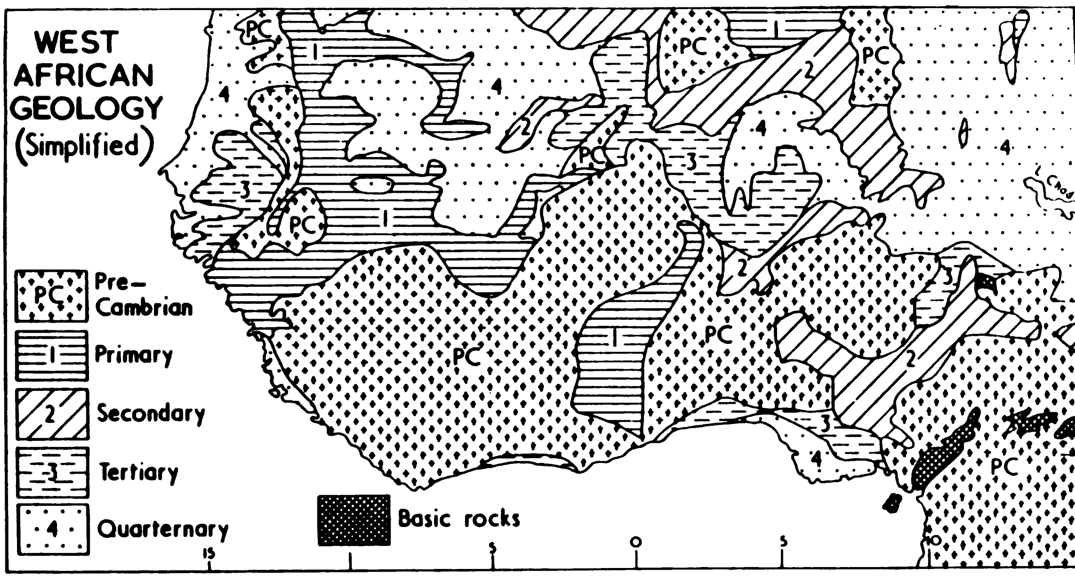
---

[53] Similar observations of extensive drought-induced mortalities in *A. albida* have been noted in Senegal, especially in trees on sites elevated further from the water table (80+ feet)(Seyler, 1993). In some areas, it is estimated that 40 percent of this species perished during the 1968-73 drought (Wentling, 1983 in Seyler, 1993), while other species suffered losses of up to 60 percent of their populations (Bradley, 1977).

[54] From this perspective, variations in soils occur in the form of 'soil regions,' having distinct patterns characterized by high uniformity within and high contrast between different areas (Van Wambeke and Dudal, 1978)

5,000 years (Nicholson, 1976) account for much of the present-day topography and macrovariations in soil types found within the OHVN zone.

Figure 11. Major Geologic Formations Underlying the OHVN Zone.[55]



The Southern Region. The soils found in the southern *secteurs* of the zone[56] are the product of a major up-folding of extremely old crystalline deposits (Ahn, 1969; Charreau, 1974; PIRT, 1989), and are generally fairly low in nutrients.[57] This pre-

[55] Source: Ahn, 1970.

[56] Southern Bancoumana, Kangaba, Oueléssébougou, Dangassa, and Gouani (PIRT, 1989).

[57] Soils developing out of the scattered schist deposits have a higher nutrient status. The varying silicate contents in parent material and intensity of weathering strongly influences the formation of different clay types, with important implications for soil fertility in terms of the ability to retain nutrients in the profile--the cation exchange capacity (CEC). Variable montmoullorite-type clay developing out of the schist deposits has a 2:1 silicate-aluminum structure with a cation exchange capacity (CEC) of 100-130 me/100 mg., roughly 50 times that of the more strongly weathered

Cambrian formation has become weathered into the broad, crumbling, ironstone-capped plateaus and undulating topography which characterize the area.[58] Scattered inselberg formations,[59] and the prominent escarpment and mountainous area of the Mandingue Plateau along the western bank of the Niger River, provide additional relief. The moderate moisture regime of the area supports abundant plant growth, important in the development of soil organic matter, yet is also responsible for leaching most of the soluble nutrients and clays from the soil profile. As a result, the majority of nutrients available for crop growth are contained in the soil organic matter, which rapidly declines through erosion losses and increased oxidation once the protective vegetative cover is removed and the unprotected soils are subjected to annual cultivation (Jones and Wild, 1975).[60] Under the American system, the soils of the southern *secteurs* are broadly classified as Alfisols and Ultisols (Steila and Ponds, 1989).[61]

---

kaolinitic clays associated with the granitic formations, which have a 1:1 structure and CEC of 2-6 me/100 mg. (Ahn, 1970).

[58] The parent formations of the entire OHVN zone have undergone at least two major cycles of uplift and leveling that resulted in the formation of extensive, nearly flat peneplains. Intensive weathering of these plains led to the formation of ironstone and hardpan sheets covering much of the zone. As these sheets were desiccated through continued weathering, the characteristic topography of the area emerged. It is thought that these iron-rich deposits act as the 'parent material' in the formation of new laterite horizons (Ahn, 1969; Charreau, 1974).

[59] Inselbergs are isolated mountainous outcroppings that have become deeply buried in their own debris.

[60] Loss of the nutrient uptake by the extensive root systems of perennial species also contributes to the increase in nutrient loss through accelerated leaching (e.g. Maignien, 1961). Further declines are associated with the reduced quantity of organic matter input, and through the removal of nutrients in the form of harvestable produce and fodder for annual crop species.

[61] Also classified as ferruginous, ferrisols, and ferrallitic soils in the international classification scheme, and as *'sols ferrugineux tropicaux non ou peu lessives'* in the French system (Ahn, 1970; Charreau, 1974).

The Northern Region. The predominantly sandy soils of the northern portions of the zone[62] have developed from extensive sedimentary deposits heavily weathered during the Quartinary period (Ahn, 1969; Charreau, 1974). As in the South, widespread hardpan formations have degenerated into crumbling plateaus, blocks, and beds of plinthite pebbles (Ahn, 1969; Charreau, 1974), which, with the eroded hillocks and broad sand plains cross-cut by dry-wash stream beds, are characteristic features of this landscape. In the far northern reaches of the zone, ancient, fossilized sand dunes from the Quartinary period are also visible. This series of NE-SW facing dunes have long since been stabilized by vegetation (Charreau, 1974; PIRT, 1989) and is characterized by its own unique hydrological and pedological processes.

Although the lower rainfall in this area limits production of above ground biomass, and consequently affects topsoil development, the limited rainfall has also allowed these soils to retain a larger share of their initial nutrient stores in the upper horizons (Jones and Wild, 1975).[63] The majority of soils in the northern areas are classified as Alfisols under the American system (Pond and Steila, 1989).[64]

---

[62] Northern Bancoumana, Koulikoro, Sirakorola, Banamba, and Boron *secteurs* (PIRT, 1989).

[63] The dry deposition of nutrient-rich topsoil from the dust-laden *harmattan* winds may play an important role in soil fertility in this area (Jones, 1938). Recent research suggests that crop residues used as mulch in fields can act as a highly efficient 'trap' of wind-blown topsoil, rich in nutrients, that can increase crop yields by up to 400 percent and which has actually helped to increase soil depth (Anon., 1992).

[64] Corresponding to ferruginous soils and brown and red soils of arid and semi-arid areas in the international system, and *'sols rouge et brun'* in the French system. Although these well-drained, predominantly sandy soils generally contain little organic matter, they have a larger clay fraction near the surface, comprised mainly of montmoullorite clays, giving them a higher CEC and therefore greater potential of retaining the available nutrients than those soils found further to the South (Jones and Wild, 1975).

Microvariations in Soils

The locally occurring soils found in the OHVN zone, regardless of their composition, exhibit a number of important features of both random and systematic variation. These variations, originating from either natural or anthropogenic causes, consist of both relatively permanent alterations and less durable features which dissipate over the course of several cropping cycles (Brouwer et al., 1993; Moormann and Kang, 1978). Such variations can be systematic, such as the finer scale differences in the individual soil series, or random in their origin.

From the soil taxonomist's perspective,[65] variations in the topography, parent material, vegetative communities and secondary weathering on specific locations can be described in terms of sequential soil series. From such a perspective, the lithosequence, toposequence and biosequence[66] of specific sites contribute to a systematic transition in soil types across the landscape (Wilding and Drees, 1978). The concept of *catena* (Latin for chain)(Milne, 1935) is commonly used to explain the sequential changes in soil types "encountered as one goes from hill top to valley bottom" (Ahn, 1969; p.60). In this conceptualization, the transition in soil series is largely explained by the positioning, physical movement and hydrological influences on common parent material. Colluviation of material and minerals from the upland soils on to the lower slopes, and interaction with the progressively wetter moisture regimes and more vigorous plant communities at the valley bottoms, combine to form distinct soil bands. The general *catena* characteristics, illustrated by the example in Figure 12,

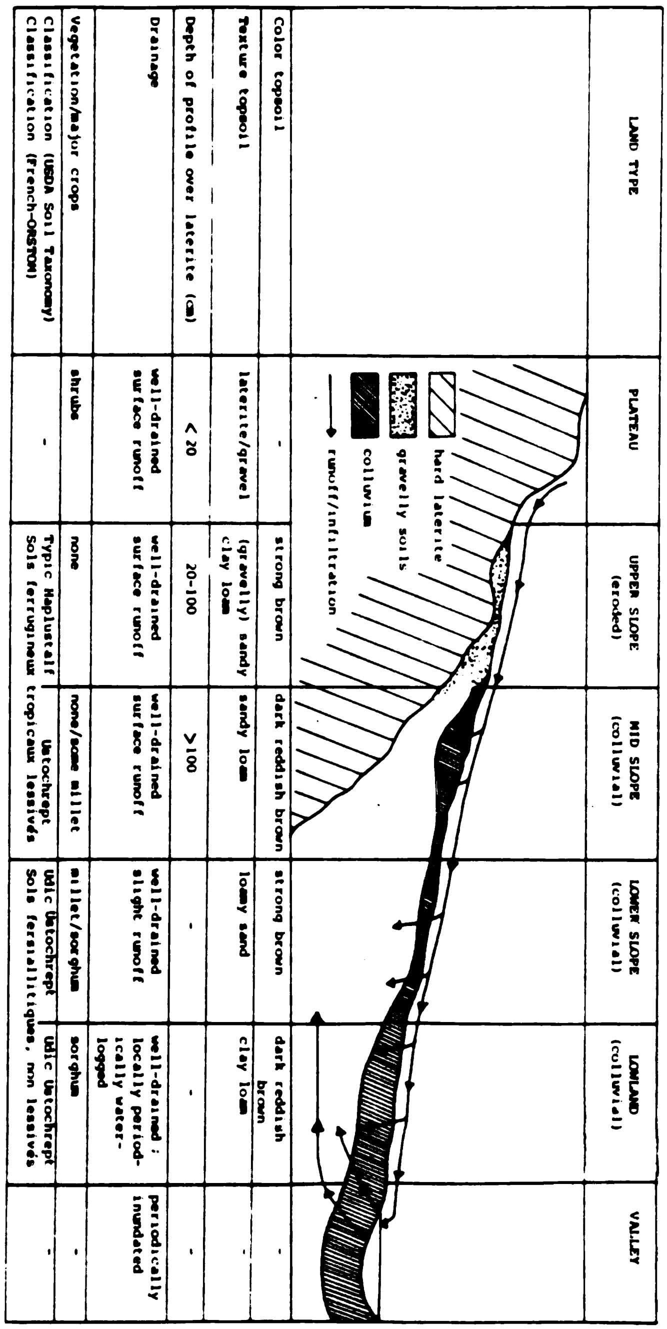
---

[65] Where soil variations are seen in much finer detail, distinguishable over short distances in specific localities (Van Wambeke and Dudal, 1978).

[66] These sequences refer to the transitions in parent material (lithosequence), topography (toposequence) and vegetative and invertebrate communities (biosequence).

vary significantly from site to site, corresponding to changes in any one of the major contributing factors (Ahn, 1969).

Figure 12. A Profile of the Soil Sequence Found in a 'Typical' Sahelian *Catena*.[67]



---

[67] Source: Stoop, 1987a.

Differential rates of wind and water erosion across seemingly uniform surfaces, the impact of specific biological features, and irregularities in the surface topography and underlying hydrology provide examples of some of the different sources of random variance which can influence agricultural production, yet which cannot be generalized or accounted for in any systematic fashion (Wilding and Drees, 1978). Moormann and Kang (1978), as well as others (Brouwer et al., 1993), suggest that biogenetic forces are responsible for much of the microvariations found within individual toposequences. Differences in vegetative cover, the effects of individual trees on soil organic matter content and microclimatic influences (e.g., Charreau and Vidal, 1965), the activities of termite communities which increase drainage and bring to the surface fine, often nutrient-rich materials, including clays (Warner, 1991),[68] and human disturbances in the form of mixing soil layers, disruption of structural integrity, changes in vegetative cover, accelerated (and abated) erosion levels and the removal and addition of organic matter, all play significant roles in the formation of microvariations and the evolution of soil structure and fertility in specific sites. At the field level, such variations across the landscape begin to define the realities that farmers face in managing their different production systems (e.g., Carter and Muwira, 1995).

---

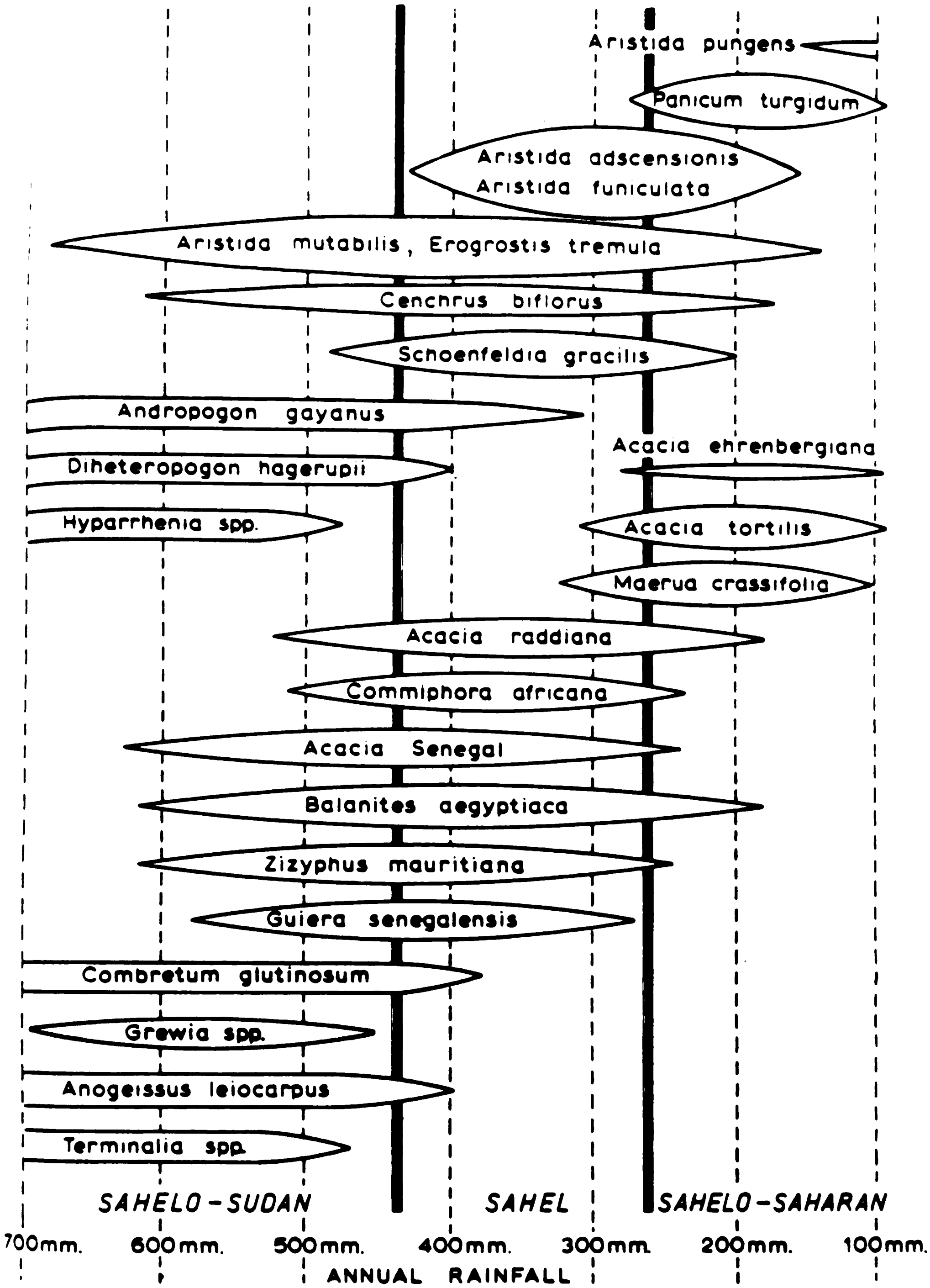
[68] In the Sahelian and Sudanian environments of West Africa, as much as 70% of the above ground woody biomass is thought to pass through termites. The short and long-term management implications of this are poorly understood and possibly under-appreciated (Josens, 1983). The density of termite mounds varies by area and species. In Nigeria, mound densities average 32/ha, equating to roughly 2-3 percent of the land surface being covered (Kang, 1978). Termites can bring to the surface significant amounts of clay that have been translocated from the surface soil horizons. In addition to contributing to moisture retention, these clays can also increase the CEC of the soil, improving the nutrient-holding capacity of the areas immediately adjacent to the termite mounds (Miedema & van Vuure, 1977).

Vegetative Cover

Large Scale Categorization

The composition and location of plant communities within the OHVN zone are the result of two main categories of influences: those associated with the 'natural site,' or basic growing requirements of each species, and those of 'socio-economic site' which, through various human activities, delimits the range where species are allowed to grow (von Maydell, 1990). The natural sites for different species are primarily governed by water availability--the quantity and distribution of rainfall, the water-holding capacity of different soils, the proximity to groundwater, the topographical concentration of seasonal flows, and the ability of species to endure annual periods of drought, as well as longer-term fluctuations (Lawson, 1986; Hills and Randall, 1968; Bille, 1977). Species distributions therefore not only follow general rainfall boundaries, but also topographical contours and underlying variations in soil types and hydrology. Aspects of this can be seen in Figure 13, which shows the distribution of the more common agroforestry and locally dominant species based solely on rainfall. While some species exhibit a great deal of elasticity in their overall requirements, others are much less tolerant (von Maydell, 1990). Variations in soil properties (nutrient stores, pH)(Hills and Randall, 1968), sensitivity to varying levels of sunlight, shade, alleopathic reactions, grazing, fire and wind are additional parameters that shape the positioning of individuals within suitable sites in the landscape.

Figure 13. Range of Common Tree and Grass Species Based Upon Rainfall Requirements.[69]



[69] Source: Bradley, 1977.

A common characteristic of species inhabiting semi-arid environments is their extensive underground nutrient stores that provide them with a great deal of plasticity in responding to significant and enduring shortfalls of precipitation.[70] In general, the vegetative communities (both living and represented in the soil seed bank) of the Sahel are very resilient and will 'spring back' to their former structures if left alone. Observations in the OHVN and results of several exclusion studies[71] show that even on the most degenerated sites, a significant 'rebirth' of vegetative communities is possible if they are left undisturbed (e.g., Hopkins, 1965; Bradley, 1977).

Because of long-term human influences within the Sudanian and Sahelian zones of West Africa, very few 'natural' vegetative communities remain. Historical evidence indicates that fire has been a major factor shaping the Sudanian and Guinean zones for possibly the past 2,500 years (Müller, 1855 in Hopkins, 1965). In some areas prolonged and excessive grazing pressure has meant a reduction in fragile and more desirable species, causing a shift towards plant communities of hardier and less palatable species. In addition to brush fires and livestock grazing, the cutting of trees for fuelwood and charcoal manufacture, and over-harvesting of secondary products are among the many influences identified as contributing to the general decrease in species diversity and a reduction in the overall density of above-ground vegetative cover in the Sahelian region (e.g., Gretzner, 1988; NRC, 1984b).

---

[70] Studies completed in Senegal during the 1968-73 drought showed that while rainfall in the area had dropped by 45%, herbaceous biomass production initially fell only 20%, although as the drought continued biomass production dropped to virtually nil (MacDonald, 1986).

[71] Studies where specific sites are fenced-off to allow natural regeneration and growth to occur without interference from domestic livestock.

The Distribution of Vegetative Communities Within the OHVN

Since the initial classification of West African vegetative zones (Guinean, Sudanian, and Sahelian zones) proposed by Chevalier (1900), a number of schema and descriptors have been used to differentiate the relatively seamless transition from closed canopy moist forest to open desert (see Lawson, 1986).[72] Following Lawson (1986), this discussion uses Chavelier's (1900) vegetative zones to delimit general divisions in the plant communities found in the OHVN zone. Special attention is given to the range of dominant and useful species, especially those occurring in the principle agroforestry associations common to the zone.

The Northern Guinean Zone. At a minimum, perennial species inhabiting this zone must be able to endure the eight month dry season between rains, which bring 900-1250 mm of precipitation each year (Lawson, 1986). Expanses of open canopy dry forest are common, with patches of closed canopy forest, especially along riverain and undisturbed low-lying areas. The primarily deciduous tree species allow a grass understory to exist in most areas. This grass cover varies from scattered tussocks in more heavily forested areas, to tall grass savanna species (>80 cm.) in the open areas of grassland. Farmers in this area report the appearance of 'new' weed species in recent years, species whose range has apparently shifted southward with the downturn in precipitation.

Plant communities in this zone are thought to be fire climax. The influence of dry season fire is the basis for commonly referring to this area as 'derived savanna,'

[72] The lack of consistency in the various perspectives on delimiting vegetative zones is demonstrated by the 1981 and 1983 map series of West African Vegetation produced by UNESCO. The former uses 'savanna' types as its primary descriptive unit, while the latter uses 'woodlot' types.

evident in the abrupt transition from savanna to closed canopy moist forest (occurring in less than 150 meters further to the south)(Hopkins, 1965). In the absence of fire and other forms of human disturbance, this zone, as well as much of the Sudanian zone, would revert to closed canopy dry forest (Lawson, 1986). In agricultural areas, trees with economic importance, dominated by karité (*Vitellaria paradoxa*), form the extensive 'agroforestry parklands' for which much of West Africa is noted.

Table 4. The Principle Grass and Tree Species of the Northern Guinean Zone.[73]

Trees	Grasses
Afzelia africana	*Andropogon gayanus*
Bauhinia rufescens	*Andropogon pseudapricus*
Cordyla pinnata	*Ctenium newtonii*
Daniella oliveri	*Cymbopogon giganteus*
Erythrophleum guineense	*Vetiveria nigritana*
Ficus guaphalocarpa	
Isoberlinia doka	
Khaya senegalensis	
Pterocarpus erinaceus	
Vitellaria paradoxa	

The Sudanian Zone. In the somewhat drier Sudanian zone, averaging 600-900 mm of rainfall per year, the impact of a historically higher population density,[74] with its associated agriculture, grazing, and use of fire, is much more apparent in the structure of woody perennial populations. Save for riverain and protected areas, mature closed canopy forest is scarce, although dense tree stands and thickets are common. The wooded savanna and open glades are populated with both shorter stemmed grasses

[73] Source: IBPGR, 1984; PIRT, 1989; Steentoft, 1988; von Maydell, 1990.

[74] The higher population density of this area is associated with the historical prevalence of 'river-blindness,' and trypanosomiasis carried by the tsetse fly, in the moister regions of the South.

and broad and fine leaf deciduous species, characterized by their thick fire-resistant bark. As with the Northern Guinean zone, the dominant woody perennial in highly populated areas are those with economic value (such as karité, tamarind (*Tamarindus indica*), and néré (*Parkia biglobosa*), although their densities decline noticeably as one moves northwards.

Table 5. The Principle Grass and Tree Species of the Sudanian Zone.[75]

Trees	Grasses
Acacia albida	*Andropogan gayanus*
Adansonia digitata	*Ctenium elegans*
Annona senegalensis	*Hyparrhenia spp.*
Azadirachta indica	*Pennisetum spp.*
Bombax costatum	*Panicum anabaptislum*
Cassia sieberiana	
Grewia bicolor	
Lannea acida	
Lannea microcarpa	
Parki biglobosa	
Tamarindus indica	
Vitex doniana	
Ximenia americana	

The Southern Sahelian Zone. Averaging between 250 and 600 mm of rainfall per year, the Sahelian zone supports both lower human population levels and plant densities. Just below the northern limits of this zone, woody perennial are able to obtain sufficient moisture to spread out beyond the seasonal water courses, reaching densities of up to 40 percent coverage in some of the better sites of the southern Sahel (Steentoft, 1988). Following a north-south transect, species diversity shows a sharp increase, from just over 30 in the extreme North, to over 120 species in the

[75] Source: IBPGR, 1984; PIRT, 1989; Steentoft, 1988; von Maydell, 1990.

South (von Maydell, 1990). This area is dominated by a variety of thorn-bearing acacia and other species that lend themselves to the description of 'thorn-scrub.' Due to the lack of sufficient fuel load to support brush fires (Lawson, 1986), fire is less of a factor in shaping the structure of plant communities in this area. However, intensive grazing and the lopping of branches by herders has resulted in wide expanses of exposed soils and the characteristically architectured shrubs and trees.

Table 6. The Principle Grass and Tree Species of the Southern Sahelian Zone.[76]

Trees	Grasses
Acacia senegal	*Aristida spp.*
Acacia seyal	*Cenchrus spp.*
Acacia tortilis	*Chloris spp.*
Balanites aegyptiaca	*Eragrostis tremula*
Boscia senegalensis	*Panicum turgidum*
Grewia bicolor	*Schoenefeldia gracilis*
Moringa oleifera	
Sclerocarya birrea	
Ziziphus mauritiana	

Chapter Summary

The constantly interacting and evolving natural resource systems described in this chapter present farmers with a dynamic mosaic of resources which they must attempt to manage. Certain elements of these systems, such as soil nutrient levels, are relatively stable, showing moderate, discernable year-to-year changes that are open to management interventions. Other variables, such as yearly rainfall (its on-set, duration, and spatial and temporal distribution) and the associated flood levels, can only be anticipated and reacted to within the context of a particular season. The composition

[76] Source: IBPGR, 1984; PIRT, 1989; Steentoft, 1988; von Maydell, 1990.

of the different vegetative communities, and changes in weed populations, provides yet another source of variation that reflects elements of both long- and short-term environmental changes, as well as the influence of human activities.

In sum, farmers living in areas at the margin of secure agriculture face greater extremes in environmental variability, and must contend with an overall larger range of contingencies, and do so with fewer resources, than is the case with their counterparts living in more stable and well-endowed regions. As Chapters IV and V will illustrate, the lack of abundant and stable natural resource systems requires farmers to rely upon their detailed knowledge of local environmental variations and adaptive creativity to secure their livelihoods. The major attributes of the physical environment also demand that the formal research and extension system adapt its activities to reflect the overall limitations of the area, and respond appropriately to the specificity of conditions which farmers face, if they are to play a significant role in assisting agricultural development within this area.

CHAPTER IV. Agricultural Performances, Diversification, and Household Economic Production Portfolios

In recognition of the major influence that the environment of the OHVN zone has on farmers' behavior, this chapter examines the basic patterns of individual and household responses to the fluctuating physical and social conditions of the zone. Richards' (1989b) conceptualization of agriculture in 'complex, diverse, risk-prone' environments as a fluid 'performance' provides the point of departure for this chapter's discussion of some of the principle themes associated with farmers' adaptive behavior. At the household level, agricultural performances are described as being but one, albeit central, part of a larger set of 'household performances' that involve the investment of resources in a wide range of agricultural, on-farm, value-added processing, and on- and off-farm non-agricultural activities. In analyzing the different patterns of household economic diversification found across the OHVN zone, the concept of household economic 'portfolios' is introduced as a way to characterize the array of investment opportunities and production constraints which households face in various locations. These concepts--individual performances, household economic diversification, and portfolio areas--are important not only to gaining a clearer understanding of the nature of agriculture in the region, but are also critical to understanding the development of local knowledge systems and farmers' innovative skills. Furthermore, the patterns of individual and household responses described in this chapter represent essential aspects of local production systems that external agencies must recognize and respond to if their efforts are to have a significant and lasting impact.

Agriculture as Performance

At the local level, the heterogeneity of natural resources outlined in Chapter III is paralleled by an equally variable set of household resources, production objectives, and personal attributes of individual managers. Under such conditions, agriculture is best described as a dynamic performance (Richards, 1989b), or, more accurately, as a set of linked performances through which individuals respond to the evolving set of physical and social conditions of each production cycle. The general nature of these performances is described by Moris (1991:27):

> African farmers respond to an unfolding scenario of changing opportunities and constraints (e.g., wet vs dry years, early vs late onset of the rains, pest outbreaks in a particular crop, unplanned labor shortages, and so forth)...[T]hey bring to their farming an accustomed 'script' (Vierich, 1987), modified as the season unfolds in a manner Richards (1989) likens to a musical performance, or which Stewart (1986) describes as 'response farming.'

The concept of 'agriculture performances' is used in this chapter to represent the application of rural peoples' knowledge, skills, and creativity in adapting to the conditions of each season as it progresses.

At the onset of each production cycle, farmers begin with a fairly general plan for the allocation and management of the available physical and household resources (e.g., land, labor, equipment, inputs, seed stock). In any given year, however, constraints imposed by any number of the essential resources may cause even these initial plans to deviate significantly from what farmers know as the 'best' practices. As the season unfolds, changes in the productive potential of the available resources, coupled with unforeseeable delays or variations of other influences (e.g., rainfall, plant disease and pest outbreaks, human illness and equipment failure), require farmers to modify and reformulate their initial plans. As Richards points out, the "layout of different crops in a field is not a design but a result, a completed performance. What transpired in that performance and why can only be interpreted by reconstructing the sequence of events in time. Each mixture is a historical record of what happened to a specific farmer on a specific piece of land in a specific year" (1989b:40). Viewed in this way, farmers' agricultural performances represent elements of both 'scripts' of traditional, or preferred, response patterns, and provisional adaptations that farmers elect, or are required, to implement in response to unforeseen events. In furthering Richards' (1989b) analogy between agriculture and music, these two features, tradition and adaptation, can be seen as representing the melodic themes and improvisational nature of farming in Sahelian West Africa.[77]

Agricultural Themes

Although a range of individual practices exists at the local level, farmers never wholly depart from their proven agricultural themes, except under the most extreme conditions.[78] Certain elements of these basic 'themes' are evident in the data

---

[77] This improvisation should not be interpreted, as by some (e.g., Batterbury, 1993), as suggesting that Sahelian farmers are incapable of conceiving and carrying out plans for the management of natural resources. The timeframe of natural resource planning (e.g., tree planting and construction of erosion control structures), and the responses made by farmers in managing their crops during the course of a single season, are separate, but not mutually exclusive, aspects of agricultural management.

[78] Under conditions of severe drought, farmers may be forced to abandon much of their regular crop production activities and devote their remaining energies and resources to collecting wild grains, fruits and vegetables. Some village elders interviewed related the now familiar anecdote of having to raid ant and termite stores to secure grain during the worst of the droughts. Most of the older farmers interviewed told of having had to rely to some extent upon 'wild foods' (e.g., *Paspalum spp.* and *Dioscorea spp.*) during the past droughts, although they said that this was of declining necessity because "the trucks" now arrive to deliver relief food during times of crisis.

collected on cropping patterns. In the OHVN zone, as throughout the region, intercropping accounts for 70-80 percent of the cultivated surface area, dominated by a half dozen principle crop associations (DRSPR/OHV, 1992; Norman et al., 1979). These major associations, as reported by farmers (shown in Table 7), illustrate some of the common elements of farmers' decisions concerning intercropping mixes--legumes paired with cereals, and crops with different maturation periods, nutrient, and moisture needs paired with each other. When specific soil types are considered, farmers also utilize a number of well-documented pairings of crops and specific varieties with soil types.[79]

---

[79] For example, varieties of red sorghum, tolerant of water-saturated soils, are planted in clayey soils and the annually inundated *bas fonds* areas, while millet is planted in the droughty upland soils, and white sorghum and maize, with higher nutrient needs, are typically planted in the inner and more fertile bush fields (e.g., Harlan and Pasquereau, 1968; Matlon, 1980; Stoop, 1986; 1987a; 1987b; Vierich and Stoop, 1990). Further examples are provided in Chapter V in terms of farmers' management of 'microenvironments.'

Table 7. Major Cropping Associations for Three Types of Farmers in the Northern and Southern OHVN Zone.[80]

Culture	Kanika (North)			Déguéla (South)		
	Type 1[81]	Type 2	Type 3	Type 1	Type 2	Type 3
Mil/Sorgho		.10				
Mil/Niébé/Sorgho		4.43	2.65			
Mil/Niébé		2.00				
Sorgho		.55	.78	2.25		1.23
Sorgho/Niébé		2.49	1.45	1.00	2.42	.90
Sorgho/Arachide		.34	.54	.25	.21	
Maïs		.35	.03	.50	.22	.22
Arachide		.15	.23	.22	.18	.30
Dah		.10		.06		
Vouandzou		.25				
Mil		.60	.03	5.00	2.00	.75
Mil/Niébé/Sorgho/Dah			3.00			
Maïs/Mil			.15	3.00	1.67	3.00
Maïs/Mil/Niébé						
Riz			.40	3.50	1.56	1.19
Coton/Niébé			.05			
Sorgho/Dah			.15			
Maïs/Sorgho				2.75	1.20	1.39
Coton				2.00	1.00	
Arachide/Dah				.26	.16	.28
Maïs/Mil/Courge/Cala				4.00		
Fonio						.25

Other aspects of farmers' general 'themes' can be seen in farmers' preferences for handling specific types of adversity. In the OHVN zone, for example, farmers make a range of adjustments in their management practices during low rainfall years. In order to reduce competition for scarce soil moisture in low rainfall years, the principle cereal fields receive an additional weeding in the hopes of salvaging some kind of a harvest, while other fields are, in effect, abandoned. In years when major replantings are necessary, farmers abandon specific marginal sites, such as the thin and gravelly upland soils and inundated *bas fonds*, and concentrate their remaining resources on the

---

[80] Source: DRSPR/OHV, 1992a.

[81] See Chapter VII for definition of Farmer 'Types.'

more fertile inner and outer fields (see Matlon, 1980). When major replanting is required, or the initial planting is delayed, farmers favor crops and varieties with shorter maturation periods. Both men and women farmers identified a number of such shifts in the importance of specific food and market crops and specific varieties during 'poor' as opposed to 'average' years (see Table 8).[82]

Table 8. Change in Importance of Food Crops in 'Good' Versus 'Bad' Years, in the Northern and Southern OHVN Zone.

Kanika (North)				Samako (South)			
Men		Women		Men		Women	
Good	Bad	Good	Bad	Good	Bad	Good	Bad
Millet (long) Millet (rapid) Arachide Sorghum	Millet (rapid) Sorghum (rapid)	Millet Sorghum Horicot Arachide	Millet (rapid) Sorghum (rapid)	Sorghum Arachide Millet/ Maize	Maize Sorghum (rapid)	Sorghum Maize Arachide Rice	Maize Sorghum

Agricultural Improvisation

In order to understand and appreciate the more improvisational aspects of local farming practices, it is necessary to look beyond the general 'themes' in farmers' behavior. The data collected on intercropping, for example, typically treats one millet-bean intercropping pattern the same as the next.[83] The use of specific varieties,

[82] In these discussions, farmers were encouraged to apply their own subjective definition of 'good' and 'bad' years. The only caution given was that they should not equate "bad" with disastrous. The intent of these discussions was to elucidate the general types and range of changes farmers tended to make once they felt such actions were necessary, rather than their survival strategies under dire circumstances.

[83] More detailed studies on farmers' intercropping practices have found as many as 23 different crops involved in 230 to over 300 intercropping associations (e.g., Norman et al., 1979; World Bank, 1979). Many associations are planted in only a portion of an entire field, and are often sown at a later date, by a different manager, as time and resources permit. Such minor associations constitute an important

planting densities, and variations in the temporal and spatial arrangements of different crops[84] are not accounted for, yet these features are critical not only for understanding the specific agroecological interactions taking place, but in completing the story of how and why a particular association was established. As cautioned by Richards (1989b), it is also important not to confuse the apparent logic of farmers' practices with the results of a completed performance. Certain types of variation, for instance, are due to the specific technologies selected, rather than as a result of concerted planning on the part of the farmer. As one example, a common labor-saving practice used by farmers in the OHVN is to mix millet and/or sorghum and cowpea seeds to a desired proportion (often based upon seed availability) in a small gourd bowl for planting. 'Pinches' of this mixture are then sown with a short-handled planting hoe, *daba*, in holes spaced according to the stride length of the individual performing the operation.[85] Not only are the exact number and kinds of seeds planted in each hole variable, but the total stand density in these fields can vary, depending on whose labor (stride) was available for planting.[86] In this example, farmers' behavior is driven more

---

resource for the household cuisine and sources of income for specific individuals.

[84] In the OHVN, for example, Dah (*Hibicus spp.*) was found to be planted in four different ways in a single sorghum field: as a border crop; as alternate plants within a single row; in alternate rows; and in the furrow between rows. Each of these arrangements have different inter-species dynamics, yet would be recorded as a single intercropping mix in most surveys (if recorded at all).

[85] A more labor-intensive strategy is to delay the planting of beans in millet fields in order to minimize moisture competition with the primary cereal crop during early growth, as well as to reduce the risk of an early season drought harming the bean crop, which is more susceptible during this period.

[86] Selection of planting material, and the related cultural operations, are part of a larger set of performances carried out in response to the particular characteristics of the field, its fertility level, soil structure, weed populations, and the availability of household resources to till, plant and weed.

by labor constraints than by an intent to "implement a general theory of inter-species ecological complementarity" (Richards, 1989b:40).[87]

Just as general survey data on cropping patterns can obscure the important agroecological and social dimensions of farmers' management practices, so, too, can hypothetical discussions on management decisions lose sight of the various real-life influences which ultimately determine what actions are undertaken. For example, farmers' general comments concerning their responses to early or mid-season drought do not necessarily represent the actual management practices used in a specific year. Such comments provide an impression of what farmers would choose to do, all other variables remaining constant, rather than an actual record of farmers' completed performances in a specific year. In one sense, farmers' comments solicited in this way are "out of time" (Richard, 1989b:40), devoid of the intervening 'in time' circumstances of Sahelian life that constantly force farmers to alter their behavior.

Observations of farmers' 'in-time' behavior under real-life conditions reveal a far more dynamic process of adaptation in the face of multiple, and often countervailing, influences. Watts (1983), for example, describes a number of different types of adjustments in field use, plant spacing, and crop and varietal selection that farmers make in response to particular stresses, while Mortimore (1989) provides details of the broader, inter-annual production strategies adopted by households with differing levels of assets (cf. Toulmin, 1991). This kind of data exemplifies the more improvisational

[87] In another illustration, the highly integrated agroforestry gardens found in the southern part of the zone are typically manured with kitchen wastes and planted to thin stands of cereals. The household wastes contain a large number of viable seeds (a fact known by farmers) from a number of different crops (the composition of which is not known), which are then allowed to prosper wherever they sprout. The result is a randomly "intercropped" plot which may contain over a dozen different varieties, giving the appearance of a highly integrated cropping system for those trained to look for such things, yet produced entirely through chance associations.

aspects of agricultural performances--aspects that portray agriculture as the product of a series of decisions, made 'on the fly,' and influenced by both a farmer's knowledge and her or his access to resources, rather than as the implementation of a unitary plan or a series of fixed contingencies.

Household Economic Performances[88]

The economic strategies pursued by rural households reflect many characteristics similar to those illustrated by farmers' individual agricultural performances. Depending upon the conditions of each season, what resources are available, and the particular household's preferences and needs, investments are made in a wide range of economic activities that not only provide security, but also serve to fully exploit the available opportunities. In general terms, household economic systems can be characterized as "multi-enterprise production units...far from purely agricultural...[where]... household members are typically part-time farmers and are simultaneously engaged in a variety of non-farm production activities" (Hunt, 1991:49). Studies in the OHVN, as well as elsewhere in the region, show that non-agricultural activities provide from 40 to nearly 70 percent of household revenues (DRSPR/OHV, 1992c; Matlon, 1977; Reardon et al., 1992; Reardon et al., forthcoming; Sundberg, 1989). This point is underscored by the fact that a majority of households in the central OHVN zone are not self-sufficient in basic grains; roughly 20 percent of the grains for consumption are purchased, with a greater share being purchased during years of poor production (see Steffen, 1992).

Household wealth is an important influence on the degree and types of

---

[88] This section builds upon an earlier draft of this material in Bingen et al., 1994.

household economic diversification; the poorest and wealthiest households[89] tend to have the most diversified household economic systems, although for very different reasons (Lewis, 1979; Koening, 1986a; Grosz-Ngaté, 1986). In the OHVN, poorer households (which in most cases are those with fewer members) diversify through necessity; they are unable to make ends meet through agriculture alone. Wealthier households, on the other hand, tend to diversify based on ability; sufficient labor and accumulated capital allow these households to release labor from agriculture to invest in other activities (cf. Reardon, et al., 1992). Seasonal labor migration (e.g., Lewis, 1979; Mazur, 1984; Reardon et al., 1992; Reardon et al., forthcoming; Van Westen and Klute, 1986) and the economically and nutritionally important resources gathered from common property reserves (e.g., Falconer, 1990; Scoones, et al., 1992) are just two examples of the broad spectrum of opportunities from which household decision-makers choose in attempting to maximize their opportunities, maintain social solidarity, and reduce economic uncertainty and risk. Just as with individual agricultural performances, the allocation of household resources in various economic activities is not static, but rather reflects the particular conditions of the season, individual preferences, and skills of individual household members. Understanding the breadth and fluidity of this diversification is an important starting point for organizations interested in improving the economic welfare of rural households.

The Social Organization of Household Production Systems

Most decisions on economic diversification evolve out of the social organization of the household--i.e., who controls what resources. Based upon field observations and

---

[89] The use of 'poor' and 'wealthy' are used here as relative concepts. Household wealth was not measured, nor were households ranked, in this study.

several detailed anthropological studies on the social organization of land, labor and other resources in Bambara-Malinké households and communities (e.g., Becker, 1990; Koening, 1986a; Lewis, 1979; Grosz-Ngaté, 1986; Toulmin, 1991; 1992), a number of generalizations can be made regarding the organization of household production systems in the OHVN zone.[90] Each village is organized around a male-dominated hierarchy of lineage and age, with the eldest member of the oldest generation, generally of the founding family, serving as village chief (e.g., Lewis, 1979). Within the village, the extended family household is the primary unit of social organization. Households are commonly referred to as the *gwa* (meaning literally 'the hearth'); "the unit that farms a common field and eats most, if not all, of its meals from a common granary" (Toulmin, 1991:117).[91] While households may average from 18-20 members, in reality they constitute a bi-modal population of larger complex households of 23-30 members, and smaller, generally newly-formed or economically insecure, households of 7-10 individuals (e.g., Toulmin, 1991; Becker, 1990).[92] Polygamy is common. Families, presided over by the eldest male, are grouped into compounds, or *du*, where common walls of the various dwellings, pens and appendages form a self-contained unit surrounding a central courtyard(s). Depending on the village, individual

---

[90] The OHVN zone is populated by three dominant agricultural groups and one pastoral group. The Bambara are by far the most numerous, occupying the central part of the zone, with the Malinké concentrated in the southern and westernmost *secteurs* of Bancoumana, Kangaba and Kati (BEÇIS, 1991). Several authors note that there is little difference in the social structures of these two groups, and have accordingly treated them as essentially the same (Koening, 1986a; McConnell, 1993; Moseley, 1993). To the north, the Sankoré populate much of the Boron, Banamba, and parts of Sirąkorola *secteurs* (BECIS, 1991). The pastoral Peuls reside throughout the zone.

[91] Family groups with more than one *gwa* may be showing signs of an imminent breakup (Lewis, 1979).

[92] 72-84 percent of the households are of the larger, complex type (Becker, 1990; Toulmin, 1991).

compounds can be linked together, organized into neighborhoods or wards within the larger village,[93] or separated into a loose federation of individual concessions spreading over several square kilometers. Some villages that have experienced significant growth have splintered, due often to resource pressure (e.g., land, water) and/or social tensions, into a number of separate hamlets located at some distance from each other.

Under the management of the eldest active male, family members of each household hold first allegiance to the cultivation of its main communal fields. Tasks are generally gender-based, although the exact division of labor can vary considerably by household and region (e.g., Lewis, 1979). Men generally perform the heavy tasks of clearing fields, plowing, and use of animal traction, with women doing much of the planting, weeding, and harvesting. Other activities, such as winnowing grain, are exclusively a woman's task. Around the age of ten, children begin to accompany their parents into the fields and begin learning their separate gender roles in earnest (e.g., Cross and Barker, 1991). By age 12-14, children are active workers in the communal fields (Grosz-Ngaté, 1986).

In addition to contributing labor to the cultivation of the main communal fields, individuals may also cultivate one or more joint or personal fields subject to land availability and the adequacy of household labor.[94] For men, individual fields are generally planted to a cash crop. Depending on their age and the status of local land

---

[93] Wards are often established along kinship or religious lines (e.g. Lewis, 1979).

[94] Lewis (1979) notes that personal fields detract from the yield performance of communal fields, and a household whose members operate a number of individual fields may be showing signs of internal discord. This latter contention is rejected by Becker (1990), who maintains that an increased emphasis on personal fields may in fact represent an organizational innovation to increase the flow of cash to individual family members within an increasingly market-oriented rural economy.

availability, women may cultivate a field of peanuts, millet, or rice.[95] Women use their personal fields to generate cash, and to cement social ties and supplement the household cuisine (Lewis, 1979; Grosz-Ngaté, 1986). Most women also manage a small garden plot. These garden plots have become increasingly important sources of dry-season income.

Aside from the intra-household demands for labor, individuals also take part in a number of other labor-sharing arrangements and remunerative work groups. Depending on the solidarity of the village, this may include work in age-set groups (*ton*), ward labor, or *ad hoc* and gender-specific arrangements, such as house or granary building for men, or the winnowing of grain for women (Lewis, 1979). Although there is some outright granting of assistance to poorer households, most loans of labor, equipment or animals involve the remuneration of cash, grain or labor in kind (for more detailed discussions see Lewis, 1979; Grosz-Ngaté, 1986; and Toulmin, 1991).

The Diversity of Household Economic Activities

<u>Agricultural Surplus and Cash Crops</u>. To generate income, farmers from all areas of the OHVN zone rely upon the sale of surplus food stuffs and one or more cash crops.

---

[95] Women are generally able to secure individual fields once they have reached menopause (often synonymous with being the senior wife who controls the hearth and is no longer responsible for making the *tô*--a stiff West African porridge made from ground sorghum or millet)(pers. com. Arnoldi; Grosz-Ngaté, 1986), and their labor is no longer needed in the communal fields. In some locations, the women of the household may jointly manage a separate field (cf. Lewis, 1979). In others, as with the case in the southern OHVN where severe land shortages existed, women may only be able to secure *usufruct* rights to their husbands' fields during the peanut rotation of the cropping cycle. Younger women can at times secure a small plot of valuable rice land for themselves by doing favors for an older woman, such as bringing food out to the fields.

While the sale of surplus grain is generally dependent upon the growing conditions that year, the decision to engage in cash crop production reflects individual preferences, household capacities, and a number of other factors, including agroecological limitations, market proximity and access to transportation, and institutional support.[96] The staples most commonly sold are millet, sorghum, fonio and maize,[97] while common cash crops include cotton, peanuts, tobacco, garden vegetables (e.g., tomatoes, onions, okra, eggplant, pepper, and many others), fruit (e.g., mangoes, citrus, bananas, watermelons), livestock and animal bi-products (e.g., eggs, milk, and, more recently, manure sales).

On-Farm Agricultural Activities. In addition to sales of agricultural produce (crops, seeds, animals and by-products), households also rely heavily upon earnings from a number of on-farm value-added processing activities. Farmers identified over a dozen major income-generating activities involving the transformation of produce and by-products from their cropping systems (see Table 9).

[96] In a survey conducted by the DRSPR/OHV, food security was indicated as the main objective in crop production for 80 percent of the households sampled (DRSPR/OHV, 1993c).

[97] In some of the more remote villages visited, farmers expressed a reluctance to engage in sales of grain that resulted in grain leaving the village (cf.Lewis, 1979). In one village, farmers involved in a seed multiplication program had sold very little of the improved seed they had produced, preferring instead to keep virtually all of it in warehouses for village food security. Other communities were building communal granaries into which each household would place a certain amount of grain for use in the case of emergencies.

Table 9. On-Farm Value-Added Processing Activities.

Gardening (dried veg.)	Tamarind (dried; beverage)	Forage (dried)
Karité (butter; soap; etc.)	Dah and Sisal fiber (cord)	Baobab (dried leaves & fruit)
Néré (powder; soumbala)	Henné (dye)	Skins (dried & tanned)
Dah (fermented & dried)	Sorghum and Millet Stalks (mats; construction material)	Prepared foods & Cheese

Many of these activities involve the processing of 'secondary' or indigenous crops that are an integral part of the local production systems. In Mali, as many as 90 percent of the households engage in processing karité where it is common. In the OHVN, the sale of 'wild' fruit products are women's most important source of income (DRSPR/OHV, 1993c), with as much as 60 percent of their income coming from the sale of products made from karité oil (Luery, 1989). Local economies in many areas are driven by sales of karité products to the extent that, in years with low nut production, local market activity is depressed (Grigsby, 1989).[98]

On-Farm Non-Agricultural Activities. On-farm, non-agricultural activities include the gathering of fuelwood, charcoal production, collection of wild and cultured honey, fodder production, pottery making, and numerous others (see Table 10). These activities require varying degrees of skill and/or the use of specialized equipment. In the larger towns of the zone, sufficient demand and market integration allows

[98] Karité nut production fluctuates widely between years. Although the cause and control of this variance has as yet eluded researchers and farmers alike, it has been noted that late dry season fires can damage the flower set of the trees, affecting their productivity (SPORE, 1991). Areas in the northern part of the zone have lost significant numbers of karité and other trees through the past decades of drought and reduced rainfall.

individuals to specialize in certain enterprises as bona fide tradespersons (e.g., merchants, tailors, bakers, butchers, jewelers, etc.).[99] In most rural areas of the OHVN, however, these activities fall far short of full-time vocational occupations, and in no way should be confused with the occupations associated with specific ethnic groups and castes, such as herding, blacksmithing, and commercial fishing, or even with calabash mending, which is performed by women of the woodworker caste (Lewis, 1979).

Table 10. Types of On-Farm Non-Agricultural Income Generation.

Bee Keeping	Jewelry Making	Wood Cutting	Bricklaying
Baking	Hunting/Fishing	Petty Commerce	Cloth Dying
Tailoring	Pottery	Basket Weaving	Charcoal
Trad. Medicines	Carpentry	Cloth Making	Secco Construction
Well-digging	Midwifery	Yarn Spinning	Repairmen

Many non-agricultural activities involve the exploitation of local common property, or open access, resources.[100] However, throughout the zone, villagers report a range of ownership patterns exerted over different forest resources. For example, the majority of wild fruits and other tree products are treated as open access resources, available to anyone who chooses to spend the time collecting them. Specific species, on the other hand, such as the karité, often have some degree of

[99] In the early part of this century over 380 distinct trades were recognized in Northern Nigeria. Over 60 percent of these have since disappeared with the influx of cheap European imports (Watts, 1983).

[100] Open access resources are those for which there are no functional rules of management or use, while common property refers to those jointly owned resources where a group both exercises exclusionary control and enforces rules of conduct (e.g., NRC, 1986).

control applied to their use, as in a common property resource. Other species, such as the baobab, are often individually owned, either through inheritance, planting, or on a less-permanent basis, established by pruning their branches to increase productivity (Lewis, 1979). Traditional systems of local control and management over entire forested areas have largely broken down through the imposition of governmental legal codes. In one of the northern study villages, economically marginal households and the elderly (through the assistance of a NGO) were much involved in the cutting and sale of fuelwood. Although villagers noted a marked reduction in forest cover and the diminished availability of certain medicines and other forest products because of the decimation of their forest, they were legally powerless to do anything because the individuals involved in the cutting had obtained the necessary government permits.[101] In contrast, another of the study villages in the South has maintained exclusive control over a seasonal fishery which it has successfully managed and shared with two neighboring villages for generations (McConnell, 1993). Villagers reported that, in general, these local, non-agricultural activities involving open access and common property resources are of greater importance to the incomes of women, the elderly and economically marginal households.[102]

---

[101] Cutting permits are issued on a time basis, i.e., for a specific number of days, unrelated to the area of forest or quantity of timber cut. This particular village was lobbying the forest service to declare their remaining forest land *Foret Classé*, thereby effectively protecting it from any further degradation. In some of the southern areas of the zone, outsiders have come in and logged off all of the valuable species (Moseley, 1993). The problems related to common properties in Mali and the dissolution of communal control over resources has been widely studied (Thomson et al., 1986; 1987; Djibo, et al., 1991).

[102] A recent market study in Burkina Faso, for example, found that 91 percent of the people selling forest products were women (Guinko and Pasgo, 1992)

Off-Farm Employment. For most households in the zone, the economic contributions from off-farm employment, and remittances from those on *exode rural*, are another important source of income to the overall financial security of the household. Off-farm employment is most important during years of poor rainfall, which affects agricultural harvests as well as the production of many of the secondary products used in other income-generating activities. Off-farm employment is also commonly used to cover shortfalls in household food production, to meet specific needs, and to take advantage of surplus labor or capitalize on unique money-making opportunities. (e.g., Lewis, 1979; Reardon et al., 1992) Typically, off-farm employment is sought during the dry season for periods of three to nine months. Multi-year sojourns, *exode rural*, are also common (see DRSPR/OHV, 1991a), and involve both agricultural and non-agricultural labor. Common destinations for both types of off-farm employment are nearby urban centers, the capitol city, Bamako, and for those leaving on *exode*, several key international destinations. While in the past international opportunities were commonly sought, in recent years international travel has become less important as the domestic labor markets have improved and the international markets have declined. In some rural areas, the increasing awareness and concern about AIDS has resulted in a negative social stigma being attached to those who have migrated to neighboring countries, making it difficult for men to find wives upon their return (pers. com. Gnägi).

One of the most widely discussed and criticized (by the extension service) off-farm employment activities in the OHVN zone is gold-digging. For many individuals from villages along both sides of the Niger River in the southern part of the zone, the operation of placer mines is one of their most important dry-season activities. It's importance varies by location, with as many as 95 percent of the households in some villages reporting economic benefits (DRSPR/OHV, 1991a). Those involved in gold digging also vary by village. In one village, 75 percent of the young men are involved in digging, while in another village, gold digging occupies 90 percent of the women (DRSPR/OHV, 1991a). On a daily wage basis, women who work in the gold fields can earn wages comparable to those obtained from group field labor. Yet in gold digging, women can personally keep all of their earned wages, unlike in group labor, where wages often go into a group *cache* (Luery, 1989).

Household Economic Portfolio Areas[103]

Variances in the physical environment, proximity to markets, and access to reliable and affordable means of transportation are all factors that shape the economic opportunities and production constraints faced by households in different areas of the OHVN zone. One way of interpreting the varying patterns of household performances in the different areas is through an examination of the portfolio of activities in which households invest their resources. The portfolio concept is used here as a descriptive tool to illustrate the differences between the opportunities and constraints of the natural, social, and economic systems in various areas of the OHVN zone. The concept of household economic portfolios refers to the constellation of agricultural and non-agricultural, on- and off-farm economic opportunities in which households invest resources in meeting their consumption and economic needs:

> The idea of a household economic portfolio draws upon a conceptualization of household decision-makers as investors who allocate their scarce human, financial and physical resources according to perceived short- and long-term, low and high risks. Like those who play the stock market in industrialized societies, rural producers constantly scan the investment horizon to identify the best ways of allocating their resources to protect and improve their standard of living (Bingen et al., 1993:3).

---

[103] This section expands upon an earlier presentation of this material by the author in Bingen et al., 1994.

The term, first applied to households in the OHVN by McCorkle and Kanté (1986), is expanded upon and developed here into a set of descriptive regions depicting the major changes in opportunities and constraints facing households in different areas of the OHVN. Similar to farming systems research recommendation domains (e.g., CIMMYT, 1980), portfolio areas reflect the geographic range of distinct cropping systems (see Table 11) that correspond to the agroecological as well as economic/institutional conditions of the different areas. Unlike recommendation domains, however, which are generally limited to agricultural activities alone, the portfolio descriptions attempt to locate agricultural activities within the larger context of the entire range of household economic performances,[104] aspects of which have been outlined in preceding sections. This ability of research and extension organizations to identify the range of principle economic activities in specific areas is of critical importance to improving their ability to provide farmers in these areas with relevant assistance and services.

[104] This view is generally supportive of the argument calling for a fusion of farming systems research with household economic studies, as advocated by Low (1986).

Table 11. The Transition in Importance (Ha.) of Cereal Crops by *Secteur*.[105]

Secteurs (North to South)	Millet (ha.)	Sorghum (ha.)	Maize (ha.)	Rice (ha.)
Boron	12,200	3,853	80	-0-
Banamba	18,974	9,390	63	15
Sirakorola	14,300	7,763	240	94
Koulikoro	9,700	8,840	485	177
Kati	1,752	5,642	3,077	224
Gouani	2,194	5,350	1,211	124
Dangassa	2,075	4,805	1,366	463
Bancoumana	1,367	4,453	1,900	567
Oueléssébougou	2,194	4,255	597	265
Kangaba	1,044	3,365	3,116	1,908
Totals	65,868	57,516	12,135	3,837

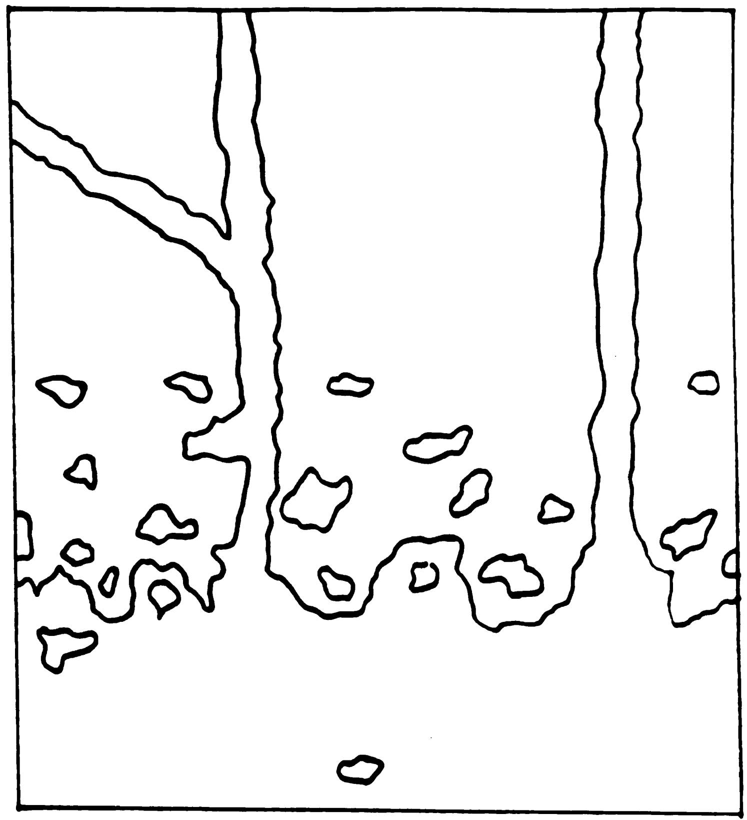
The level of precision in differentiating between portfolio areas is limited; it cannot highlight the unique characteristics of individual households and villages. However, it is far more detailed than regional generalizations that are based upon agroecological criteria alone. Because each portfolio area is a composite of production opportunities and constraints, each of which has their own geographic limits, the boundary lines between the different portfolios are necessarily vague. The similarity of conditions in each area begins to break down into broad transition zones, resembling, in many ways, the 'patches' of landscape ecology, where increasingly frequent pockets of households begin to have access to and are able to take advantage of new opportunities (see Figure 14).[106]

---

[105] Source: OHVN, 1992a.

[106] As suggested earlier, the exact portfolio of activities undertaken by any household, in any of the different portfolio areas, is most notably influenced by the size of its labor force (Toulmin, 1991; 1992; Koening, 1986a). Because of this and other

Figure 14. The 'Patchiness' of Conditions Along Portfolio Borders.[107]



The Far North Portfolio

Throughout much of the Boron and the northern half of Banamba *secteurs*, low and highly variable annual rainfall (<600 mm) strongly influences the range of household agricultural and other investment opportunities (see Figure 15).[108] Common to most of West Africa, farmers in the OHVN zone use a system of 'inner'

---

influences, inter-household differences within portfolio areas may actually exceed the differences between portfolio areas. However, while inter-household differences are fairly constant across all areas of the zone (i.e. wealthy and poor households), the specific constraints and opportunities identified within each of the portfolio areas have geographic limits (i.e. cotton production and the marketing of perishable fruits).

[107] Source: Hopkins, 1965.

[108] The northernmost portion of Boron *secteur*, with its extremely low rainfall, may constitute an entirely different set of opportunities that this research does not cover.

fields, fertilized with animal manure and household wastes, and 'outer' fields, managed under a fallow system, in order to maintain soil fertility and spread their production risks. The cultivation of short- and long-season local varieties of millet, and to a lesser extent sorghum, often intercropped with cowpeas (*Vigna unguiculata*), is a central feature of the Far North Portfolio. Beans grown in these associations are generally destined for use as fodder,[109] while households use separate fields to optimize the production of beans (for consumption) and other crops, such as fonio (*Digitaria exilis*), small parcels of dah (*Hibiscus spp.*) and henné (*Lawsonia inermis*). Farmers still rely upon peanuts,[110] often intercropped with Bambara groundnut (*Vigna subterranea*) and incidental millet plantings, as their main cash crop. There is a rising interest in producing sesame as an additional cash crop, but limited planting material and marketing opportunities have curtailed widespread cultivation.[111]

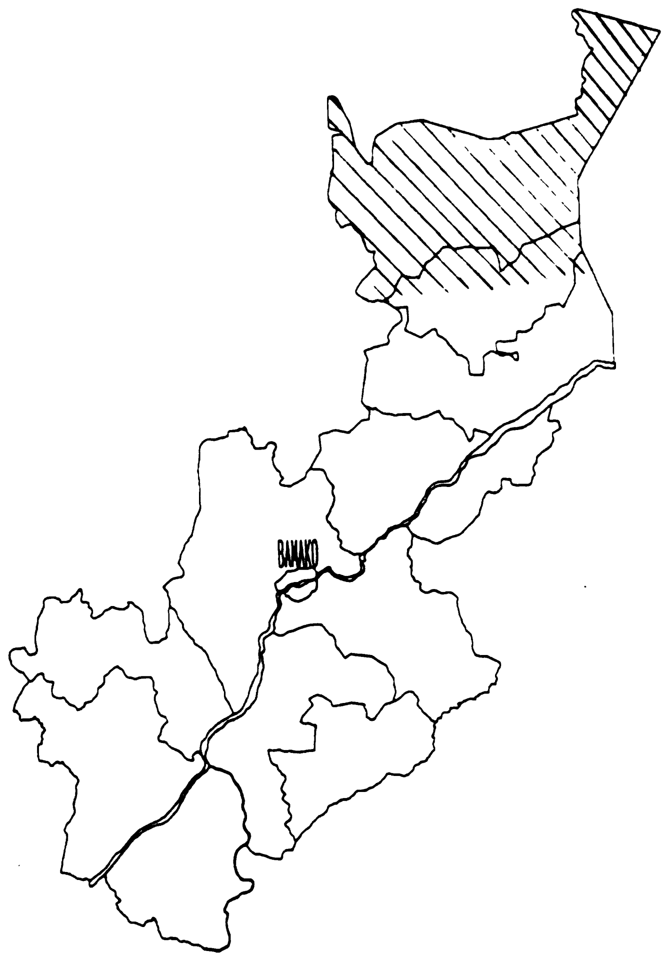
---

[109] As one farmer put it, these associations are used not because the beans are known to benefit the production of the millet, but because it is a way of getting something extra out of the field without hurting the production of the principle cereal crop. Dah, on the other hand, a crop commonly intercropped in cereal fields further to the south, is planted separately in the far North because of its noted negative impact on millet (possibly due to moisture competition).

[110] Related to their past association with the OACV, which promoted the cash cropping of peanuts.

[111] Sesame is grown as a traditional crop throughout Mali and neighboring countries. As in the past, the OHVN is currently attempting to create a market for sesame for the benefit of farmers in the northern areas of the zone who do not have a major cash crop. Difficulties in securing favorable market prices, however, have limited the success of this effort.

Figure 15. The Far North Portfolio Area.



Farmers utilize a mixture of traditional, adapted, and 'improved' cultural practices in their cropping systems. Farmers estimate that animal traction is used to cultivate roughly 70 percent of land in this area; the rest is cultivated by hand labor. Although bullocks are preferred, the use of horses as draft animals is common, and dominant in some areas.[112] Other than the plow, use of animal-powered implements is low. Cultivation of most fields begins after the first rains, although some farmers

[112] Donkeys are only infrequently used as draft animals in this area, although farmers in other parts of Mali and neighboring Sahelian countries commonly use donkeys as draft animals.

and will plow and plant before the rains begin. Most fields are prepared using ridges, which help conserve soil moisture and deter erosion, even though farmers are much less concerned with soil loss than with keeping young plants down slope from being buried. On steeper slopes, farmers create narrower fields and align their furrows down slope to facilitate the quick evacuation of excess water. This helps to eliminate the risk of water, ponded during intense downpours, breaching a ridge and cascading down slope, causing extensive damage. The use of ridges requires fields to be hand planted, because the available mechanical seeders cannot be effectively operated along ridges. The main cereal fields are generally hand weeded twice, except in low rainfall years when an additional weeding is performed to reduce moisture competition and increase the chance of a harvest. As noted among farmers elsewhere in the OHVN zone, and region (e.g., Gubbels, 1992), the use of traditional soil conservation techniques such as rock and vegetative barriers has fallen into disuse, possibly due to the influences of plowing.

In association with their field crops, farmers retain and manage extensive agroforestry arrangements in their fields. The use of *Acacia albida* for fertility management is recognized, but not practiced in all locations in this area. Although less dense than the classic 'agroforestry parklands' found further to the south, farmers protect a variety of income-generating tree species in their fields. Common species found in fields include baobab (*Adansonia digitata*), néré (*Parkia biglobosa*), duguru (*Cordyla pinnata*), and desert dates (*Balanites aegyptiaca*). The change in rainfall patterns during the past several decades has led to widespread mortalities and the disappearance of several species in certain localities, with the concomitant loss of their high value products and beneficial contributions to natural resource management.

The investment in livestock plays an extremely important role in household financial security, where animals serve as 'walking banks.' Although some smallstock (sheep, goats), young cattle and draft animals are kept in the village, most other livestock are placed under the care of Peul herders and taken *en brousse*. This relationship between the Peul and farmers, common throughout the OHVN zone, is based on the complementary management specializations of herders and cultivators, allowing households to diversify their investments into both crop and livestock production. Herders and agriculturalists also enter into additional reciprocal relationships through the exchange of access to water and crop stubble for manure.[113]

In addition to the cash earnings from peanuts and surplus millet production, farm households, and especially women, reported relying upon a range of less well-known agricultural products as important sources of revenue. Some of these include the sale of *A. albida* seed pods as fodder, karité butter, henné dye, wild and cultivated fruits (including those from karité, baobab, tamarind, duguru, among others), gum arabic (*Acacia senegal*) (gum from *Acacia seyal* is also collected), fresh milk, meat and hides, fresh vegetables, and various leaves used in sauces. Households sell some of these products fresh, but process others (karité soap, henné dye and dried fruits and sauce leaves) by fairly simple (mainly fermenting and drying) and, as in the case of karité, sometimes time-consuming techniques. Women in this area have begun to experiment with vegetable production in small-scale market gardens, with the assistance of NGOs; market proximity and water shortages, however, limit current opportunities. As found throughout the OHVN zone, households in the Far North also selectively pursue various other types of small-scale, skilled and unskilled income-

---

[113] Toulmin (1992) further details the relationship between cattle, wells, manure, field productivity and Bambara household size.

generating activities, including honey and wood gathering, carpentry, blacksmithing, butchery, basket-making, petty commerce, cloth making and dyeing, and well-digging.

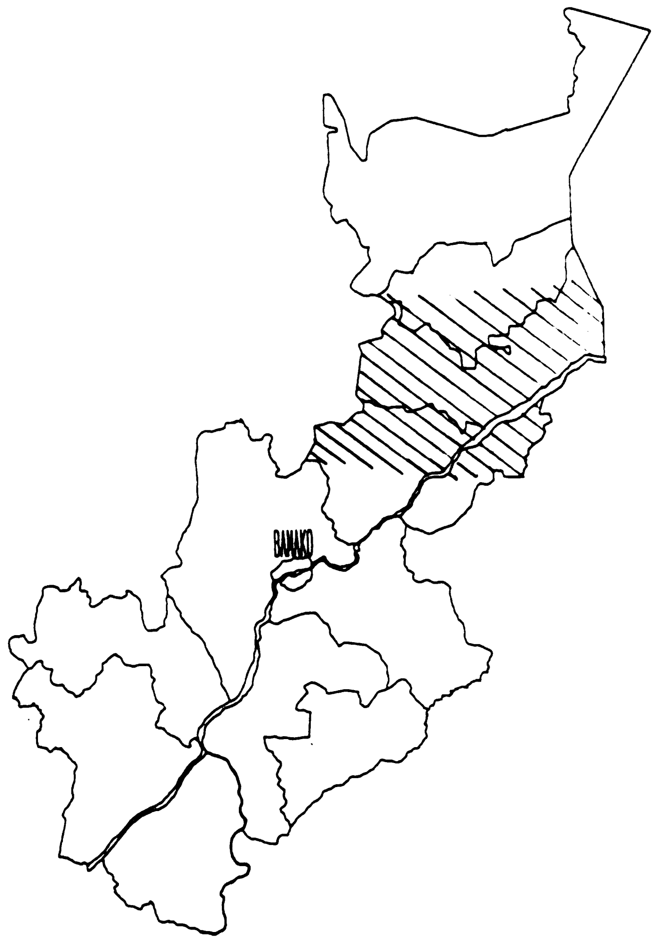
The Near North Portfolio

The Near North portfolio occupies an area extending from the southern portion of Banamba *secteur* into the northern part of the Koulikoro *secteur* (including all of Sirakorola *secteur*)(see Figure 16), with annual rainfall averaging between 600mm and 800mm. Due principally to the higher rainfall, this area supports more diverse cropping systems and associated economic activities. Local varieties of millet and, increasingly, sorghum remain the principle cereal crops which, as in the Far North, are often intercropped with an incidental bean crop.[114] Fonio, which provides relatively high yields on the infertile fields where it is typically planted,[115] commands a high market price throughout the year and is cultivated for both home consumption on important occasions and for sale. Farmers are also interested in the economic possibilities offered by sesame production but, as yet, access to seed stock and market guarantees have been limited and strictly controlled by the extension service.

[114] Improved cereal varieties, introduced through the FAO Seed Multiplication Program and OHVN extension efforts, have not been widely adopted. Farmers reported that their yield performance and taste do not compare with local varieties.

[115] Fonio is generally planted as the last crop in a field before it is fallowed when the soil has become too impoverished to produce another millet or sorghum crop.

Figure 16. The Near North Portfolio Area.



The higher rainfall allows farm families to complement their staple cereal and legume production with the garden-type production of several vegetable and various leaf crops, along with an 'insurance' crop of manioc. Farmers also use these gardens as nurseries for henné, which is then transplanted into the main fields where it remains for up to eight to ten years. Henné dye is an important source of dry-season income. Pourghère (*Jatropha curcas*), and another unidentified species, is commonly used as a living fence along field boundaries. In addition to its utility in helping to control livestock, this plant has medicinal value and is widely used in traditional soap production.[116]

Significant soil and climatic variations in this area create a variety of localized production environments capable of supporting a range of unique investment opportunities, including the limited cultivation of maize, cotton, and even small quantities of rice. Locally grown mangos are found in the Banamba market, and other high-value tree products are available from the extensive agroforestry associations of néré, baobab, dugura, desert dates, karité (*Vitellaria paradoxa*), tamarind (*Tamarindus indica*), nsaban (*Saba senegalensis*), and other species. The limited production of specialty crops includes sugar cane, sweet potatoes, and watermelon. In addition, a growing number of women are producing dry-season vegetables for sale in local markets and home consumption.

Additional income-generation opportunities arise from the value-added processing of numerous agricultural products and by-products: karité butter; the preparation of soumbala from néré seeds; henné dye; mats made from the stalks of long-season sorghum and millet; and cord made from dah fiber. Natural resource extraction, through fuelwood cutting, honey collection, traditional medicines, and non-timber products gathered from the dry-land forests, also offers important sources of revenues to certain households, as do sales of manure for use as fertilizer.

Many households rely upon earnings from dry season employment elsewhere in the country. International travel in search of employment within the region is reportedly on the decline, although labor migration (*exode rural*) is common, especially during years of poor rainfall to compensate for production shortfalls.

---

[116] The oil extracted from *J. curcas* seeds also has several industrial applications and can be used as a fuel in running diesel engines (Henning, 1989; 1992; Jones and Miller, n.d.).

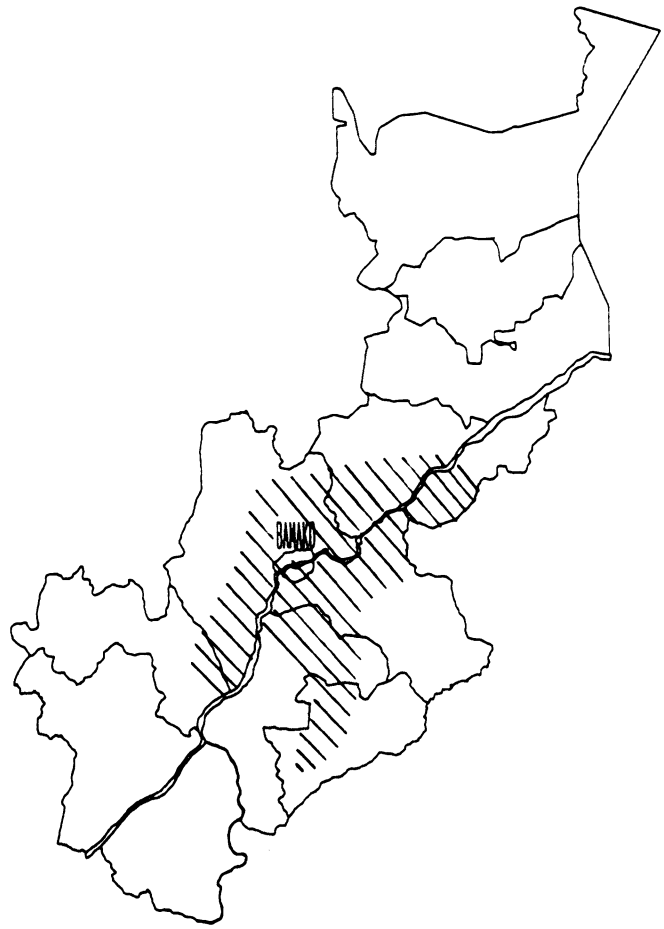
The Bamako Central Portfolio

The generally favorable annual rainfall of this area (800-1,000mm) permits the production of a wide variety of fruit and vegetable crops, in addition to staple cereals, maize, and legumes. More important, easy access to the major roads serving Bamako encourages a wide range of agricultural and off-farm activities geared towards exploiting Bamako market opportunities, which affect communities as far away as Koulikoro to the north and Oueléssébougou to the south (cf. Akasaka, 1973)(see Figure 17).[117] Some of these niche markets include fodder production for urban livestock, market-oriented animal production, eggs, milk, honey, fresh vegetables, and even chew sticks (a toothbrush substitute), among others.[118] Urban business also offers significant seasonal off-farm employment opportunities.

[117] This area covers portions of several OHVN *secteurs* (eastern Kati, southern Koulikoro, northern Bancoumana and Dangassa, and parts of western Gouani). The significantly different agroecological conditions of the Mandingue plateau area (mainly Kati *secteur*) may be the basis for identifying a separate portfolio.

[118] The activities described as part of the Bamako portfolio are separate from the very small, but intensively managed, urban market gardens found throughout Bamako proper. These gardens provide a large share of the fresh vegetables consumed in Bamako. Because of the highly specific nature of these urban garden systems, plus special land tenure issues, they constitute a special sub-set of the Bamako portfolio (see Diarra, 1975; Swindell, 1988).

Figure 17. Bamako Central Portfolio Area.



Absentee landlords, including both government officers and traders from Bamako, are some of the major investors in crop and animal production in this area. Their small- to medium-scale plantations and agroforestry systems are widespread throughout the greater Bamako area and along the major roads leading out of the capitol.[119]

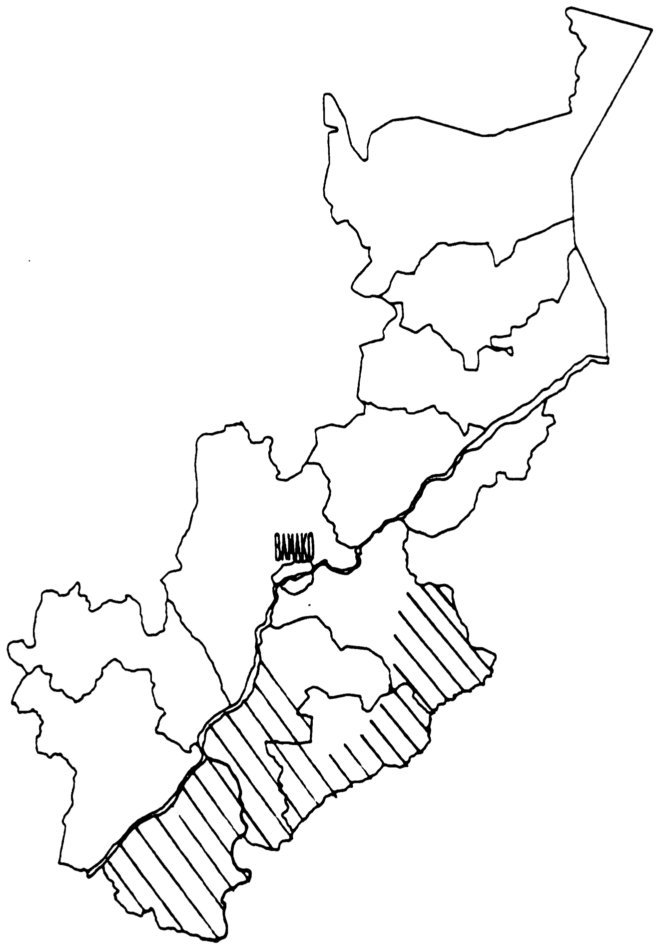
[119] Major investors in the early spread of these plantations were Malian civil servants who were given long-term leases to land that they in turn hired others to manage (Jones, 1976).

The Southeast Portfolio

In the *secteurs* of Gouani, Oueléssébougou and the central and southern parts of Dangassa, cotton production has a dominant influence on the production decisions of most farm families. Annual average rainfall in excess of 1,000 mm permits the cultivation of a broad range of crops. To meet consumption needs, farmers rely upon their numerous local varieties of sorghum (up to a dozen varieties in some localities), millet, African rice (*O. glaberrima*) and maize. Although millet is of declining importance among farm households in the higher rainfall areas (due, in part, to high rates of bird predation), farmers still cultivate short-season varieties, as well as short-season determinant varieties of maize, as protection against poor rainfall years. The extent of maize cultivation in recent decades has risen significantly, largely in response to a decrease in flood levels which has prohibited extensive rice cultivation.

In addition to these staple cereals, household production includes beans, peanuts, Bambara groundnut, and gourds (calabash, *Lagenaria siceraria*, and edible varieties) in their cropping rotations. Small vegetable gardens, managed by women, produce numerous condiments, while men often maintain a small garden of an 'insurance' manioc crop, as well as an annual tuber crop such as yams (*Dioscorea spp.*). Yams are an important food and economic crop in some communities around the Oueléssébougou area. Gardens in this area also supply large quantities of tomatoes, peppers, okra, eggplants and other vegetables to buyers for the Bamako market. Many families also plant watermelon as a late season cash crop.

Figure 18. The Southeast Portfolio Area.



Irrigated rice and dry-season tobacco production is possible for those living near the Niger River.[120] Products from the extensive karité parks interspersed with néré, tamarind, raisonier (*Lannea microcarpa*) and other species are widely used to meet both consumption and cash needs. Bee keeping is another prominent activity in this portfolio. With a secure and fairly profitable money-making opportunity through cotton production, off-farm non-agricultural activities play an important, but less vital, role for the majority of households in this portfolio.

---

[120] Throughout the OHVN zone, villages located on both banks of the Niger River have distinct production opportunities which should be considered as a separate 'River Portfolio,' although insufficient data prevents this study from accurately describing the characteristics of the area.

Crop rotations are used to help manage soil fertility levels and weed pressures, and reflect the importance of cotton, which is typically grown in the most fertile fields, to the household production system. Maize generally follows a cotton crop in order to take advantage of any residual fertilizer, and a peanut rotation is used in cereal fields to disrupt the emergence of serious weed infestations. Land pressure in some areas has begun to restrict women's access to fields.[121] Women generally tend to utilize a nearly universal cropping pattern of peanuts, intercropped with Bambara groundnut, and over planted with millet and okra. Most villages in this portfolio area are situated near low-lying areas, where women engage in rice cultivation.

The Southwest Portfolio

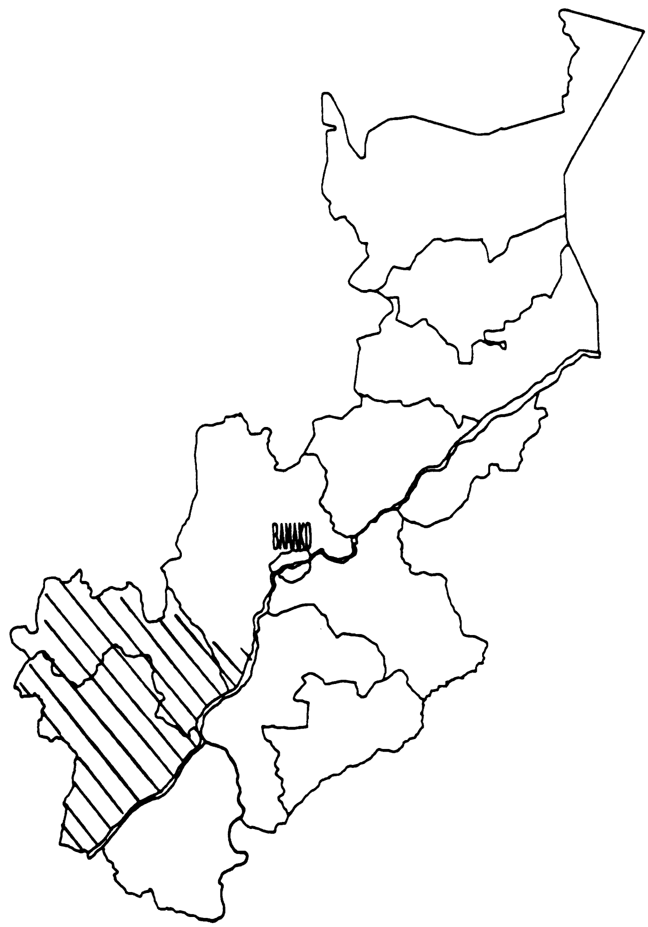
Throughout most of the Bancoumana *secteur* and all of Kangaba *secteur*, farmers manage highly diverse cropping systems divided between lowland and upland fields. Intensely integrated agroforestry systems, including plantations of mango, citrus, guava, banana, and other perennial fruit species, intercropped with cereal and vegetable crops, are common for many households.[122] In addition, polders constructed during the colonial era, and low-lying areas improved with check-dams constructed of rock and wire-mesh gabions, allow extensive production of aquatic and floating rice varieties (*Oryza spp.*). Upland rice is commonly planted in fields that lead down to these flooded areas.

---

[121]In some areas women are able to secure only *usufruct* rights to their husbands' fields during the peanut rotation in the cropping cycle.

[122] These highly integrated garden plots typically contain a wide variety of fruit tree species and vegetable crops oriented towards market sales. These plots, planted near the village, are usually established as a farmer gets older and represent a shift in production strategies.

Figure 19. The Southwest Portfolio Area.



Management strategies are based upon the extensive use of local varieties. For example, in crop rotations, varieties are often selected for their tolerance to weed pressure. Rice producers in particular draw on more than a dozen local varieties to deal with both weed pressures and anticipated water depth. In some locations, varieties of traditional 'red' rice (*O. glaberrima*), selected for their weed resistance, are used as the last crop in the rotation in much the same way as fonio is used when soils become impoverished. Other varieties of 'red' rice are used in rattoon culture, selected for their ability to be harvested three times during the growing period.

The declining precipitation over the past 25 years has precluded the ability of farmers to double-crop their fields, and has caused many of the polders and flood areas to no longer receive sufficient quantities of water necessary for maintaining desired production levels. In some locations, cotton production has partly compensated for the decline in rice cultivation. However, since cotton is managed solely by men, this change in cropping patterns has negatively affected women, who previously benefited from rice production.

As elsewhere in the southern *secteurs*, Peul herders, driven southward during the droughts, have settled near some villages. In most cases these herders have entered into reciprocal relationships with agricultural villagers, managing village cattle in exchange for rights to cultivate land and other payments.

Most families manage their own nurseries within their garden plots, using wells for dry season watering. Some farmers have significant grafting expertise, which they use in developing their own varieties for both personal use and sale. Pourghère fencing is common, and the seeds are also used by women for local medicines and soap production. As found elsewhere in the zone, farmers rely upon a variety of traditional technologies to protect their crop yields. 'Bitter' herbs, leaves of the neem tree (*Azadirachta indica*), smoking, and ashes are commonly used as protective agents in crop storage.

In the absence of a strong orientation towards a single cash crop, households look to a wide range of income-earning opportunities, from specialty crops such as okra and onions, to a number of non-farm and non-agricultural activities. Commerce along the Guinea frontier and gold digging are among some of the more important and common activities. In addition, farmers with specific skills, such as tree grafting, seek seasonal employment on private plantations near Bamako.

Chapter Summary

The dynamic nature of the physical and social environments within the OHVN zone requires that farmers maintain an adaptive outlook in managing their agricultural activities. Unplanned fluctuations in labor availability, human and animal health, the state of equipment repair, market prices, among numerous other influences, require endless adjustments in farmers' management plans. When set against the backdrop of a highly variable climate, disparate soil fertility levels, as well as disease outbreaks, predation and weed pressures, farmers rarely, if ever, face the same set of annual production decisions.[123]

The need for adaptive management responses extends well beyond agriculture, and, in fact, permeates the very nature of household decision-making concerning the investment of scarce individual and household resources. To moderate risk, farmers spread their resources across a diverse range of income-generating activities, the array of which changes each season in response to the prevailing constraints and opportunities. The widespread influences of certain environmental conditions, marketing opportunities, and transportation infrastructure, among other factors, provide households across large areas with fairly similar sets of opportunities. By examining the portfolio of enterprises exploited by households in different locations, at least five, and possibly as many as eight, distinct portfolio areas can be described in the OHVN zone.

These concepts--agricultural performances, household economic diversification,

[123] It has been suggested that the forces of natural selection alone are enough to require farmers to continually seek out and develop new management adaptations over the long term (Biggs and Clay, 1981). This view is supported by many of the major environmental changes noted in Chapter III that have occurred in the OHVN zone in recent decades.

and economic portfolio areas--provide useful tools for better understanding farmers' behavior in difficult environments and hold valuable lessons for external agencies attempting to assist farmers and farm households in the area. By adopting the underlying principles of farmers' individual and household behavior--adaptiveness and diversification--as their primary orientation in developing new technologies and support services, external agencies could enhance their effectiveness in providing the types of needed and truly beneficial assistance that households require in meeting the challenges of a wide range of conditions. To assist the research and extension programs in taking a more responsive approach to farmer development, the next chapter explores the issues of what farmers do and do not know, how they develop new management responses, and communicate these to one another.

CHAPTER V. Farmers' Knowledge, Communication, Innovation and Experimentation

Farmers' ability to undertake the adaptive performances and exploit the wide range of economic opportunities described in Chapter IV is based largely upon their extensive knowledge of both the physical environment and biological processes, as well as their ability to develop, communicate, and adapt new techniques in managing these systems. This chapter describes some of the major features and attributes of farmers' agricultural knowledge. Findings are then presented on the local patterns of communication and the acquisition of information and materials involved in local, farmer-driven change. A number of social factors are identified that strongly influence both the context within which an individual's observations and learning experiences take place, and the types of communication channels to which different individuals have access and use in exchanging information and materials with one another. The chapter concludes with a look at farmers' innovations, including the types of experimental processes used, and examples of concerns that farmers are attempting to address in their production systems. An improved understanding of each of these aspects of the informal system--farmers' knowledge, communication, and innovation--are critical if research and extension are to draw upon, collaborate with, or contribute to the informal system in the generation, refinement and communication of new agricultural technologies.

Farmers' Environmental Knowledge

Farmers' environmental and ecological knowledge is of central importance to agriculture and natural resource management. Such knowledge serves as the foundation upon which households select, adapt and reject technologies, and allocate scarce resources in meeting their various production objectives. Many of the ecological and economic rationales of traditional farming systems have been documented (e.g., Brokensha et al., 1980; Francis and Sanders, 1978; Kessler et al., 1992; Kremer and Sidibé, 1991; Rao and Wiley, 1980; Richards, 1985; Warner, 1991; Warren et al., 1989), and are becoming better understood through studies on various agroecological aspects of farmers' production systems (e.g., Alteri, 1987; Alteri and Hecht, 1990; Carroll, et al., 1990; Francis, 1986; Gliessman 1990; Vandermeer, 1989; among others). However, less is known about the specific environmental and biological knowledge held by farmers and how they use this knowledge in making their management decisions (e.g., McConnell, 1993; Sharland, 1991)(see Appendix C). In Mali, and across the Sahel, rural people's differentiation of environmental niches (e.g., marshes, flood plains, uplands, plateaus), indigenous soil typologies, and knowledge of the local flora and fauna,[124] illustrate the degree of specificity, as well as the extent, of rural people's detailed knowledge of their production environments (e.g., Cross and

[124] In the Bambara creation myth, the combination of the four base elements (earth, water, air, and fire) "forms a framework in which an identification of 968 forms of animal life and as many or more plant forms are made" (Zahan, 1979:4). Western studies on the biological diversity of Malian fauna have identified 950 species of mammals, fish (in the Niger basin), reptiles (data on amphibians is lacking) and birds (Warshall, 1989; WRI, 1994), a figure remarkably close to that of the traditional assessment of biological diversity.

Barker, 1991; Niamir, 1990; Warren, 1992).[125] An improved understanding of the structure and organization of farmers' local environmental knowledge is still needed before more systematic efforts can be initiated in engaging this vital resource in formal research and development processes.

Farmers' Management of Microenvironments

One of the hallmarks of agriculture in CDR environments is farmers' use of their detailed agroecological knowledge in exploiting what Chambers (1991) refers to as 'microenvironments.' As elaborated in Chapter III, neither all farmland under the control of a community, nor all land within a single field, has equal agricultural potential, a fact not lost upon farmers who use their generic and specific knowledge in adapting their practices to the local environmental variations.

Farmers select crops and individual varieties to match general soil types and moisture regimes (cf. McConnell, 1993; Moseley, 1993; Stoop, 1987b; Matlon, 1980, among others), as well as to match individual field conditions, including levels of soil fertility and weed infestation (cf. Richards, 1986). Farmers involved in rice cultivation must also select varieties in anticipation of water depth (cf. Richards, 1985; Harlan and Pasquereau, 1968). In the southern and central *secteurs*, farmers sometimes use the humid conditions found beneath karité and néré trees to plant crops of tomatoes and peppers (*piment*), while in the far North these same microsites are at times used to support limited plantings of moisture-demanding sorghum (with the surrounding

[125] These examples are similar to the general observations of rural people's environmental knowledge that have been reported elsewhere in Africa (e.g., Allen, 1965; de Schlippe, 1956; Knight, 1974; Reij, 1991) and among rural peoples around the world (e.g., Bentley, 1992; Conklin 1957; 1972; Kee, 1981; King, 1911; Ruthenberg, 1980; Wilken, 1987).

areas planted to millet)(cf. Cross and Barker, 1991; SPORE, 1993). Small corner plots with unique hydrology, hedge rows, and boundary areas are all used for both specific production activities and as reservoirs of wild plants maintained to meet various household needs. Specific sites, such as perched basins on the hardpan plateaus that retain water during the rainy season, are used to support limited rice production (e.g., Moseley, 1993), while the nutrient-rich and moisture-retentive soils near active and abandoned termite mounds are used for the cultivation of specific crops or varieties. Within the context of the household production system, farmers' knowledge about, and their use of, these and other microenvironments provide an important set of economic opportunities that farmers exploit on an individual and household basis.

Farmers' Taxonomic and Descriptive Knowledge

Farmers' descriptive knowledge and systems of classification are some of the most studied aspects of local ecological knowledge (e.g., Aubert and Newsby, 1949; Bradley, 1983; Diallo, 1991; Guillet et al., 1995; ICRISAT, 1989; Inglis, 1993; Johannes, 1989; McConnell, 1993; Moseley, 1993; Niamir, 1990; Pawluk et al., 1992; Richards, 1979; Sikana, 1993; Warren, 1992). Among farmers, a general understanding of the local systems of classification is broadly shared, while knowledge of the more specific details of individual objects within these classifications is not equally shared. The breadth and qualitative depth of individual taxonomic knowledge is closely related to the range of personal experiences involved in managing and using different resources in specific ways. Such knowledge is most strongly influenced by the type of activities that each person regularly performs, and their length of association with specific resources. Children, for example, who gather wild crops from the village's communal lands, possess a different 'cognitive map' of these areas than do elder hunters who have used these same areas for tracking game over several decades. These more detailed aspects of individual knowledge that are gained through personal experience tend to be fragmentary, highly personalized, and under continual construction (cf. Scoones and Thompson, 1992).

Within the OHVN zone, as with much of West Africa, farmers' indigenous soil taxonomies have received a great deal of scrutiny. Although farmers possess general knowledge of local soils and those of neighboring areas, gained through first-hand experience, travel, or discussions with other farmers, the more detailed knowledge of specific soil attributes important to crop management tends to be limited to those soils under each farmer's management.[126] Such an experience-based view of knowledge is illustrated in the existing data on indigenous soil taxonomies, presented in Table 12. Not surprisingly, the most detailed taxonomies have been recorded by researchers who contacted the largest number of farmers from the widest range of locations (e.g., Dabin, 1951; Moseley, 1993). A study conducted in Zambia (Sikana, 1993) reached similar conclusions where, on average, farmers were able to name and describe in detail at least three soil types, generally those that they farmed. Beyond this, the level of knowledge became increasingly vague, with farmers possessing general knowledge of several additional soil types, but unable to identify many of their specific attributes. This finding underscores the importance of differences in individual knowledge and has significant methodological implications for recording and accessing local knowledge,

---

[126] In general, local classification systems, such as soil taxonomies, are themselves often not organized in a highly systematized form, where all objects are measured against some fixed, or absolute, scale and ordered in ascending or descending fashion. Rather, indigenous systems of classification tend to be structured along comparative or relational lines, where objects are defined by their relation to one another, and not to some separate scale.

as well as for establishing partnerships with farmers.

Table 12. Indigenous Soil Taxonomies in the OHVN (Djitoumou) and Segou Areas.

Soil Texture[127]	Segou Area (Aubert and Newsky, 1949)	Segou Area (Dabin, 1951)	Djitoumou Area (Moseley, 1993)[128]	Djitoumou Area (Diallo, 1991)	Djitoumou Area (McConnell, 1993)
*Sand w/ gravel			Bele	Bèlè	Bele
*Loamy-sand	Tien-Tien[129]		Cencen	Cencen	Cencen
*Sandy-clay-loam		Séno	Daba		Daba
	Séno				
		Séno-fing	Bira	Bira	
*Clay-loam					
		Danga	Fugagwili	Fuga-gilin	Fugagwili
	Danga				
	-Danga-blé		Gwili		
	-Danga-fing				
		Danga-blé	Farado/Tafa		Farada
		Danga-fing	Bogo		Bogo
		Dian	Bale		
	Dian				
		Dian-péré	Babogo		
*Silty-clay	Dian-péré				
		Moursi	Fara/Fala		Fara
	Boi			Fala	
		Boi			
	Mourcis				
		Boi-blé			
		Boi-fing			

[127] Based on texture analysis of these soils by the *Laboratoire des Sols Sotuba* (Diallo, 1991; Moseley, 1993).

[128] The data collected in assembling this taxonomy also contained eight synonyms for the soils listed, as well as three additional non-arable soils or uncorroborated soil groups, which have been omitted.

[129] Tien Tien and Cencen are the same soil type, rendered distinct by the lexicon used by the different authors.

The studies shown in Table 12 clearly identify two distinct soil taxonomic regions,[130] while the observations within each of these regions highlight the differences in detail obtained by the different researchers.

Soil texture and structure are the primary characteristics used by farmers in differentiating between soil types in their indigenous taxonomies[131] (e.g., Aubert and Newsky, 1949; Dabin, 1951; Diallo, 1991; Moseley, 1993; Sikana, 1993). These characteristics often correspond to other attributes, such as the soil's position in the landscape, parent material, or coloration, that are important in indigenous classifications (e.g., Warren, 1992; Bradley, 1983). In his study, Bradley (1983) analyzed collections of 120 and 178 soil samples, classified by farmers into indigenous categories, for 13 attributes (chemical, structural) measured through laboratory testing. His findings clearly indicate that the majority of indigenous classifications possess distinct chemical and physical properties (cf. ICRISAT, 1989). Although some degree of latitude was present in the placement of soils into the different categories by each farmer, the greater tendency was for the specific attributes of the different categories themselves to shift, moving towards the dominant soil quality of the area (Bradley, 1983). For example, in areas with predominantly sandy soils, all categories would contain a higher sand content than the same soil categories found in regions with an overall lower sand content (Aubert and Newsky, 1949). This supports the observation that indigenous classification systems are "relative and site-specific rather than

[130] Two studies (Aubert and Newsby, 1949; Dabin, 1951) were conducted just north of Segou, while the remaining three studies (Diallo, 1991; McConnell, 1993; Moseley, 1993) were conducted in the Djitoumou area of southeastern OHVN. These two areas are, in fact, representative of the two distinct soil regions described in Chapter III.

[131] Similar to the texture triangle of sand-silt-clay used in the USDA system of soil classification.

absolute and universal" (Sikana, 1993:16; cf. Aubert and Newsky, 1949; ICRISAT, 1989).

A second important attribute of indigenous soil taxonomies is that "farmers' systems of categorizing soils...[are]...oriented towards practice...Farmers are most interested in features of topsoil...[that]...influence important management decisions" (Sikana, 1993:15; Pawluk et al., 1992). For farmers in the OHVN zone, low moisture retention and fertility are the two most prominent soil-borne constraints on crop production. The indigenous classification systems, based upon texture and structure, are able to accurately represent both of these characteristics. The macro and micro pore structure of a soil largely determines its moisture retentiveness; soil structure and texture are also related to the proportions of clay, silt and sand, and the presence of soil organic matter. A high clay content in the surface horizon, especially montmoullorite-type clay, represents a higher capacity to hold nutrients in the soil profile where plants can access them. By contrast, in highly leached soils, and those without appreciable clay contents (or the appropriate type of clay) in the upper horizons, the nutrients are concentrated in the soil organic matter, thus making soils with the highest organic matter content the most fertile. Farmers in the OHVN zone use their knowledge of these different soil properties in determining where to plant specific crops and varieties, and in deciding what management action to take, such as how long to place a field in fallow.

A third attribute of indigenous taxonomies is that they not only tend to reflect the most limiting factors affecting production decisions, but they also tend to be based upon the more easily observed characteristics of these resources. For example, acidity and aluminum toxicity, which are widely prevalent in the OHVN zone (e.g., Diallo, 1991; Moseley, 1993) and can significantly affect the yields of certain crops, are not well recognized in indigenous classification schemes, such as those examined by Bradley (1983). These soil features are relatively 'invisible,' not easily linked to the observable characteristics of the soil type, and their influence on crop performance is easily masked by other more obvious stresses (such as moisture availability). Thus farmers do not recognize these 'invisible' features as important variables in crop production.[132] This phenomenon, as explained by Bentley (1992), is based upon the following "two principles: ease of observation (or conspicuousness), and cultural importance (or perceived importance)" (Bentley, 1992:10). Acidity certainly ranks low on observability, particularly when it tends to be a general condition of the majority of soils in an area, as is the case in the OHVN, and may even rank low on perceived importance if it can not be separated from other influences and directly linked to crop performance. In a study of farmers' entomological knowledge in Central America, Bentley (1992) notes that even insects of major importance to agriculture, such as parasitic wasps that help control populations of serious pest species, are accorded little attention by farmers because their actions are inconspicuous and rank low in perceived benefits. This conclusion clearly highlights some of the limitations of local knowledge systems, and supports both the observation that 'what farmers don't know can't help them' (Bentley, 1989; 1993), and the need for integrating the informal and formal knowledge systems.[133]

---

[132] Not surprisingly the principle cereal crops, millet and sorghum, indigenous to West Africa, are tolerant of acidic soils, and in the case of millet, can stand high levels of soil aluminum (NRC, 1995)(although at very high levels yields are affected (ICRISAT, 1984). This is not the case for maize or many of the other vegetable crops, which are more recent introductions into the region.

[133] In another example, it can safely be said that farmers throughout the world are often unaware of the magnitude of their erosion problems. In a study conducted in the U.S., less than two percent of farm managers, and none of the land owners, identified severe erosion problems, whereas the Soil Conservation Service identified 82 percent

Farmers' Knowledge of Agroecological Processes

Farmers' environmental knowledge extends well beyond descriptive and categorical systems, to include an appreciable understanding of important biological and physical processes. For example, farmers are well aware of the fluctuating nature of soil fertility, depleted through cultivation and restored by crop rotations involving nitrogen-fixing legumes, the addition of organic matter, chemical fertilizers, or fallow.[134] Following the climatic changes that began in the late 1960's, and the rapid increase in rural population levels in many areas, farmers in the OHVN zone and across the Sahel have noted a general decline in the productivity of their environments (e.g., Cross and Baker, 1991; Gubbels, 1992; McCorkle et al., 1988). In some areas, farmers have linked a decline in soil fertility to specific changes in their management systems, such as the reduction in fallow length, or the increased use of the plow. Farmers in the major cotton producing areas of the OHVN recognize the negative impact of cotton production on their soils in terms of increased soil erosion (cf. Moseley, 1993). Farmers often describe these processes in terms that are different from, but parallel to, Western systems of understanding, often referring to the

---

of the farms as having major erosion problems (Batie, 1983). In Mali, soil erosion rates calculated in the southeastern portion of the OHVN zone present a level of seriousness that far exceeds farmers' perceptions of threat (e.g. Bishop and Allen, 1989; Day, 1989; van der Pol, 1992).

[134] Interestingly, farmers value chemical fertilizer the least in restoring soil fertility, especially in the case of combating invasions of *Striga spp.*, which is most prevalent in infertile fields. Use of a legume rotation, fallow, or, when possible, the addition of animal manure, were all considered more effective than the use of chemical fertilizer in combating this major parasitic weed. This may be partially explained by the method of application of the different fertilizers. Organic fertilizer is typically broadcast over the field before planting, whereas purchased inorganic fertilizers are generally applied to individual plants/rows well after emergence (once it is obvious that the plants will survive), by which time striga may already have established itself (see Riches et al., 1993).

'tiredness' or 'oldness' of land with declining nutrient stores. While at times this has been misconstrued as evidence that farmers are ignorant of the effects of soil erosion, archeological evidence from sites across Africa indicate that farmers have a history of using soil and water conservation measures that dates back several centuries (e.g., AZANIA, 1989; Reiji, 1988; 1991).[135]

As in the case of soil typologies, much of rural people's knowledge regarding biological and physical processes appears to be based upon those features that are readily apparent, e.g., in the form of a causal relationship, and linked to the principle limiting factors within the production system. Women farmers in the southern part of the OHVN zone, for example, when asked if they recognized any positive benefits of their intercropping pattern (a nearly universal, dense association of peanuts, Bambara groundnuts, millet and okra), lamented the lack of benefits, stating that they only used intercropping practices because of the scarcity of land--they would need more land in order to grow the same amount of each crop separately. While they did not view it as beneficial, it is obvious from their response that these women recognized the 'over-yielding' potential of intercropping systems.[136] In this instance, the benefits of intercropping were not interpreted in terms of yield, but rather in terms of the women's most limiting resource--land. Although these women did not acknowledge it as such,

---

[135] Farmers in other areas have referred to the appearance of 'wrinkles' caused by erosion as another sign of a site that has grown 'old' (Jungerius, 1985), and report the 'growth' of stones in fields where the soil has washed out, leaving the rocks behind. In villages of the OHVN zone where farmers have been encouraged to adopt the use of rock lines, farmers maintain that this is a traditional practice, even though it is not currently in use. Farmers in the southern areas reportedly come across abandoned stone lines as they bring fields out of long fallow (Moseley, 1993).

[136] Through direct facilitation and a more complete exploitation of the available resources, intercropping systems are often said to 'over-yield,' referring to their ability to produce more on a per-unit basis than if the same crops are grown in separate mono-culture stands.

they obviously understood that more crops could be grown through associations in a given parcel than through mono-cropping. Male farmers in the same area, who are less constrained by land availability (men typically control land allocation), assert the positive benefits in terms of yield resulting from certain associations and rotations involving cereal crops and legumes. Similarly, farmers in the drier North report that their planting of beans in millet fields did not noticeably help or hurt the primary millet crop, but if there was sufficient rain, the beans would provide an additional crop as well. In this case moisture, and not soil fertility or land availability, was the limiting factor around which farmers based their judgements. The bean populations in these intercropping associations were far too low for the legume's nitrogen fixation abilities to benefit the cereal crop, or for the beans to strongly compete for soil moisture, yet with sufficient rainfall both crops could prosper and provide a yield. These brief examples illustrate that farmers understand the essence of what has come to be known as the competitive and facilitative production principles of intercropping (Vandermeer, 1989).[137] Even though farmers may not perceive, or explicitly apply, these aspects of their knowledge as management principles, apart from the specific context of their production systems, farmers' understanding of such interactions does provide an entry point for researchers and extension agents to work with farmers on problems of immediate concern.

---

[137] The competitive production principle refers to the more complete exploitation of available resources through inter-species competition, while the facilitative production principle refers to the actual transfer of benefits from one species to another.

Communication and the Social Differentiation of Knowledge

Group and individual interviews reveal a 'topography' of local knowledge, where individual producers possess heterogeneous sets of knowledge consisting of both commonly held (consensual) wisdom and individual understanding that differs in quantity and quality, within as well as between villages. Obvious differences in individual knowledge based upon gender, age, and ethnicity are affected by other less apparent, yet equally important, influences such as kinship ties, religious affiliation and wealth (cf. Swift, 1979). At any one time individuals are part of a number of different, overlapping social networks from which they receive and contribute information. These different associations not only influence the type of information to which individuals have access, but also serve to delimit the type of experiences and opportunities for observation and communication with others. Each individual's ascribed and achieved social roles help to define some of the most active channels of interpersonal communication used in the diffusion of new information. Friendships help to facilitate the exchange of information and material along, and less often across, standard lines of communication. Specific locations, such as public spaces and markets, and certain activities, such as group labor and other social events, provide the physical and social context for the exchange of information between individuals. Certain types of exchanges, such as those that occur at markets, help to bridge both geographic and social distances in the movement of information. Together, these and other social forces define the range of personal experiences, opportunities for observation, and communication linkages that are most important in understanding the differentiation of local knowledge holdings and pathways of information exchange.

Families. The family and larger kinship groups of Bambara society constitute an individual's most important set of social relations.[138] The family structure not only represents a fairly independent, self-replicating social unit that affects the distribution of knowledge within the larger community, but it also serves as the context within which other divisions in knowledge holdings (e.g., gender and age) and communication channels are acted out. Through direct instruction and modeling, young girls and boys receive the majority of their respective role training from the adults in their immediate families (e.g., Cross and Barker, 1991). The decisions made by the household head and others within and outside of the family reinforce these social roles (e.g., Grosz-Ngaté, 1989), helping to shape many of the subsequent experiences and, consequently, much of the specific knowledge acquired by individuals within the family. While many of the variances in familial behavior ultimately reflect differences in the financial stature and production objectives of particular households, others reflect the customized practices and efficiencies developed by different family groups.

Farmers generally reported that one of the most important sources of information and new genetic material were their families (see Table 13).[139] This includes both the immediate, resident family unit and their marketing forays and seasonal labor sojourns, as well as relocated family members who exchange

[138] As Lewis (1979) notes in differentiating between offspring and descendants within Bambara society, it is the successful integration of offspring into the network of obligations and social relations that gives rise to true descendants. A process which is reflected in part by individuals' tendency to refer to themselves as "Bambara" rather than "farmers" (Lewis, 1979), with the implication that being Bambara is more than just a birthright, but is an achieved status (Grosz-ngaté, 1986).

[139] Despite the fact that several studies in the OHVN zone have commented on the break-up of the family unit (e.g., Becker, 1990; Gnägi, 1991).

information during occasional visits.[140] Both women and men farmers in the zone reported a number of such exchanges, mainly of genetic material, that occur through long-distance familial ties. Because marriage in Bambara society traditionally occurs between individuals from different villages, with the wife taking up residence in her husband's natal village,[141] visits by married women to their village of origin was cited as another very important source of information transfer. Other studies have found similar patterns (e.g., Coughenour and Nazhat, 1985; Nazhat and Coughenour, 1987), noting that close and distant relatives are one of the most important initial sources of information about new varieties, particularly for women, and constitutes the most important source of information for both sexes in making planting decisions involving new varieties.

[140] Similar examples are presented by McCorkle et al. (1988) in their case study of communication linkages in rural communities in Niger.

[141] See Lewis (1979) for a discussion of the established 'marriage-routes' within his study area. The inter-family transfer of information and agricultural practices along marriage lines is also noted by Knight (1974) in his study of agricultural change in Tanzania.

Table 13. Relative Importance of Various Sources of Information and Material.[142]

General Sources of Information & Material	Men (n=11)	Women (n=10)
DRSPR	4	1
OHVN	3	2
GOs/NGOs	3	-
Radio	4	1
Elders	7	5
Family	6	5
Marabou	2	-
Group Members	1	7
Friends/Neighbors	6	1
People at Market/ *Commerçants*	5	1
Others	3	-

At times farmers may delay telling others outside of their immediate families about new varieties, thus slowing down the local inter-household transfer of information or new varieties within the village. This is reportedly done not only to save face, in case the variety fails, but also to keep others from begging seeds that are in short supply,[143] as well as to gain a year or two advantage if the new variety proves superior (Nazhat and Coughenour, 1987). The local flow of information is driven primarily by experience; that is, individuals, and consequently their kinship groups, who have the greatest experience with an innovation serve as a principle source in diffusing

[142] Responses are drawn from group interviews (11 male extension groups; 10 women's groups).

[143] Except in instances where the entire seed stock must be replaced, such as following a particularly bad year or personal misfortune, farmers typically buy new varieties in small quantities, or exchange them with others on a measure for measure basis.

that new technology to others in their area. Because each kinship group maintains different channels of communication, their relative importance in acquiring and diffusing new technologies is continually changing.

Gender. As would be expected, group discussions reveal a tremendous amount of difference between men's and women's knowledge. The gender-based differences in knowledge are tied to two major themes: the specialization, or genderization, of specific household production activities, and the presence of resource constraints that are gender specific. As observed in the brief discussion on the organization of household production activities in Chapter IV, most agricultural activities are divided along gender lines under the ultimate direction of the eldest active male, with the eldest active female serving to coordinate and organize the activities relegated to the household women. The gender-based divisions of agricultural activities, however, are by no means consistent among communities, or across all households within a single village.[144] For example, in most areas of the OHVN zone, rice production is an activity carried out predominantly by women. Yet in at least one village in the *secteur* of Bancoumana, rice cultivation is exclusively a male-dominated activity, even though in villages as little as 15 km. away, rice cultivation remains solely a women's activity. In each village, farmers maintained that the growing scarcity of land, aggravated by the decrease in rainfall during recent decades, was the basis for their decisions regarding access to remaining rice areas. The village males, who control land allocation, felt that there either was not enough land suitable for rice production and, therefore, was of no interest to them, or that there was not enough land for women

[144] See Lewis (1979) for a description of the inter-household differences in providing sauce ingredients for the family cuisine.

to be allowed access. Further to the south, in the *secteur* of Kangaba where rice farming has, and continues to play a more significant role in the household production systems, and where rice land is more abundant, both men and women are engaged in rice cultivation. Not surprisingly, group discussions in each of these locations revealed gender differences on such things as the characteristics of different rice varieties and the importance of different rice weed and pest species which varied according to the degree of involvement in rice production.

Similar differentiations of individual knowledge are visible throughout all aspects of the household production systems, where the cultivation of specific food and cash crops, the collection of wild fruits and leaves, and activities such as the processing and preparation of food, are assigned to different age and gender groups. One common feature in these divisions is that women are generally burdened with the more labor-intensive, low-value activities, as well as nearly all those involved with the family cuisine, child care and domestic chores.

In most areas, younger women are prohibited by the male household head from cultivating personal fields. However, once women gain access to land (around the time of menopause), they are able to exercise complete autonomy in making planting decisions, varietal selection, granting minor land concessions[145] and field management, given their access to related resources. While women in one area reported receiving all of their seed stock from their husbands (i.e., family ties), this was not, however, true for the majority, who reported locating, conserving, and

[145] Older women at times grant small plots of land to young girls or women who perform various favors for them, such as bringing food out to the field (pers. com. Short). These young 'assistants' were observed assisting their older mentors/benefactors in performing a number of different field operations, and in this way learn a great deal about specific agricultural techniques that they will be able to apply on a larger-scale in their own plots once they reach maturity.

exchanging varieties separate from their husbands. In some areas of the southern *secteurs*, eligible women are being denied access to individual land as population densities have increased and the availability of arable land has decreased with declining rainfall.[146] In these areas, women are able to secure annual *usufruct* rights to their husband's fields only during the peanut rotation in the cropping cycle. Thus confined in their choice of crops and their degree of control over the land, women's opportunities to experiment with alternative management practices have been severely limited, while their knowledge and expertise in implementing a single-season peanut production strategy has increased.

Gender also serves as the basis for important lines of communication.[147] As noted in the discussion of kinship ties, the socialization patterns of men and women in Bambara society can act as an important force in knowledge differentiation. After the age of 8-10, the instruction of children within the family occurs almost exclusively along gender lines, as children begin to accompany their parents into the fields--boys with fathers, daughters with mothers (e.g., Cross and Baker, 1991). As they gain skills, children become increasingly involved in a number of gender-specific activities and work groups. Their increased responsibility for daily chores brings with it a growing participation in a broader range of communication channels. Women, for example, exchange information and experiences in the course of performing many

---

[146] This includes seasonally-inundated areas that are no longer able to support rice production, and the use of certain free-draining soils that are no longer farmed, or which are no longer preferable, because of their droughtiness under the present regime of low rainfall.

[147] As an aside, in villages with a relatively 'weak' (male) chief, both men and women will seek the counsel of more knowledgeable and 'powerful' older women on issues that normally would be taken up with the traditional village leader (pers. com. Short).

regular domestic and agricultural tasks, including among other, getting water, gathering fire wood, and while walking to and from fields or local markets.

For women, their association meetings and group labor activities are among the most important periods for information exchange (see Table 15). This is quite different from men, who report almost no exchange of information or materials with other members of their extension groups, but who cite a high number of such exchanges with 'friends and neighbors' outside of these groups. Unlike the all-male extension groups, which are formed through the encouragement of the OHVN extension service, women's groups are indigenous social organizations founded upon mutual need and personal ties (see Table 13). Many, if not most, of a women's close friends are members of one or more of her different group associations, where the group activities provide the context in which much of their interaction takes place.

In addition to the male extension groups and women's associations, gender-based associations at the village level take a number of other forms. After the harvest, women often form *ad hoc*, multi-household winnowing groups. The presence of males beyond the age of infancy during winnowing is strictly forbidden (Lewis, 1979), providing women a period in which they can freely discuss events and activities that would otherwise be constrained by the male-dominated social hierarchy. The male age-set *tons* represent another form of gender-based organization. In hiring themselves out for field labor, *tons* members are exposed to a number of different production styles and gain valuable information from their peers and the farmers in whose fields they are working (cf. McConnell, 1993). Farmers who contract group labor often submit at least partial 'payment' for these services in the form of advice or wisdom relating to agriculture (McConnell, 1993). In a study on traditional apiculture practices in the Oueléssébougou area, Gnägi (1992) found that when honey gatherers (all male) congregate and return to the village at the end of the day, they engage in highly personal discussions that range from experiences with their hives to commentaries on the state of the fields through which they are passing, as well as personal problems (pers. com. Gnägi).[148]

Age. The influence of age on differences in personal knowledge and communication pathways is another culture-wide phenomenon. Wisdom gained from long years of experience is, in general, widely revered in Bambara culture (cf. Rosenmayr, 1988).[149] Men and women farmers throughout the zone view village elders as sources of information that are as equally important as kinship groups (see Table 13). At times, older, more experienced male farmers, 'retired' from active cultivation in the family fields, give advice to young farmers who are not part of their immediate kinship group, forming apprentice-type relationships. As noted previously, elder women perform the same role in their relations with younger assistants in their personal fields.

In Bambara society, the first born, or eldest children, are reportedly given more detailed agricultural instructions by their elders than are their younger siblings (McConnell, 1993) and, in turn, are responsible for much of the education and development of their younger brothers and sisters. Elder children are also the first to assume positions of leadership and responsibility within the family as they reach

[148] These types of discussions appear to be fairly common (e.g., Hoskins, 1994), and served as an important period of information collection for McConnell (1993) in his study.

[149] In economic terms, the factor of production most open to change is that of technology, "the know-how which, in rural Mali, is traditionally acquired gradually over time and which the old are suppose to have the most of" (Meillassoux (1960) in Jones, 1976:285). Technical expertise is the elderly's essential contribution to production, and is hence the basis for their position of authority.

maturity. In this way, age results not only in a quantitative knowledge difference, due to the degree of experience, but also includes elements of a qualitative difference, due to the nature and level of detail contained in the information exchanged between members of each generation.

In general, women expressed greater respect for their elders as important sources of agricultural information and advice than did men. In several areas, younger members of the male-dominated extension groups spoke derisively of their elders' inabilities to provide 'correct' agricultural information. This was especially true of younger farmers in the southern centers of cotton production, who were exceptionally eager to adopt the 'modern' practices promoted by the extension service. At the same time, these younger farmers possessed significantly less knowledge about traditional farming practices and local varieties. This phenomenon, however, was not universal. In neighboring villages, where farmers were equally involved in cash crop production and reliant on external inputs, but where the relationships with the extension service were strained, no such glowing impressions of modern practices existed; even the youngest farmers were both respectful of their elders and highly conversant in traditional farming methods. These examples point to the significant influence that extension programs can have on the local social fabric, and the care that must be exercised in designing information campaigns to avoid fostering unintended consequences that may hamper overall development objectives.

Ethnicity, Lineage, and Class. Ethnicity contributes to some of the most pronounced forms of social division and differentiation in individual knowledge, and has been identified as a very important factor in the local exchange of information (e.g., Nazhat and Coughenour, 1987). Within the OHVN, the most striking example of ethnic division is that of herders and agriculturalists. Peul herders, forced to relocate in the southern *secteurs* due to drought, have increasingly begun to adopt settled systems of agriculture. Their agricultural efforts are regarded with some mirth by the resident farming communities as 'novice' at best, and replete with numerous 'mistakes' (probably due to both farming practices held over from their previous environs, and unfamiliarity with the new). At the same time, because of their unquestionable superiority in skill and knowledge of herding livestock, the Peuls are entrusted exclusively with the care and management of the agriculturalists' livestock, which constitutes the latter's major form of investment.[150] Although there are a great number of cultural similarities between the two dominant ethnic groups in the OHVN zone, the Bambara and the Malinké, newcomers entering a village dominated by the other ethnic group are often discriminated against and excluded from the resident decision-making bodies (e.g., Gnägi, 1991). It can be assumed that they are also excluded from the intra-group exchanges of information and genetic material as well. The same exclusion of 'outsiders' may also be true in the northern *secteurs*, where the Soninké represent a significant part or majority of the population in many villages (BECIS, 1991).

Another major factor influencing knowledge distribution and communication is that of familial status, based on lineage and class divisions.[151] In most villages in the

[150] Although not covered by this dissertation, the Peuls and other pastoral groups possess a tremendous amount of specialized knowledge and expertise in herding animals (see for example Niamir (1990), Mathias-Mundy and McCorkle (1989), and Slaybaugh-Mitchell (forthcoming).

[151] Traditional Bambara society is structured around three classes: nobles, slaves and craftpersons (Diop, 1971; Lewis, 1979; N'Diayé, 1970a), as well as a number of distinct ethnic groups (N'Diayé, 1970b) whose lifestyles are often associated with specific activities, such as fishing or herding. The social structure of each village, including the origin of the village and the social relations of each family group, is well

OHVN zone, status as a member of the founding family(ies), generally tied to class divisions,[152] continues to wield significant influence. In one of the study villages, a particularly sharp division between lineage groups virtually eliminated the possibility of broad-based communal discussions. Gnägi (1991) reports similar conditions in neighboring areas of the OHVN zone. In other instances, members of the former slave class have successfully come to occupy positions of authority, effectively replacing the dominant founding families of the noblemen caste (Gnägi, 1991).[153]

Visitors to Bambara villages commonly engage in a form of playful social jousting, tracing their heritages through the established hierarchies of noblemen, slaves or craftspersons. Within some communities, membership in one of the remaining active professional castes, such as blacksmiths, can serve as the basis for an individual's exclusion from certain activities, such as the extension *groupe de vulgarisation* meetings (although farmers are loath to acknowledge such discrimination). Caste membership, however, is not an entirely negative influence, and can include access to specialized spheres of knowledge that is not available to other members of the community.

---

known by its members. In one of the study sites in the southern part of the zone, the village name translates literally to "the place where two rest together." As the story of the village's creation goes, during an early period of warfare a group of hunters gave refuge to some neighboring fisherfolk who were under attack. These two groups retreated inland from the river a short distance and eventually settled and established a village. The hunters asserted their seniority based upon their prior use of the land, and because their guns had provided the protection. A strong division in the village exists to the present day, with two wards demarcating the different lineage groups.

[152] In Bambara society, villages were traditionally established by families of the noble caste (Lewis, 1979).

[153] In certain cases, if there is no one of the senior age group from the founding family with sufficient personal stature to assume leadership, the chieftainship can transfer to a member of another family and caste group (Lewis, 1979), although this transfer may not be permanent and is not inherited.

Religion and Initiation Groups. In many areas of the OHVN, the gradual incursion of Islam into previous strongholds of traditional belief has significantly influenced a number of aspects of individual knowledge, production objectives, and lines of communication. Muslim *Marabouts* have become an important source of agricultural advice in many areas, especially sought out for their advice on when to plant (see also Swift, 1979:42; Coughenour and Nazhat, 1985; Cross & Barker, 1991). The influence of Koranic schools in the traditionally undereducated rural areas of Mali is also very important. Individuals attending these schools receive a different type of education, often of a much higher quality than that available through the public schools and adult literacy centers. In addition, Arabic literacy opens up a much broader pool of printed material than does the *Bamanan* that is taught in adult literacy classes. For the devout Muslim, the mosque becomes an important social focal point and a significant hub of information exchange. Those attempting to fulfill their obligations of visiting *mecca* must acquire the necessary capital, and in the process greatly alter their household production systems. For the *el Hadji* (the honorary title given to those who have made the journey), the experience of visiting new lands is a significant eye opener. Discussions with these individuals generally showed them to be the more inquisitive and experimentally-minded farmers, as well as among the wealthiest.

The fading traditional system of ancestor worship is centered around a series of initiation groups, one of which, the *Tyiwara*, focuses on agricultural performances.[154] Zahan (1960; 1974) notes that while women are excluded from all the other initiation groups, they are allowed to participate in every aspect of the

[154] Lewis (1979) argues that counter to Zahan's (1960; 1974) contention, the different initiation groups may not represent a progressive continuum, but may, in fact, constitute independent entities.

Tyiwara, except for discussions concerning agricultural implements. Symbolized by the *Cwere*, the antelope who taught the Bambara agriculture, the *Tyiwara* encourages the development of a strong work ethic and agricultural prowess. Beyond their function of exchanging information and instilling values, these groups also serve as the basis for inter-village competition in performing field work (e.g., McConnell, 1993; Moseley, 1993).

Wealth. Wealth, as an achieved attribute, cannot be easily separated from other social factors that influence the distribution of knowledge and lines of communication, as in the example of the *el Hadji*. However, wealth is an extremely important factor in terms of its influence on the structure of the household production system. Varying degrees of wealth allow households to support different production strategies, and consequently provides individuals with different ranges of experience in resource management (e.g., animal traction). Farmers and households possessing the means to invest resources in cash crops, more mechanized forms of cultivation, the construction of wells, and capital-intensive, non-agricultural enterprises acquire in the process a very different set of managerial experiences and skills.

In the context of village development, wealthy individuals are constantly sought-out by external agencies as the opinion leaders of their communities, as well as the most likely candidates for adopting new, capital-intensive production techniques. This bias (e.g., Chambers, 1983) is clearly visible in the typologies used by researchers, as well as the formal research and extension services, which use measures of wealth to differentiate between households in both their discussions and planning activities (e.g., Koening, 1986b; DRSPR/OHV, 1992). Contrary to much of the development rhetoric of working with the rural poor, greater wealth more often than not attracts greater attention from outside agencies, which, in terms of access to information, often means that these individuals are among the first to learn of new alternatives.[155]

Friendships. An important influence on the exchange of information, cutting across the other social dimensions discussed thus far, is that of friendships. Close interpersonal relationships help to accelerate the diffusion of information among individuals of similar social standing, as well as help to bridge the otherwise separate social spheres created by ethnicity, gender and other influences.[156] Both men and women had the greatest number of information exchanges occurring between themselves and friends (for women, other members of their women's associations are generally their age-mates and closest friends)(see Tables 13 & 14). Friendships can even mediate the most hardened social divisions, such as those along ethnic lines. In virtually all communities, Peul herders remain socially and physically separated from the agriculturalists with whom they co-exist; their compounds are typically located at the outskirts of the agricultural villages. Friendships, however, established among younger farmers and pastoralists through *ton* membership and other contacts, suggest that such divisions can be bridged, thereby offering a channel for the exchange of information and genetic

[155] Farmers who are slightly more prosperous, on the other hand, are careful not to incur any negative feelings within their communities due to disparate wealth levels. The vagaries of local production, and occasional bad luck, almost ensure that at some point the tables will turn and the now prosperous households will cycle through periods of poverty.

[156] Lewis (1979) refers to the 'joking' relationships that commonly develop between men and women, which provide a socially-sanctioned medium through which individuals of different gender can talk with one another. Friendships between members of the same sex can also evolve into highly codified relationships, e.g., *amis intimes*, or blood brother-type relationships (pers. com. McCorkle).

material between otherwise socially separate groups.

Table 14. Principle Sources in the Local Exchange of New Genetic Material.[157]

	OHVN	DRSPR	FAO	Markets and Traders	Neighbors and Friends	Family	Unknown
Millet	2	1	-	4	3	2	3
Sorghum	9	1	3	3	4	2	6
Maize	3	2	-	1	-	-	-
Rice	-	2	-	3	4	2	-
Peanuts	-	-	-	8	1	-	-
Fonio	-	-	-	1	-	-	-
General	1	1	-	1	8	4	-

The exchange of managerial information between friends is of particular significance because, as discussed in Chapter IV, the knowledge involved in agricultural performances can be highly personal, and is deeply intertwined with household production strategies that have evolved to accommodate such sensitive areas as labor availability and financial liquidity. A certain degree of intimacy, such as provided through friendships, may therefore be required before information on specific management practices can be freely exchanged. As a number of studies illustrate, friends not only serve as one of the major sources of new information but, along with

[157] Responses are drawn from group interviews (n=21).

family members, are one of the most trusted and influential sources in farmers deciding to adopt new technologies (e.g., Coughenour and Nazhat, 1985; Lionberger, 1959; Lionberger et al., 1975; McArthur, 1978; Nazhat and Coughenour, 1987; Ryan and Gross, 1943). In the OHVN zone, farmers consider their friends as their most important general source of new genetic material (in this case, local varieties), second only to market contacts in the total number of successful adoptions.[158] New crop varieties, for example, obtained from a friend, often come with specific planting instructions, or as part of a management 'package' involving the variety and specific cultural practices. In the rice growing *secteurs* of the South, such packages commonly consist of information on the proper water depth in which new rice varieties should be planted, and the levels of weed infestation that can be tolerated.

Locations and Activities. Locations and the performance of specific activities deserve special attention, as they provide the context in which many of the exchanges of information and material take place. As shown in Table 15, farmers mentioned, and were often observed, socializing at the village mosque, public gathering places such as large shade trees or the ubiquitous *mirador* (the raised log platforms found in virtually every village in the OHVN), in the courtyard and vestibule of the village chief, at village wells, mills, stores, along paths leading to the fields, in community garden areas, while performing field work and, most importantly, at local and regional markets (cf. McCorkle et al., 1988; Nazhat and Coughenour, 1987).

[158] While farmers freely experiment with the information and materials obtained from market sources, they also reported the greatest number of rejected technologies originated from these less personal contacts.

Table 15. Important Locations in the Local Exchange of Information.[159]

Locations	Men (n = 11)	Women (n = 10)
Magasin/ Storage Shed	2	-
Chef's House	3	-
Mirador/ Public Place	7	-
President's House/ Group Meeting	2	4
Market	4	3
Family & Communal Fields	4	4
Other[160]	1	4

Village markets provide individuals the opportunity to meet and share ideas and experiences with friends, acquaintances and members of their extended kinship group, as well as interactions with a wide range of other contacts. Farmers from smaller, isolated villages must venture out to markets in neighboring villages to interact with others, while farmers in larger villages, with a regular market, are able to remain within their own village to receive information from the surrounding areas. For farmers in the OHVN, local and regional markets, and passing traders (*comerçants*), are one of their more important sources for acquiring new genetic material (see Table 14). For example, peanut varieties from Senegal, and rice and bean varieties from the Gambia and Guinea, were obtained through commercial channels, and were some of the most widely diffused innovations from any source in the OHVN zone. Merchants in local

[159] Responses are drawn from group interviews (11 male extension groups; 10 women's groups).

[160] Including: village wells, routes to market, and the location where specific chores are performed.

markets, encouraged by the government's growing emphasis on expanding the private sector, have also been responsible for much of the extensive diffusion of farming implements and inputs (fertilizers and insecticides and herbicides). Some of the larger national and international commercial interests have attempted to expand their influence beyond the market by conducting village demonstrations to help promote their products. However, farmers view these as differing little from the on-farm trials of the formal research and extension services; the technologies promoted in this way have generally been perceived as inappropriate, or less effective than current practices.

As referred to earlier, travel, whether for the purpose of seasonal labor, visiting distant kin, attending a funeral, circumcision, or embarking on a religious pilgrimage, is another major avenue for acquiring new information. As one farmer stated, "anyone who travels" becomes an immediate source of information. Similar to marketing, travel opens up a range of opportunities for individual observation, discussion and purchase that can be truly regional, national, and international in scope (e.g., Coughenour and Nazhat, 1985; Hoskins, 1994; Knight, 1974; McCorkle et al., 1988). Farmers acquired new varieties and planting techniques, such as the use of mechanical seeders with rice and the use of water-holding basins on the hardpan plateaus for rice production (Moseley, 1993), through travel. Other farmers with significant grafting experience, who have found dry season employment on plantations in the Bamako area, return to their villages with seedlings, in some instances of genetic stock imported from abroad, which they either plant directly or use in their own grafting experiments. Those who have visited *mecca* have returned to experiment with fish farming, and have constructed grass-lined gutters through their villages, similar to those observed during their travels.

Farmers' Innovations and Experimentation

Farmers' informal manipulation and experimentation with the different elements of their agricultural production systems represent one of their most important sources of new information. This includes both lessons learned from making continual adjustments and adaptive changes in their cropping systems, as well as acts of more explicit experimentation. Men and women farmers in the OHVN zone engage in a wide range of innovative activities aimed at improving nearly every aspect of their farming systems. Examples of farmers' experimentation range from varietal trials, adjustments of planting densities and spatial arrangements, and intercropping patterns and agroforestry configurations, to experiments on soil fertility management, erosion control, and water conservation. These innovative activities can be classified in three general categories: adaptive experiments involving adjustments to established practices; integrative experiments oriented towards verifying, adjusting and integrating new techniques and ideas that have originated elsewhere into the existing production systems; and explorative experiments, involving the investigation of original ideas stemming from personal insight, specific need or curiosity--as one farmer put it, to simply "see how it works."

Farmers in the OHVN zone employ many of the same logical steps used by formal researchers in conducting their adaptive and explorative activities (i.e., screening new genetic material for desired characteristics, identifying a suitable growing environment (soil and moisture regimes), and integrating new varieties into the existing cropping systems)(cf. Potts et al., 1992). However, farmers in complex, diverse, risk-prone (CDR) environments, such as the OHVN zone, generally do not treat their experiments as 'fixed' investigations of discrete research questions; rather, they allow the conditions of the particular season and their own managerial knowledge to guide the investigative process, changing the nature of the query and 'treatments' as the season unfolds (e.g., Stolzenbach, 1992).

Farmers' willingness to discuss their experimental activities varied widely, from obvious pride in their accomplishments to great reluctance, acknowledging their experimentation only after examples were stumbled upon in the course of field visits. Some of this hesitancy may be due to feelings of inadequacy, of not doing it 'right' in comparison to their perceptions of formal research procedures; however, more may be explained by the deeper influences of semantic and conceptual differences (cf. Stolzenbach, 1993). Local languages may contain a word or phrase that expresses experimentation or trial,[161] but they may not capture the same set of attributes that are implied by Western uses of the terms. Farmers, for example, readily experiment with a wide range of new crop varieties. However, the subsequent adjustments in planting densities, use with different soil types, intercropping patterns and management practices were rarely offered as examples of experimentation. Farmers largely view these subsequent adjustments as an integral part of the farming process, and not as a separate activity. As one farmer responded in Stolzenbach's study, use of a completely new planting practice, in conjunction with a variety he had adopted in the preceding year, was not considered an experiment because, in his words, he already "knew the varieties" from the preceding season (Stolzenbach, 1993). In other words, the initial planting of the variety was considered experimental, while the subsequent innovations with its use were not.

As described in Chapter IV, farming in CDR environments is an adaptive process

[161] In Bambara there are at least two: *lajè*, which means to try something (an object) to see if it is any good; and *i bila a da la*, which means to take an action to see if it is successful (Bailleul, 1981).

requiring farmers to respond to high levels of variability in their physical and social conditions. In such situations, farmers are forced into undertaking some type of experimental activity nearly every season. As a result, experimentation is part of the norm rather than the exception to farming. Certain influences, such as periodic changes in the level of institutional support, market prices, or long-term fluctuations in rainfall patterns, create immediate needs and opportunities that accelerate the rate of change in local systems, while other influences, such as farmers' own inquisitiveness and the genetic evolution in crop, weed, and insect species, insures that a certain background level of change will always be occurring.

The following examples illustrate the type and nature of farmers' experimental activities as they attempt to improve both their production systems and their abilities to manage the physical environment (a broader review of the impacts of these activities in terms of their contribution to local agrarian change is presented in the following chapter, Chapter VI). These examples represent only a thin slice, in terms of time, location, and theme, of the total wealth of innovative activities occurring within the informal sector across the OHVN zone. While some farmers are more adventurous than others, and some are more systematic than others, the important thing to note is that all farmers experiment. The full range of experiments and adaptive adjustments being carried out by farmers must, in reality, be multiplied across the approximately 800 villages and more than 40,000 households within the zone. Because these changes are generally small, it is easy for external observers (especially researchers and extensionists) to underestimate the cumulative effects of this informal experimental process. Yet, when viewed over time, each instance of farmer-based innovation and adaptation is a contribution to the incremental evolution of the existing farming systems.

Cropping Systems

Farmer interviews and field visits revealed that the highest level of experimental activity occurs in the areas of varietal screening and the adaptive adjustments that farmers make in their cropping systems. As a first step in familiarizing themselves with a new variety, farmers typically conduct screening trials, with small test plots established in favorable locations, such as within homegardens or more fertile portions of larger fields.[162] If farmers are satisfied with the initial results, the new variety is then normally sown on a larger scale. At this point, farmers may make some adjustments regarding where the variety is planted (if they feel that it would be better suited to a different soil type or moisture regime), as well as initiate the process of either integrating the new variety into the existing cropping pattern, or changing the standard practices slightly to better exploit the desirable characteristics of the new variety.

During field visits, farmers identified a number of fields where they had planted new varieties at the field level for the first time. If a new variety was obtained from the market, or another fairly anonymous source, farmers appeared to manage it in the same way as similar varieties already in their possession. If, on the other hand, the variety was obtained from a friend or relative, the seeds often came with specific planting instructions, or as part of a management 'package' involving the variety and specific cultural practices or use of specific niches. Moseley (1993) reported the

[162] These small screening plots serve both as a first test of the variety, and as a way of multiplying the seeds for planting on a larger scale. Farmers also reported growing varieties specifically for sale as seed stock. In local markets, individual vendors offered seed stock for sale separately from grain meant for consumption. The purchase of seed for planting from larger merchants is considered by farmers to be less desirable than homegrown seed, because of the poorer quality and lack of genetic purity.

spread of a new rice variety and production technique for growing rice in the water-retaining depressions of the hardpan plateaus, a niche previously overlooked by farmers in his study area.

In addition to varietal trials, farmers also actively conduct experiments involving a number of other aspects of their cropping systems. These additional experiments include major adjustments in the timing of sowing different crops, seeding densities and plant spacing to match reduced moisture levels, as well as numerous intercropping arrangements. The decreased moisture availability associated with the regional downturn in rainfall has forced farmers in the far North to abandon their previous practice of planting parallel rows of peanuts down each ridge. Farmers' initial response was to simply reduce the number of rows on each ridge from two to one, effectively halving their plant density. However, farmers in these northern areas have been experimenting with a method of planting peanuts in a zig-zag fashion, alternating sides of the ridge with each seed pocket, which allows them to maintain a higher plant density without the risk of excessive moisture stress due to competition. By the second year of the trials, this practice had spread to most of the other farmers in the village.

Experimentation with different intercropping associations is also common. Some of the more speculative of these are carried out in test plots located within the homegardens, while others are implemented directly at the field level. One farmer in the southern part of the zone was running a series of intercropping trials that involved different arrangements of bananas, tobacco and manioc. Others were experimenting with entirely new crops, such as pineapples and various market vegetables.

Agroforestry Systems

In addition to field and garden crops, agroforestry associations are another area of high activity in local experimentation. Farmers across the zone are beginning to experiment with producing and planting a wide range of tree species in their main agricultural fields and homegardens. Farmers in Boron *secteur*, in the hopes of increasing soil fertility and gaining an additional cash crop (in this case, seed pods as fodder), were, with encouragement from the DRSPR/OHV field agents, beginning to experiment with planting A. albida in their agricultural fields for the first time. In the South, farmers are experimenting with planting nèrè, karité and other species directly into their main production fields. Individuals with grafting experience have developed their own varieties of mangos, both for their own personal use and sale.

Soil Conservation and Water Control

Farmers in many areas are also actively experimenting with soil fertility management, and different methods of soil and water control. Farmers in Boron *secteur* are experimenting with residue retention as a means of increasing fertility and reducing wind erosion during the dry season.[163] Elsewhere, farmers in several areas are experimenting with physical control measures as a way to help control the evacuation of runoff from their fields and lessen their erosion problems. Examples of the different measures include, the use of hand-dug canals, grasslined waterways, and re-learning how to use rock barriers (a traditional practice) as a means of filling and

---

[163] Recent findings from the TROPSOIL CRSP (Anon., 1992) show that residue retention, in addition to reducing surface temperature and windspeed, increasing moisture retention, and helping to curb water erosion, can add needed biomass to the soil and serves as such an efficient trap for windborn dust that it actually helps to increase soil depth (this windblown dust is a significant source of soil nutrients, e.g., Jones (1938); Scott-Wendt et al. (1988)).

controlling the spread of existing gullies.

Land Use

The decline in rainfall levels has led farmers to experiment with several types of changes in their cropping systems. In the past, farmers, even in the northernmost areas, were able to produce limited amounts of rice in seasonally inundated areas. Now, however, these areas are used for limited maize and sorghum production, and in some cases are considered prime millet land. Farmers in the southern *secteurs*, who initially had replaced much of their rice production with maize in response to the early droughts, are finding that, during years with slightly higher rainfall, maize becomes waterlogged and will not produce well. As a result, farmers in these sites are experimenting with the use of upland rice varieties that can tolerate the occasionally higher moisture levels.

Chapter Summary

In many respects, farmers' knowledge, communication pathways, and ability to innovate represent the real lifeblood of local adaptation and survival. Farmers possess detailed environmental knowledge, utilize resource taxonomies and systems of classification, and apply their knowledge of biological processes in carrying out the complex agricultural performances and management of diverse household production systems described in Chapter IV. On an individual basis, knowledge is acquired largely through personal experiences and numerous overlapping communication pathways, which in turn are strongly influenced by a number of social factors, including gender, age, ethnicity and family ties, among others. Farmers' innovative capacities are not only a vital force in allowing each individual to meet her or his immediate personal and household needs but, as covered in the next chapter, farmers' innovations serve as a major source of new information and materials critical to the adaptation and advancement of household production systems within their immediate communities, and beyond.

Chapter VI. Change in the Household Production Systems

Farmers' own innovations and their adaptation and adoption of technologies developed by the formal system have led to a number of significant changes in the household production systems of the OHVN zone. Through the individual and group interviews, farmers voiced their observations concerning the changes that have taken place in their management practices. Data were collected over three general time periods: the period since the time of their parents; the recent past (last three to five years); and the present. In these discussions, an attempt was made to link identified changes with a specific 'source' of information and material that had helped farmers to modify their production activities. This chapter summarizes farmers' observations and other data on the changes that have taken place in the OHVN zone. This summary illustrates the extent to which farmers have contributed to agrarian change, and sets the stage for examining the impact of the research and extension system on this change process.

Cultural Technologies

As reported by farmers, the most dramatic change to occur in the evolution of their production systems since the time of their 'fathers' or 'mothers' has been the spread of animal traction (AT) and use of the plow. Although animal traction may have developed as an indigenous technology in Northeast Africa (see Pingali et al., 1987), the practice was first introduced into the OHVN area during colonial occupation in the early 1930's (Leynaud and Cisse, 1978). According to farmers' estimates, between 40 and nearly 100 percent of their farmland is currently cultivated using AT. In general, poorer households and women continue to rely most heavily upon manual cultivation, although consecutive bad years and unique circumstances can force even relatively wealthy households to divest of their capital assets and revert to manual cultivation.[164] Although farmers perceive a major increase in their ability to cultivate more land with AT, apart from relieving the drudgery of manual cultivation, empirical studies in the OHVN zone and elsewhere in Mali and West Africa show that the use of the plow has had little effect on the amount of land cultivated per individual worker; at most, an insignificant increase or, in some cases, even a slight decline (e.g., Adesina, 1992; IER, 1978; Jaeger, 1986; Coulibaly, 1987). Labor bottlenecks involving operations that are still largely performed manually, or for which superior mechanical options have yet to be developed, such as thinning and weeding, continue to prevent any major increase in the amount of land cultivated per worker.[165]

Although the implements seem to have been adopted without any major physical modifications,[166] the cultural practices associated with their use has

---

[164] Taxes, loan payments, subsistence needs following poor harvests, and other emergency expenses lead farmers across the Sahel to enter a continual cycle of investment and divestment of animal traction systems.

[165] Problems with cash flow and learning curves of managerial efficiency are other significant factors affecting adoption rates of animal traction systems and the level of proficiency achieved by farmers using them (Jaeger, 1986). It is estimated that it requires five years of experience before farmers are able to reap the full benefits of AT. For farmers on the financial margin, five years of continued ownership of a functional AT team is difficult to achieve.

[166] Village blacksmiths typically create templates of the common parts of each implement's design and use these for making replacement pieces. Thus, while the quality of the base materials may change due to local availability, the integrity of the

undergone significant adaptation to fit local conditions. In the OHVN, farmers' traditional mound culture, once common throughout most of Africa (e.g., de Schlippe, 1956; Miracle, 1967; Knight, 1974; Warner, 1991),[167] has been largely replaced, not by the practice of flat plowing, as recommended by the extension service, but by the use of ridges, an indigenous adaptation created by making consecutive dead-furrows with the plow. As the formal research system is discovering, farmers' use of ridges is more effective than flat plowing in conserving soil moisture, the principle constraint on crop production in much of the OHVN zone (e.g., SRCVO, 1992). In the main cotton-producing areas of the South, where the use of flat plowing is more widespread, farmers recognize that this practice is also accompanied by a significant increase in soil erosion.

The introduction of animal traction and the development of new plowing techniques have also had a secondary influence on manual cultivation. Although the use of mounds is still found, albeit on a much reduced scale in scattered locations across the zone, farmers relying upon manual cultivation commonly mimic the ridges produced with a plow. As with mounds, ridges bury weeds and concentrate the fertility of the scant top soil in the seed bed. In both cases, runoff is slowed and allows for greater infiltration of the available rainfall than flat plowing.[168] To enhance the

basic design is preserved. However, since blacksmiths and farmers were not extensively interviewed concerning their modification of equipment designs, this may not be as static as it appears.

[167] In only one village did farmers report the widespread use of anything but the traditional mounds during the preceding generation.

[168] In areas outside of the OHVN, where mound culture is still widely practiced, the innovation of 'tied mounds,' analogous to tied ridges, has been developed by DRSPR/Mopti, and is gaining widespread acceptance among area farmers (Kingsbury et al., 1994)

conservation potential of ridges, farmers typically align them across the slope, although they often do not follow the changes in contour. In areas with steeper slopes, however, farmers will sometimes create narrower fields and orient the furrows downhill, or on an angle, to facilitate the rapid evacuation of rainwater and thus reduce the risk of water ponding behind a ridge, breaking free and causing a complete washout of the hillside.[169]

The general transition to ridge cultivation has also been accompanied by an increase in the prevalence of row planting. With the exception of those crops that are still commonly planted by broadcasting seeds, such as fonio and rice, the majority of cereal crops are now planted in rows, regardless of the method of land preparation. Even in highly integrated intercropping associations, such as women's mixing of peanuts, Bambara groundnuts, millet and okra, one or more of the species are often planted in rows (which was not the case under the previous system of mound cultivation).[170]

In comparison to the plow and AT tool bars, the use of other implements such as the harrows and mechanical seeders promoted by the extension service is much lower.[171] Farmers cite cost and utility as the major reasons why they have not made

---

[169] This same strategy is used by farmers in East Africa, as well as in areas of South America.

[170] In this particular intercropping system, women commonly plant their fields in rows (one row of millet to every 3-4 rows of legumes, and then over-seeded with okra or *dah*), or they plant the entire field to peanuts and Bambara groundnuts, and then over-plant millet in rows or large rectangles, with the okra scattered throughout.

[171] The increase in mechanization has neither replaced nor significantly altered the range of different *dabas*, the principle handtool used by farmers in their cultivation, thinning, weeding, and planting operations. Unlike other areas in West Africa, farmers in the OHVN did not report any major adoptions or adaptations of handtools (e.g., McCorkle et al., 1986; Coughenour and Nazhat, 1985; Nazhat and Coughenour, 1987)

further use of these technologies. In some cases, farmers abandon the use of certain pieces of equipment after an initial trial period. Such is the case with mechanical seeders, which now sit idle in many courtyards across the zone.[172] These seeders, in order to operate effectively, not only require fields that are flat-plowed but residue-free; conditions that run counter to good soil and moisture conservation practices, as well as to many of the new natural resource management themes promoted by the extension service.

Those farmers who have not abandoned ineffective technologies have had to undertake significant adjustments and continue to experiment with a number of related aspects of their production systems. For example, farmers in some areas of the South have found that under their field conditions the plant spacing of cotton rendered by the mechanical seeder is too close, forcing them to manually thin each plot. Farmers in the North, using mechanical seeders with their cereal crops, have had problems obtaining good crop stands because of the reduced number of seeds placed per pocket. Low germination rates and insect or animal pest damage force farmers to bring in transplants from other fields to fill in the gaps (instead of the usual practice of thinning and transplanting within a single field). In order to get greater use out of their seeders, farmers in the rice zone are beginning to use them to plant upland rice, a practice which is not part of the current OHVN extension package, but which is used in the large irrigated projects elsewhere in the country (e.g., *Office du Niger*) and has been investigated among farmers practicing *décrue* agriculture in other West African countries (e.g., Posner et al., 1990).

---

[172] Economic analysis suggests that mechanized seeders are generally uneconomical for cereal farmers in the Sahel (Jaeger, 1986).

Land Use and Fertility Management

As discussed in Chapter V, the decline in annual precipitation and soil fertility levels has led farmers across the zone to make numerous adjustments in their traditional patterns of land use. Because of the greatly reduced rainfall, farmers in the northern areas are no longer able to produce limited amounts of rice in the seasonally-inundated areas. Such areas are now used for limited maize and sorghum production, and in some cases are considered prime land for millet, their most drought tolerant crop. Farmers in the South have converted many of their former (aquatic) rice lands into maize production. However, farmers in some areas have begun to produce upland rice, which is more tolerant of the slightly higher rainfall levels that have returned in recent years.

In some of the southern *secteurs*, Moseley (1993) found that the climatic shift has also led to the re-valuation of local land types. Villages in this area, with an abundance of free-draining soils ideal for cereal production under high rainfall conditions, have found themselves in a situation of land deficit, with shortages of moisture-retentive soils necessary for sustained production. As a result, farmers are having to adjust their production systems, as well as adopt new land tenure arrangements with neighboring communities who have a surplus of more suitable land types. Farmers in this area have also added the use of a new environmental niche to their portfolio of production sites, adopting the inundated basins on the hardpan plateaus for rice production (Moseley, 1993).

In roughly half of the communities visited, farmers reported making substantial reductions in their fallow length, when compared to the preceding generation (with farmers in several areas making the transition to continuous cultivation). A majority of farmers also reported decreasing the length of their cropping cycle because of rising weed pressures and declining fertility levels. Although the number of villages adopting continuous cultivation is quite small, the beginning of this trend has major implications for the long-term management of soil mineral stores in these areas, and the ability of farmers to sustain (and increase) current levels of productivity. In an attempt to combat declining fertility levels and yields, farmers in the far northern *secteur* of Boron have begun to retain greater quantities of crop residues in their fields, and in some areas markets for manure have developed. Farmers all across the zone are increasing their use of a number of physical measures to control water runoff, including rocklines and dikes that are promoted by the extension service. Although farmers claim that rock and grass lines are a traditional practice, none had maintained active use of the technology. As a result, farmers in a number of locations are re-learning how to use rock barriers in their fields.

Cropping Systems

In response to changing climatic and economic influences, farmers have made a number of changes in their cropping systems over the past generation. Such adjustments include changes in the timing of sowing, seeding densities and plant spacing to match reduced moisture levels, as well as the development of new intercropping arrangements and the addition of new crops to their production systems. Farmers in the far northern areas of the zone, finding that they can no longer safely plant peanuts prior to the onset of the rainy season, now attempt to time their planting to follow, as closely as possible, the onset of the rains. During the preceding generation, farmers in the northern *secteurs* also commonly planted cowpeas as the first crop in their rotations, just as a field was taken out of fallow. Now, however, due to decreased rainfall, they plant shorter season cereal crops that are less affected by the increased variability of the early rains. The lower rainfall has also forced farmers in the far northern areas to change how they plant certain crops. As described in Chapter V, farmers in some areas plant peanuts in a zig-zag fashion on alternating sides of the ridge, thereby allowing them to maintain a higher plant density without the risk of excessive moisture stress due to competition.

In the southern *secteurs* of the zone, nearly all of the farmers found value in the information on planting dates disseminated by Mali's Pilot *Agrométéologie* program.[173] While none of the farmers based their planting decisions solely on this information (i.e., planted when announcements were made), they did use it as an additional source of information to complement the many natural signs upon which they rely in determining when to begin sowing their crops in particular fields (see Appendix D).[174] The temporal and spatial diversity of rainfall throughout the region is such that individual fields, located only a few kilometers from each other, often have entirely different rainfall patterns, thus making blanket recommendations irrelevant.

The abandonment of mound cultivation and the beginning of extensive, commercial mono-culture cotton production has led to notable changes in the cropping rotations used by farmers in the southern part of the zone. Throughout the southern *secteurs*, cotton has replaced other traditional cash crops, such as dah, yams, and peanuts, as the first crop grown in the rotation. Cotton is now commonly followed by

---

[173] This program provides planting recommendations to farmers in relation to local rainfall levels. Recommendations are based upon 30 years of rainfall and yield data, and are said to provide farmers with an 80 percent probability of obtaining a harvest.

[174] On-farm trials show that significant yield increases are possible when optimizing the timing of field operations (planting, thinning, weeding)(OHVN, 1993a). These demonstrations, however, are generally conducted in isolation of the whole farm system, where, because of labor and other resource constraints, farmers are inhibited from optimizing the timing of all the operations in each of their fields simultaneously.

maize (a crop whose cultivation at the field level is fairly recent), and to a lesser extent, sorghum. The reported rise in the problem of striga infestation has also led to the increased importance of rotations involving legumes, to help combat this serious weed problem.

New Varieties and New Crops

Farmers manage and depend upon the genetic material at their disposal to help mediate the many challenges of varying soil fertility levels, endemic weed pressures, disease, and insect and animal pest problems. Local stores of genetic material, combined with farmers' detailed environmental knowledge, provide a first line of defense against the often harsh and unforgiving production environments. Over the past decade, several trends have appeared in farmers' continual addition and deletion of varieties from their repertoire of planting material. The increased aridity, for example, has led to a general increase in the adoption of sorghum and millet varieties with faster maturation periods and greater drought tolerance.[175] Most of the short season varieties introduced by the OHVN, and through the FAO Seed Multiplication program, have enjoyed only limited success with farmers. (In many cases, the new rapid maturing varieties are slower than existing local varieties. As one field researcher of the farming systems research program (DRSPR/OHV) mentioned, "there are hundreds of local varieties in the zone that are better adapted to local conditions"). Poor taste and field performance are the principle reasons cited by farmers for not

[175] Yet even these faster maturing varieties are not impervious to damages wrought by the severest droughts. Farmers in some of the northernmost areas of the zone reported that during the latest period of drought, they were forced to consume their remaining seed stock (that which was not destroyed in the field after several re-plantings) in order to survive. This included many of their shortest season varieties, for which they have yet to find replacement seeds.

adopting the extended varieties. In an attempt to mediate these problems, the FAO Seed Multiplication Program has adopted the strategy of using only improved local varieties in their multiplication program. The improvement of local varieties has been a major theme within the ICRISAT and IER breeding programs since the late 1970's. The most successful 'improved' varieties of maize and sorghum emerging from these breeding efforts have been improved local varieties (e.g., the sorghum varieties CSM-388 and *Tiémarifing*, and maize varieties *Tiémantié* and *Zanguéreni*).

Farmers continue to select varieties with specific characteristics to meet the constraints imposed by evolving conditions in their production environments. In the South, higher-yielding Asian rice (*Oryza sativa*) has largely replaced the local varieties of African rice (*O. glaberrima*). Yet farmers in several areas have begun to retain and re-acquire varieties of the local, red-hued African rice that are more tolerant of the prevailing conditions of low soil fertility and high levels of weed infestation. Farmers have also begun to widely adopt local varieties of sorghum, such as *seggatana* (*segga* is the Bamanan word for striga), that are resistant to striga.[176] In other locations, farmers had abandoned millet cultivation because of the severity of bird predation. Several improved varieties of millet offered to farmers through the research programs and OHVN extension service have been rejected because of their susceptibility to bird damage (cf. Schilling et al., 1989). However, the adoption of local varieties of millet,

---

[176] Researchers at ICRISAT have been aware of a number of local, striga-resistant varieties since the late 1970's (ICRISAT, 1979). In trials, '*seggatana*,' or '*seguetana*,' has show itself to be nearly three times as resistant to striga as the most effective 'improved' variety that researchers have developed (and is over 30 times more resistant than non-resistant 'improved' varieties)(ICRISAT, 1984).

with stiff, sharp bristles that protect the grain head from birds, are on the rise.[177]

Maize, a relatively recent introduction into the local cropping systems, is commonly planted in the rotation after cotton, to scavenge any remaining fertilizer. Although maize has been grown as a garden crop for centuries,[178] when describing the cropping systems used by their parents, farmers in only one area mentioned the use of maize in field rotations. Now, in nearly all locations of the South, farmers include the cultivation of maize in their cropping systems.[179]

The production of market vegetables and horticultural crops is another activity whose importance has continued to grow since the preceding generation. Although vegetable production had been a focus of development assistance in the OHVN area in the 1960's, only three groups reported extensive dry-season gardening as a major source of income during the time of the preceding generation. Presently, tomatoes, onions, peppers, okra and watermelon, among many others, are now major cash crops for farmers in nearly every part of the zone. The rise in importance of horticultural crops is another significant change in household production systems. Mangos, citrus and bananas are the main horticultural crops grown commercially in small, homegarden plantations, while in some locations farmers are experimenting with several less traditional species.

---

[177] Traditional methods of bird control, chasing and the use of 'scare crows' (pieces of metal and cloth strips tied to poles), are labor-intensive and quickly lose their effectiveness as the birds learn that they have little to fear.

[178] Maize was introduced to West Africa at least by the 1500's, and possibly earlier (Miracle, 1966).

[179] As mentioned, a major factor in the rise in popularity of maize is the decreased rainfall and farmers' conversion of rice land to maize production.

Homegardens, Agroforestry, and Forestry Management

In response to the recurring droughts that began in the 1960's, many pastoral groups moved southward into areas of more intensive agriculture, where they have since settled. Their relocation has paralleled a widely recognized increase in both the adoption of animal traction and local investment in livestock in southern Mali (Foltz, 1991). Consequently, during the last 20 years farmers in all but the most arid areas of the North have responded by developing systems of 'living fences' to protect their crops from roving livestock. The most common species used as a living fence is pourghere (*Jatropha curcas*), although sisal (*Agrave sisalana*) is also common in the southern areas of the zone, along with another unidentified species in the northern areas. Pourghere, a species native to the American tropics, was most likely imported to West Africa by the Portuguese (Jones and Miller, n.d.) and spread during the colonial occupation.[180] Species used as living fences are planted to form complete enclosures around homegardens or larger fields, as barriers along one or more sides of a field, and along the major pathways where livestock are taken into and out of the village.[181]

Farmers report that the present generation was the first to design and manage the extensive homegardens and household plantations that are now characteristic of the southern areas of the zone, especially on the western side of the Niger River, where commercial cotton production has historically been less important. This

[180] Pourghere, which is inedible to livestock, is used as a major ingredient in local soap manufacture, and oil extracted from its seeds can be used as a substitute fuel in diesel engines. (e.g., Henning, 1989; 1992).

[181] The animals are herded against these fences so that they do not wander into the surrounding fields. Owners of animals found to have damaged field crops are held liable and assessed substantive fines.

development reflects the general increase in importance of horticulture and market gardening to the household production systems, and the need of farmers to protect their specialty and economic crops from the pressure of increased livestock numbers. Not surprisingly, there has been a concomitant increase in farmers' horticultural skills. In the mid-1960's, a group of what farmers described as 'tourists' passed through the area and introduced them to tree grafting. Individuals have since greatly improved their grafting skills and are now actively working to expand their holdings of genetic material, develop their own varieties, as well as use their horticultural skills to secure dry-season employment on the private plantations around Bamako.

Due to the increased use of the plow, farmers in many locations noted that the tree densities in their main production fields have been dropping in recent years. In these areas, few of the naturally emerging seedlings are being protected[182] and, because of the difficulty in plowing around them, nearly all of the living tree stumps are being removed from fields as they are taken out of fallow. Counter to this trend, however, farmers in certain localities are beginning to re-establish desired species in their fields.[183] Although the OHVN extension service has recently begun encouraging farmers to plant neem, African mahogany (*Khaya senegalensis*), and a few other single-use species, the recommendations are for planting trees along field boundaries and not for the establishment of agroforestry associations within fields. On their own, farmers across the zone are beginning to experiment with producing and planting a wide range of multi-purpose species directly into their main production fields, as well

[182] The same phenomenon has been observed in Senegal (Seyler, 1993).

[183] Economic analyses show that the benefits derived from the secondary products of two of the most widespread agroforestry species, karité (*Vitellaria paradoxa*) and néré (*Parkia biblobosa*), outweigh the negative impact they have on crop production beneath their canopies (Kater et al., 1992; Kessler, 1992).

as around their compounds and in established kitchen gardens.[184] In a village in the far North, one of the more affluent farmers is producing seedlings with assistance from the *Eaux et Forêts* (National Water and Forest Service), while others in this area and elsewhere in the zone are performing these activities completely unassisted (cf. Montagne, 1986). In the South, a common feature of homegardens is small nurseries of citrus, guava, mango and neem, which are planted both for personal use and to sell.

Community plantations are a new innovation being promoted by the research and extension system to help solve local fuelwood shortages and help protect the remaining natural forest stands. In practice, however, these plantations have not secured the necessary community support for their success. The plantations observed during this study had either been installed entirely by a NGO, or communities had been persuaded to purchase seedlings produced by the government. In both cases, seedling survival rates were low, ranging from 5-20 percent due to dry season losses. Unclear tenure rights and the lack of attention paid to plantation management during the dry season have contributed to their poor performance.

The loss of local control over forest resources through the national tenure and forestry laws has been the subject of much discussion (e.g., Thomson, 1987; Thomson et al., 1986), and has contributed to the desiccation of many communities' forest reserves. In one community, however, people are attempting to use these same national laws to their advantage. In this instance, the community has applied for their forest lands to be granted *Foret Classé* status, thereby protecting them from further destruction by outsiders and village residents whose extensive woodcutting has been

---

[184] Throughout West Africa, farmers have an extensive history of protecting existing and emergent seedlings of desired species in their agricultural fields. Individual experience with actual planting exists, but is less widespread.

supported by NGO working in the area. Under the First Amendment to the USAID financed Development of the *Haute Vallée* Project (USAID, 1993), farmers in several selected areas will be involved in a pilot program that will begin transferring forest management responsibilities back to local communities.

Animal Husbandry & Livestock Associations

As noted, the southward shift of many pastoral groups, as well as the general increase in livestock investments in the southern half of the zone, has led to the full or partial enclosure of fields in many areas. For a number of communities, the past few decades have brought noticeable increases in marketing opportunities for livestock, fodder[185] and animal products, such as fresh milk and eggs. Animal manure has become an increasingly important input into most cropping systems, and has further magnified the importance of the traditional exchange relationships between agriculturalists and herders over the use of wells and consumption of field stubble in exchange for the manuring of fields (e.g., Toulmin, 1991; 1992). There is also evidence that a market for the sale of manure is beginning to emerge in the northern areas of the OHVN zone (pers. com. McCorkle).

Other Changes

Through the strong support of the research and extension services, the past decade has seen a significant increase in farmers' use of external chemical inputs. The current use of fertilizers, pesticides and herbicides are most commonly associated with cotton and, to a lesser extent, maize production; these inputs play only a minor role

[185] This includes both the fairly substantial sale of fodder to urban residents, as well as, in some instances, to passing pastoralist and rural producers.

in the production of sorghum and other cereal crops, and this typically is in the more moist southern areas.[186] Although external inputs are used mainly by men, women farmers in one area of the South have come to rely upon herbicides, obtained from their husbands, for their personal plots.[187] Farmers' use of pesticides and herbicides include both standard application procedures and the mixing of biocide 'cocktails,' where a number of different chemical agents are combined and applied in a single dosage. In 1992, with the help of a consultant, the OHVN extension service began developing an Integrated Pest Management (IPM) *thème* to help farmers use pesticides more judiciously. However, this *thème* has yet to be extended to farmers.[188]

Farmers throughout the zone reported using a variety of methods for protecting their grain during storage: chemical powders, ashes, several 'bitter' herbs,[189] and the dried leaves of the neem tree. While the use of specific insecticides for storage have been encouraged by the extension service, farmers in some locations reported using inappropriate commercial insecticides, and even herbicides, in their granaries for protection against pest loss. These spontaneous innovations have potentially disastrous consequences. Although farmers reportedly 'cleaned off' the poisons before

---

[186] The results of a recent seven year study show that the use of pesticides, even with the ultra-low volume sprayers, is not cost effective for farmers growing millet in Mali's Sahelian zone (Jago et al., 1993).

[187] Unlike pesticides, herbicides remain very effective in their control of target species and do not lead to the evolution of 'super' pests that are chemically resistant, which can happen in as little as seven generations with the continued and improper use of pesticides.

[188] USAID has supported a regional IPM program, however, no impacts of this effort were evident in the OHVN program.

[189] Benefin (*Hyptis specigera*), a member of the mint family (mint extracts have also been used successfully for pest control in storage in the United States), and the dried fruit of the Samakara (*Swartzia madogascariensis*)(Min. de al Production, 1972).

consuming the grain, the observed safety standards in handling these toxic substances, by both farmers and suppliers, were rarely adequate to ensure user safety.[190] Neem leaves are another product that appears to have been introduced fairly recently in many villages. The neem tree, native to India, was introduced to Ghana as a shade tree by an officer in the colonial administration in 1919 (NRC, 1992), and is now an established part of the Sahelian landscape. The use of its leaves in protecting stored grain, while common across India and other areas of West Africa (e.g., McCorkle et al., 1988), is uneven in the OHVN zone. While farmers in some villages claimed this to be a traditional practice, others have only recently adopted it, and others still have never heard of it.

Evolution in Agricultural Problems

Aside from decreasing soil fertility and the related rise in striga infestation, Table 16 shows that the hierarchy of major agricultural problems, as perceived by farmers today, is quite similar to that faced by the previous generation. With the exception of birds, wildlife seems to be of less concern in most areas, corresponding to the general decline in the region's fauna populations (Warshall, 1989). Problems with bird predation, on the other hand, are reportedly on the rise; as the lower rainfall supports a less abundant store of wild food, birds increasingly turn to farmers' fields for their meals. In villages where faster-maturing crop varieties are just being

[190] Kremer and Sidibé (1991) report cases of pesticide poisoning from the inappropriate use and handling of chemical agents. Research from Kenya underlines the extent of health hazards which agrochemical pose to small-scale farmers (Mwanthi and Kimani, 1993). Such incidents can be expected to increase with the rise in prevalence and use of agrochemicals, especially as some of the recommended treatments promoted by the extension service include the use of highly toxic substances (e.g., *Sijolan Rouge*, which contains chlordane and hetachlor)(OHVN, 1993b; Anon., 1993).

introduced, the less extensive plantings serve to concentrate the bird damage that would normally be dispersed over a greater area. It has been suggested that the early grain maturation of these varieties may also coincide with the migration patterns of some of the major pest species, thus making them targets of an even larger transitory population.

Table 16. Farmers' Principle Agricultural Production Problems: Past and Present.

Past		Present	
Men	Women	Men	Women
1. Locusts	1. Birds	1. Birds	1. Birds
2. Birds	2. Insects	2. Insects Storage Erosion	2. Insects Storage Fertility
3. Monkeys Insects Weeds	3. Monkeys	3. Rainfall Striga Fertility	3. Striga Locusts Erosion
4. Pigs (wild) Striga Drought/Excess	4. Locusts	4. Locusts	4. Rainfall Weeds Equipment Animals (domestic)
5. Manual Labor Mice Disease (crop)	5. Mice	5. Weeds Equipment Livestock	5. Land Labor/Time
	6. Pigs (wild) Striga Disease (crop) Equipment Drought	6. Animals (domestic)	

Chapter Summary

The examples provided in this chapter illustrate the relative impacts of the formal and informal systems on local production practices across the OHVN zone. The formal system of research and extension has had its greatest success in introducing technologies, such as animal traction and improved varieties of certain crops, that are either based upon materials or derived through procedures, which lie outside of farmers' ranges of experiences and resources. The formal system has also had some success in refining and reintroducing certain indigenously-developed management practices, such as the use of rock lines. In contrast, it is quite apparent that the informal system has been the major force in generating the stream of adjustments and improvements of the existing production systems that have allowed households to keep pace with major changes within their physical environment and economy over the past several decades. Farmers' efforts include the generation of entirely new management practices, as well as the 'salvaging' of useful bits of information and the adaptation of whole technologies developed by the formal system to fit their specific needs and conditions. In fact, the unintended, second-hand involvement of farmers in refining many of the technologies developed by the formal system has greatly expanded the level of contributions made by the formal system in the development of local farming systems. An examination of some of the underlying causes that have limited the formal system's impact is the focus of the next chapter.

CHAPTER VII. The Organization and Contributions of the Formal System of Agricultural Research and Extension

The two preceding chapters describe many of the internal dynamics of the informal system--farmers' knowledge, exchange of information, and processes of innovation--and summarize farmers' perspectives on the overall impacts that the formal and informal systems have had on local agrarian change. Farmers' observations presented in Chapter VI indicate that, on the whole, the formal extension and research system has played a relatively minor role in the changes that farmers have made in their management practices, a finding made all the more poignant by the fact that the farmers interviewed in this research reside in villages receiving some of the highest levels of input from the formal system. After describing the formal system of research and extension in terms of its organization and activities, the present chapter examines some of the reasons why it has failed to make greater contributions to agricultural change in the OHVN zone.

Up to now, reference to the OHVN has largely been regarding its geographical boundaries. Yet, structurally and functionally, the OHVN embodies several other dimensions that are of critical importance to fully understanding the dynamics of agricultural change in Southwestern Mali. Structurally, the organizational framework of the OHVN reflects an approach to rural development which has emerged from a unique blend of political/philosophical antecedents, patterns of financing, and development objectives (see Appendix D). Functionally, the OHVN and its major institutional partner, the *Département de Recherche sur les Systèmes de Production Rurale, Volet OHV* (DRSPR/OHV),[191] employ two of the more methodologically and organizationally robust approaches to agricultural extension and research, namely, Training and Visit system of extension (T&V), and Farming Systems Research (FSR), in attempting to better serve their 'client' population. The remainder of this chapter is divided into two sections: the first section examines how the organizations, charged with the primary responsibility of stimulating agricultural development within the OHVN zone, approach their tasks, and the second section assesses the results of their combined and separate efforts.

The Genesis of the *Opération Haute Vallée* (OHV)

In the early 1960's, under Mali's first independent regime, the agronomic potential of the *Haute Vallée* area received increased attention due, in large part, to a detailed study conducted by the Leynaud-Roblot Mission of 1960 (*Bureau de*

[191] The DRSPR is now know as the *Programme Système de Production et Gestion des Ressources Naturelles* (PSPGRN). However, reference to the DRSPR/OHV, which existed at the time that this research was conducted, will continue to be used throughout the remainder of the dissertation. This change in the DRSPR, and other initiatives, are part of the USAID-financed Strengthening Research Planning and Research on Commodities Project (SPARC), and related efforts (e.g., ISNAR's long-term support of IER's management capacity; the multi-donor Special Program for African Agricultural Research (SPAAR) program; and the World Bank-funded National Agricultural Research Project (NARP) initiative), which will not be covered in this dissertation. These initiatives are broadly aimed at improving agricultural research in Mali, and redressing the debilitating trend of individually-funded projects dominating the national research system agenda (a trend which was exacerbated in the mid-1980's by the adoption of structural adjustment policies, which virtually eliminated governmental support for national agricultural research. By the the end of the 1980's, 25 donor agencies were supporting over 50 separate projects, with IER directly managing less than five percent of the financial resources supporting agricultural research). Two of the major aims of the SPARC program are to decentralize the research system into six regional research centers (90 percent of the professionally trained research staff currently reside in Bamako), and eliminate the various Departments and restructure the IER around 16 research programs (USAID, 1992).

Développement de la Production Agricole, BDPA, 1960). Upon his return to France, Leynaud successfully lobbied the French government to begin funding a new development project in the *Haute Vallée* area, south of Bamako. Leynaud returned to Mali in 1964 to design the project, which the French *Fonds d'Aide et de Coopération* (FAC) began funding in 1965. In 1970, financial support of the project was turned over to the Malian government, with external assistance from the *Fonds Européen de Développement* (FED) in financing the *Action Tabac* operating in the area. During this early period of development in the *Haute Vallée*, the promotion of commercial crops shifted from cotton to peanuts to tobacco (Steedman et al., 1976).

In 1972, the *Opération Haute Vallée* (OHV) was officially recognized as an *Opération de Développement Rural* (ODR), part of the government's emerging strategy of promoting agricultural and rural development through the creation of semi-autonomous development structures constructed along agroecological lines (for a more detailed discussion on the emergence of the ODR approach, see Appendix D). Yet from the very beginning, the OHV was clearly an atypical product of the ODR formula. Unlike most of the other ODRs, which took a more sectoral approach to the development of specific commodities, the OHV lacked a narrowly-defined commodity focus. From the outset, the OHV attempted to embrace a much broader range of activities in its programming, to include: agricultural extension and research, rural health care provision, cooperative formation, road construction, and functional literacy training, in addition to a diversified range of livestock and cropping enterprises (Diallo, 1990). By the mid-1970's (due largely to pressure from the donor community to adopt integrated approaches to rural development)(e.g., UN, 1971), other ODRs in Mali also began to diversify and expand the range of services provided to farmers (see World Bank, 1974).

The OHVN Extension Program

Throughout the decades of the 1970's and 1980's, the OHV underwent a period of nearly continuous change (for a discussion on the organizational development of the OHVN, see Appendix E). Most of these changes involved the expansion of the OHV's geographic range of responsibilities, in addition to a number of internal re-organizations. These changes continued until the late 1980's, when there was a general restructuring of all the ODRs. At the same time the current 'Development of the *Haute Vallée*' (DHV) Project began, with financial support from USAID (USAID, 1988).[192] Under this current project, the OHVN extension program has organized itself around a set of specific technical themes and the use of the T&V approach to extension.

The Training and Visit (T&V) Approach[193]

Following the basic strategies of the T&V approach (see Benor et al., 1984), the OHVN relies upon a three-tiered, cascade system of organization (headquarter, *secteur, sous-secteur*) to deliver technical messages to farmers. Under the supervision

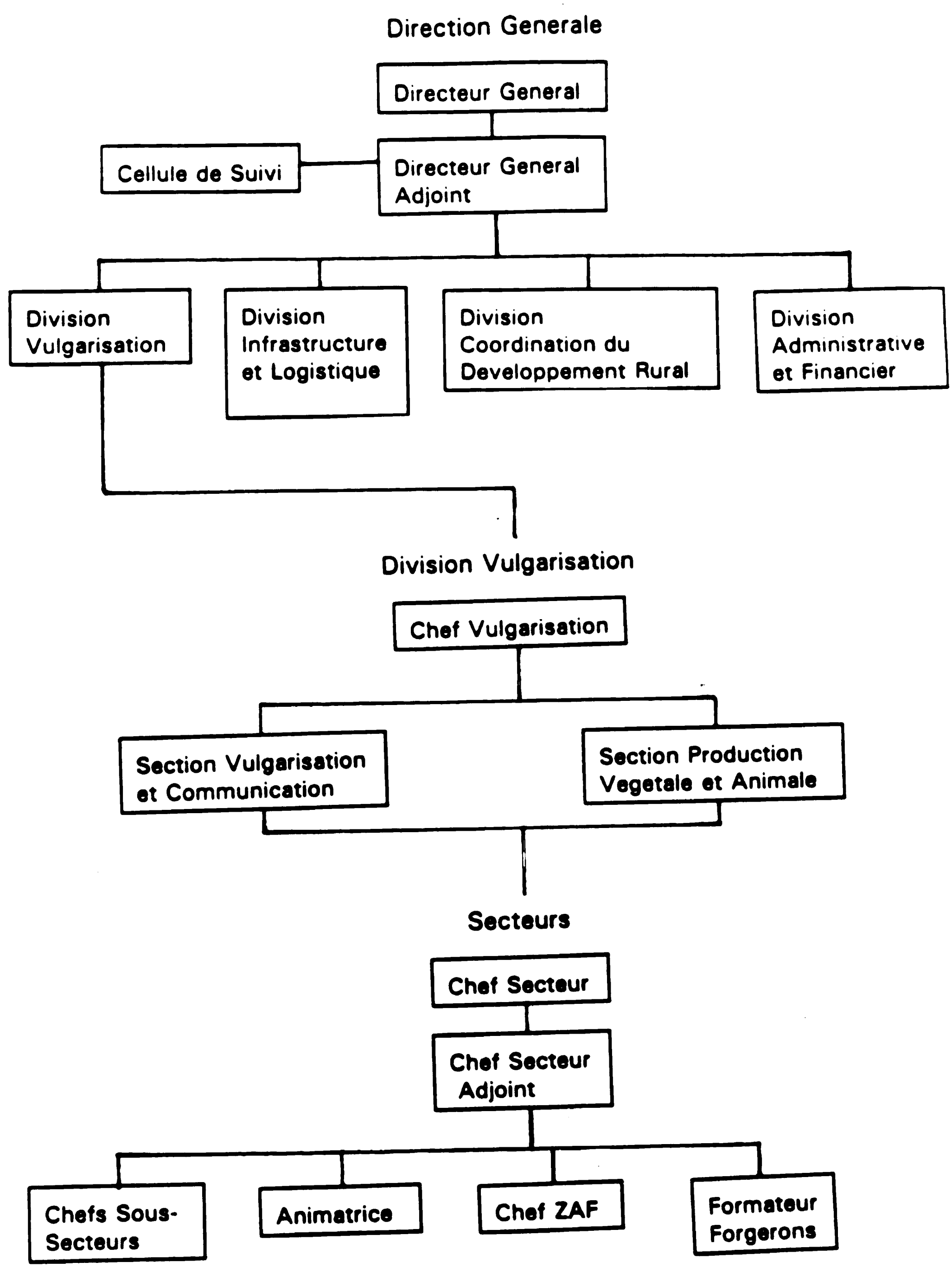
---

[192] To avoid confusion, the names of the USAID-funded projects--the Phase I *Opération Haute Vallée* (OHV) and Phase II Development of the *Haute Vallée* (DHV)--should be thought of as distinct and separate from the titles of the Malian ODR, the *Opération de la Haute Vallée* (OHV), and its subsequent elevation to the *Office de la Haute Vallée du Niger* (OHVN). While the former acronyms denote USAID funded projects, which include not only the financing of the ODR, but a range of additional activities as well, the latter acronyms denote the ODR's relationship to the national government.

[193] As part of a national initiative, the OHVN implemented the T&V system on an experimental basis in selected villages of the northern *secteurs* for a three year period, beginning in 1989. T&V is now the official OHVN approach in all of its northern *secteurs* (Boron, Banamba, Sirakorola, Koulikoro). However, in reality, the OHVN had been experimenting with a 'group' approach to extension since the mid-1980's, and presently uses the same T&V approach throughout the entire zone.

of the *Chef Secteurs* in each of the ten OHVN administrative *secteurs*, field agents, *Chef sous-Secteur* (CSS), follow a regular schedule of bi-weekly visits with village extension groups and *secteur*-level meetings. Technical support, and regular in-service training for field agents on new technical themes, are provided by the Subject Matter Specialists (SMS). The seven SMS positions are separated into two sections: Crop and Animal Production (agronomy; animal husbandry; crop protection; irrigation and mechanization; tobacco) and Vulgarisation and Women's Activities (extension; women's activities). In addition to providing support for field agents, the SMSs also serve as the principal contacts between the OHVN and the various governmental departments engaged in agricultural research.

Figure 20. Organizational Chart of the OHVN Administration.[194]



[194] Source: OHVN, 1991c.

<u>*Groupements de Vulgarisation*</u>. The CSS's principle contact at the village-level is the village extension groups (*groupement de vulgarisation*)(GV). By 1992, the OHVN reported the existence of 540 GVs in the zone (OHVN, 1992a).[195] The all-male GVs are limited to 10-15 members, in order to facilitate the efficient transfer of the technical recommendations. Under this system, the CSS works closely with contact farmers, or *paysans de contact*, who often manage demonstration plots as showcases for technologies contained in the OHVN technical package.[196] Such plots are featured in the annual village demonstrations held in many villages across the zone (local versions of the regionally-held farmer field days).

<u>*Villages Auto-Encadrés*</u>. One of the OHVN's ultimate goals for the GVs is their transformation into self-managed extension villages (*villages auto-encadrés*). Upon the review and recommendation of the *Chef Secteur*, the decision to elevate a village to *auto-encadré* status is based upon the number of farmers who follow the technical recommendations, as well as the competence of the village *animateurs*.[197] In the *villages auto-encadrés*, the village *animateurs* (who are not paid by the OHVN) assume nearly all of the regular extension duties previously handled by the CSS.

---

[195] Larger villages may have more than one GV. Some GVs are found in villages that have not yet organized an *association villageoise* (AV). Programmatically, there are no official connections between the GVs and AVs. However, many of the *paysans de contact* are also village *animateurs* who provide various services to the AVs.

[196] The OHVN reports that over 70 percent of the *paysans de contact* manage demonstration plots (OHVN, 1992c).

[197] By 1992 there were 44 *auto-encadré* villages. These were located in five *secteurs* of the OHVN zone. Nearly two-thirds (29) were located in the Oueléssébougou and Gouani *secteurs* (OHVN, 1992c), the heart of the OHVN cotton-producing area.

Journées Agricoles. In addition to the regular GV activities, the OHVN coordinates a series of annual farmer field days (*Journées Agricoles*). Farmers nominated to host the field day demonstrations receive several visits from the *Chef Secteur* and SMSs during the course of the season, to ensure that their fields are properly laid-out and managed. Seven *secteurs* conducted field days during the 1991-92 season, with reports of as many as 700 farmers attending in some cases.

Farmer-to-Farmer Visits. The OHVN, in coordination with the DRSPR and CMDT, have facilitated several farmer-to-farmer exchanges. Most visits have taken place within the OHVN and CMDT zones. However, some farmers have visited Niger and the '*pays* Dogon' in Mali to view soil and water conservation practices.

Through these visits, group meetings, field days, and other contacts, the OHVN estimates that over 26,000 farmers, or 9,000 of the 40,000 households in the zone, were contacted during the 1991-92 campaign (OHVN, 1992b). This includes the roughly 6,000 men who participated in the GVs (OHVN, 1992a), the 10,000 women contacted by the eight *Animatrices* during this same period (OHVN, 1992a), and over 4,000 people who attended the *journées agricoles*.

The Technical Content and Orientation of the Extension Program

The OHVN extension program is composed of seventeen technical themes (*thèmes techniques*)(see Table 17). These themes can be roughly divided into four areas of emphasis: crop production, animal production and management, natural resource management, and women's activities. Each theme is summarized by a series of individual technical sheets (*fiche technique*) which are distributed to field agents and serve as the basis for their discussions with farmers.

Overall, the core of the OHVN crop and animal production themes reflect a 'package' of well-known agricultural technologies, or '*thèmes classiques*' that have been the mainstay of agricultural development programs throughout West Africa for many years. (e.g., IRAT, 1975).[198] This package emphasizes the use of improved seed varieties, standardized cultural practices, the introduction of animal traction, and the increased use of purchased, in-organic inputs (fertilizer, herbicide, insecticide). In response to more recent concerns for sustainable agriculture, natural resource management, and gender issues, the OHVN has begun to introduce supplementary recommendations covering these issues as well.

Table 17. The OHVN *Thèmes Techniques*.[199]

1a. Promotion of Improved Cotton Varieties	1b. Promotion of Improved Cereal Varieties
2. Use of Animal Traction with Improved Cultural Practices	3. Use of Animal Traction with Improved Varieties
4. Improved Cultural Practices	5. Understanding and Use of Fertilizer
6. Soil and Water Conservation	7. Market Gardening
8. Animal Fattening	9. Use of Improved Fallow
10. Use of Compost	11. Animal Nutrition and Health
12. Improved Stables	13. Animal Husbandry--Women
14. Use of Pesticides	15. Use of Herbicides
16. Field Measurement	17. Improved Animal Corals

[198] See the *Memento de l'Agronome* (CIRAD, 1980), or the *Memento Techniques Culturales* (IER, 1990). The International Labor Organization (ILO) assembled many of these technical packages, which were largely based upon technologies developed under the colonial system, into manuals that served as the primary references of the ODR technical programs for years (Steedman et al., 1976).

[199] Source: OHVN, 1992a.

The OHVN extension program depends almost exclusively upon the *Institut d'Economie Rurale's* (IER) Production Systems Research Program, DRSPR *Volet OHV* (DRSPR/OHV)(the USAID-financed farming systems research program operating in the OHVN zone), for new technical information. The principle objective of the five-year (1986-1991) working agreement (*protocole d'accord*) between the OHVN and the DRSPR/OHV involved the preparation of a household classification scheme, as well as the identification of recommendation domains, which could be used by the extension and research system to target technical recommendations for different household types and different agroecological areas.[200]

Other Affiliated Programs

In addition to the OHVN extension program, there are a number of other organizations operating within the zone which provide farmers with additional information and material. Several governmental and international agencies are directly affiliated with the OHVN, and have established working agreements to carry-out their activities in limited collaboration with the OHVN extension program. Other Malian governmental departments, as well as a range of projects supported by foreign governments and international agencies, and a number of domestic and international non-governmental organizations (NGOs), also conduct activities in the OHVN zone, but do so independently of the OHVN (see Appendix F). The four principle programs affiliated with the OHVN technical services are the FAO Seed Multiplication Program,

[200] This task was first called for in the Eighth Amendment in 1983 (see Appendix E), but a number of difficulties delayed its completion. Based upon OHVN-DRSPR studies between 1984-1986, a classification scheme was developed that used animal traction and equipment ownership as its primary criteria (OHVN, 1986). In 1991, the DRSPR developed a modified typology that accounts for additional social and economic indicators (see DRSPR/OHV, 1992c; Yeboah et al., 1991).

the pilot *Agrométéologie* program, the Peace Corps, and the German *Projet Agro-Ecologie* (PAE).

The FAO Seed Multiplication Program promotes the decentralization of seed multiplication as a means to improve farmers' access to new crop varieties. Under this program, participating farmers in six villages produce improved local varieties of cereals and cowpeas for sale at a guaranteed price. In each village, an eight-member management committee (*Cellule Semencier*) oversees the multiplication and distribution activities for the producers.[201] With some logistic support from the Program, OHVN agents assist in the distribution of seed and perform some limited monitoring duties. The program offers participating farmers credit to cover the production costs of seeds, fertilizer, and insecticides. The AVs in participating villages are also provided credit to purchase the improved seed produced by farmers, as well as sacks and insecticides for storage, and a thresher and oxen cart. In addition, the Program provides the funds and materials to build a warehouse for seed storage.

The objective of the pilot *Agrométéologie* program is to help farmers increase agricultural production by improving their ability to make better planting decisions. Using 30 years of locally-collected rainfall and yield data, the Program's recommendations are based upon an 80 percent probability of farmers harvesting a crop if the recommended planting dates are followed. Starting approximately ten years ago with 16 farmers, or *paysans observateurs*, in four villages in the Bancoumana *secteur*, the Program now involves 84 farmers throughout the OHVN zone (i.e., village *animateurs*). Each *paysan observateur* records daily rainfall and delivers this information to the OHVN *secteur* office every ten days for transmission to Bamako via

[201] This committee is generally comprised of AV bureau members.

program-supplied radios. The Program also collects planting and yield information (collected by OHVN field personnel) on sorghum, millet and maize production from nearly 950 farmers who belong to *Agrométéologie* contact 'groups' (i.e., OHVN extension groups) in villages throughout the zone. Fifty-five of the *paysan observateurs* received bicycles from the project to facilitate the delivery of data to the OHVN *secteur* offices (D.N.M., 1992).

As part of the Africa Food Systems Initiative (AFSI), Peace Corps/Mali posts volunteer 'teams' composed of specialists in education, water, agriculture, natural resource management, and small enterprise development. The agriculture, water and natural resource management members of these teams are assigned to work with the OHVN.

The German-financed (DED) *Projet Agro-Ecologie* (PAE) manages a series of farmer-assisted trials in five villages in the Oueléssébougou *secteur*. In each village, project staff members work with farmer groups (four person *équipes technique*) on expanding the use of soil and tree conservation techniques. The staff also carry-out limited field trials, such as direct seeding of various indigenous tree species, and the use of neem extracts as a pesticide on cereal and cotton crops. In support of the OHVN program on natural resource management, DED has provided in-service training for the Oueléssébougou *Chefs sous-Secteurs* in the use of GRAAP (*Groupe de Recherche d'Action et d'Appui à l'Auto-Promotion*) community resource management techniques. In 1993, the DED and OHVN extended the PAE agroecology project to the entire OHVN zone.

The DRSPR/OHV Farming Systems Research (FSR) Program

Created in 1986 with USAID financing, the *Département de Recherche sur les Systèmes de Production Rurale, Volet OHV* (DRSPR/OHV), is the most recent addition to the national research system operating within the OHVN zone (see Appendix G). The DRSPR/OHV's primary responsibility to provide support to the *Institut d'Economie Rurale* (IER) in developing agricultural technologies "relevant to farmers' needs and circumstances," and to promote the effective transfer of these technologies through improved linkages within the research system and between research, extension, and farmers (USAID, 1984:1).[202]

Since its inception, the DRSPR/OHV has conceived of and carried out a full program of annual on-farm research and *pre-vulgarisation* trials, in addition to conducting a number of base-line household economic and sociological studies (e.g., DRSPR/OHV, 1993c). These activities have taken place within a network of research and *pre-vulgarisation* villages. Based upon the results of a rapid reconnaissance of the project zone, conducted in 1986, the DRSPR/OHV identified four distinct geographic areas, or recommendation domains, composed of households which face similar production conditions (e.g., soil, climate, among others)(SECID, 1987). Within these domains, the research program currently operates five research villages (reduced from eight, following recommendations from the first project evaluation)(van Shaik et al., 1991). Using criteria that are heavily oriented towards farmers' levels of equipment ownership, researchers select and negotiate annual contracts with a number of farmers

[202] The USAID FSR project supported the creation of two FSR field units, and the transfer of the national DRSPR headquarters from Sikasso in the CMDT zone to the Sotuba research station just outside of Bamako. In 1986, the first field unit, the DRSPR/OHV, was created, followed in 1991 by the creation of the DRSPR/Mopti (USAID, 1984).

in each research village to participate in that year's on-farm field trials and household economic studies (see DRSPR/OHV, 1990b, for selection criteria).[203] Researchers either install the trials in farmers' fields, or provide farmers with the necessary inputs and managerial guidance. Technologies that perform well in the research village trials are moved to a one or two-year phase of *pre-vulgarisation* on-farm testing. When conducting trials in the *pre-vulgarisation* villages, OHVN extension agents select participating farmers based upon researcher-supplied criteria. Depending upon the results of this phase, a new technical recommendation and in-service training program may be prepared for the OHVN field staff. To date, the DRSPR/OHV has prepared a farm household typology (see Table 20) and 16 *fiches techniques* (see Table 18) in support of the technical themes of the OHVN extension service (DRSPR/OHV, 1993b).

Table 18. New *Fiches Techniques* Developed for Extension by the DRSPR/OHV.[204]

-Improved Animal Corrals	-High Protein Flour (niébé & cereal)
-Improved Decortication of Cereal Grain	-Substitution of Soy in Making Soumbala
-Assisted Natural Reforestation	-Use of Living Fences
-Tree Planting Techniques	-Village Woodlots
-Use of Micro-Catchments for Tree Planting	-Reinforcement of Banks Along Waterways
-Rock Barriers	-Rock Barrages
-Rock Walls	-Rock Lines
-Use of Tied-Ridges	-Tree Wind-Breaks

[203] As described by one farmer, these participants are typically selected from a group of possible 'volunteers' nominated by the *Chef de Village*.

[204] Source: DRSPR/OHV, 1993b.

Each year the results from the research and *pre-vulgarisation* trials are written up and discussed in meetings with the other DRSPR sections (*volets*), and during joint technical review and planning sessions held between DRSPR/OHV researchers and OHVN Bamako staff. Research results are also presented at the annual Regional Technical Commission (*Regional Commission Technique*) meetings of the IER,[205] during which time research proposals for the coming season are also presented, and final decisions are made regarding which trials will be funded. Farmers input on the research agenda is solicited through annual village evaluations conducted in each of the research villages. These evaluation sessions are open to both participating and non-participating farmers, who can provide 'feedback' on the technologies being tested, as well as make additional suggestions on new areas of research.

The Prioritization of the Research Agenda

The DRSPR/OHV has conducted several studies to help identify farmers' principal production constraints. These data, obtained from surveys conducted in 1988 and 1990, have been translated by researchers into a series of research themes, and then prioritized on a three-tiered scale (see Table 19)(DRSPR/OHV, 1990b). Annual research trials are then designed to respond to these themes, e.g., herbicide trials have been used to address farmers' concerns over weeds.

---

[205] The long-term research agenda of the IER is determined through the tri-annual meetings of the *Commission Nationale de la Recherche Agricole*, while decisions on the funding of specific research trials of the various program are made at the annual IER *Commission Technique* meetings.

Table 19. Farmers' Constraints and the DRSPR/OHV Prioritization of Research Themes.[206]

Farmers' Constraints	Percentage of Farmers Reporting Constraint	Research Themes	Priority Level
Weeds	49	Labor for Weeding	1
Rainfall	39	Soil Fertility and Fertilizers	
Lack of Fertilizer	22	Poor Yields of Intern-cropping Associations	
Soil Infertility	19	Animal Husbandry	
Lack of Inputs	18	Disease, Insects, and Birds	2
Birds	11	Planting Dates	
Lack of Draft Animals	10	Crop Storage & Human Nutrition	
Nematodes	7	Animal Traction	
Insects	5	Alternative Sources of Revenue (women)	
Labor Shortage & Seeds (varieties)	4	Rotations and Land Management	3
Disease & Wind	2	Soil Preparation	
		Seeding	
		Plant Densities	
		Labor at Harvest	

Resource Characterization

The research program has characterized both the physical resources and the economic status of households within the OHVN zone to help target its research efforts. The principle objective of the first OHVN-DRSPR research agreement was to improve the ability of the OHVN to direct its technical recommendations toward specific groups of farmers across the zone. The resulting farm household typology

[206] Sources: DRSPR/OHV, 1990b; 1993c.

consisted of a four-part categorization, based primarily upon levels of household equipment ownership (e.g., OHVN, 1986).[207] In 1991, a second, and more refined, typology was developed by the DRSPR/OHV (Yeboah et al., 1991; DRSPR/OHV, 1992c), consisting of three categories and, as with the previous typology, based largely upon the criteria of livestock and equipment ownership (see Table 20).

Table 20. The DRSPR/OHV Household Typology.[208]

Group Level	Group Descriptions		Percentage of Population
1	UBT[209]	$\geq$32	3.5
	Draft Animals	$\geq$6	
	Plows	$\geq$2	
	Other Equipment	$\geq$1	
2	UBT	4-32	20.5
	Draft Animals	$\geq$3, but	
	Plows	$<$5	
		$\leq$2	
3	UBT	$\leq$4	76.0
	Draft Animals	$\leq$2	
	Plows	$\leq$1	

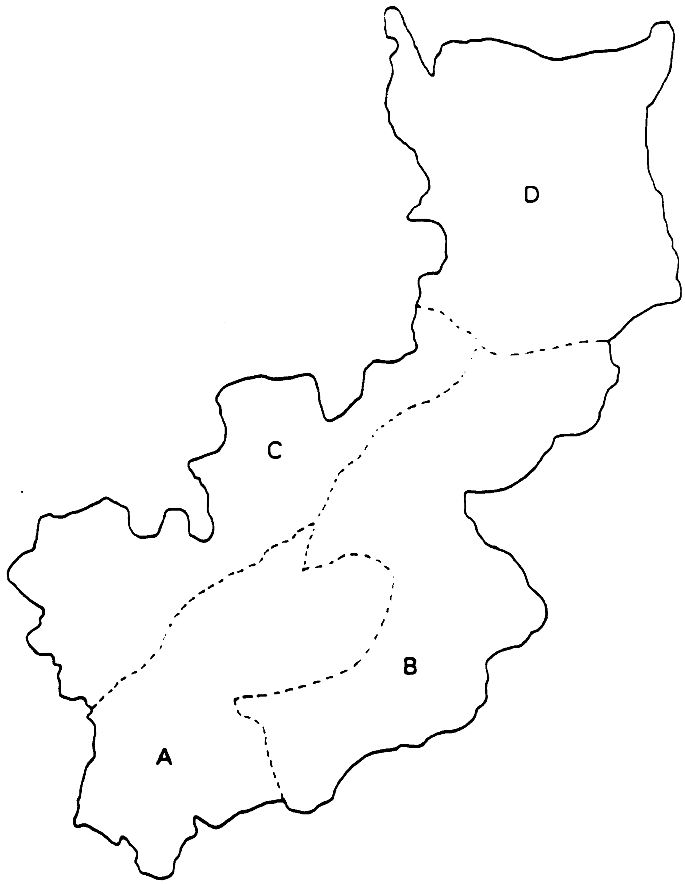
In 1986, one of the first initiatives of the DRSPR/OHV project was to identify a number of recommendation domains (North, South, East and West), representing areas with similar production conditions throughout the OHVN zone (SECID, 1987)(see Figure 21). The recommendation domains were used as the basis for identifying and establishing the research and *pre-vulgarisation* villages used by the DRSPR/OHV in conducting its on-farm research program.

[207] Knowingly or not, this typology was virtually identical to that developed by OACV in the 1970's (e.g., IER, 1977).

[208] Source: DRSPR/OHV, 1993a.

[209] In this unit of measure, the *Unité Bétail Tropical* (UBT), one cow is equal to .7 UBT, and one sheep or goat is equal to .12 UBT (DRSPR/OHV 1993a).

Figure 21. The DRSPR/OHV Recommendation Domains.[210]



Other Regional and Private Sector Research Efforts

In addition to the many GOM research units, and the regional ICRISAT program, there are several other minor research programs active in the OHVN zone. The major input supply companies, such as Comadis and Ciba-Geigy, separately and in collaboration with one or more IER research units, conduct their own research trials within the zone. These efforts typically emphasize on-farm fertilizer, pesticides/herbicides, and varietal and equipment trials that serve as both research

[210] Source: DRSPR/OHV, 1990b.

experiments and farmer-managed demonstrations of the company's products. As mentioned previously, the German-supported agroecology program and Dutch-supported FAO agroforestry program in Banamba also conduct limited on-farm trials. In all, during the 1991-92 agricultural campaign, the OHVN estimated that over 170 individual trials and experiments were carried out in the zone by various governmental and non-governmental research units (OHVN, 1992a).

Assessment of the Formal System's Activities

The remainder of this chapter assesses the combined and separate efforts of the formal research and extension programs. When examining the contributions to agricultural and rural development generated by the formal system, it is important to consider at least three different points of view. One perspective, which was the focus of the previous chapter, is that of the 'target population'--the perceived benefits and impacts that farmers associate with the efforts of formal institutions. Although farmers may not be fully aware of a program's overall goals or mission, as shown in Chapter VI they are acutely aware of both the changes that have occurred in their production systems, and the ability of extended technologies to meet their perceived needs. A second major perspective is that of the implementing institutions themselves--the self-reported impacts and accomplishments of their various initiatives. The third major perspective is that of outsiders--those not directly affiliated with the institutions or local social systems in question, but who are called upon to evaluate or analyze an organization's activities. The remainder of this chapter reviews the latter two perspectives: the self-reported achievements and the observed performances of the

OHVN extension service[211] and DRSPR/OHV research programs. The focus in these discussions is assessing the relevancy of OHVN technical themes to farmers' needs, the efficacy of the T&V system in communicating these messages to farmers, and the ability of the DRSPR/OHV to develop new material appropriate to farmers' conditions throughout the OHVN zone. The major features of the physical production environment, household resources, and farmers' needs for adaptive and highly diversified managerial responses, discussed in previous chapters, all serve as critical features in assessing the extension and research system's activities.

The OHVN's Technical Program

The lack of new extension messages has long been a major weakness of the OHVN extension program (Bingen, et al., 1993; Kagbo, 1986; Lebeau, 1986; OHVN, 1988; OHVN, 1989; OHVN, 1991a; OHVN, 1991b; Sélingué, 1992; RONCO, 1985; USAID, 1982; 1986). Although the extension program is no longer directly involved in technology generation (research responsibilities were transferred out of the OHVN with the creation of DRSPR/OHV), the role of the OHVN in helping to define the DRSPR/OHV research agenda, as well as in compiling new technical information, preparing *fiches techniques*, and targeting these messages to specific groups of farmers, is still central to the evolution of the technical program.

The annual reports of the IER *Commissions Technique* meetings, as well as other *Ministère de l'Agriculture de l'Elevage et de l'Environnement* reports, contain a

[211] This chapter limits itself to the accomplishments of the OHVN technical program. It does not cover the wider array of related DHV project components, such as functional literacy training, rural road construction, credit, AV formation, and so on, except where these directly overlap with elements of the technical program. A discussion of the larger range of issues of the DHV project is found in Bingen et al. (1994), and Kingsbury et al. (1994).

wealth of information on a wide array of research topics. However, there is no evidence that any of these research results have found their way into the OHVN technical program. The SMSs, whose task is to collect results from the various research programs in Mali, as well as regionally, and use this information to strengthen the OHVN technical program, have been relatively ineffective. As the head of the OHVN extension division has noted, "difficulties in extension obtaining research results" is one of the major constraints of the OHVN program (Sélingué, 1992; OHVN, 1992c). The OHVN has made strides towards catching up with farmers' current practices only recently, with the introduction of technical material on gardening, use of living fences, agroforestry and grafting techniques

Appropriateness and Technical Coherence. Despite the projected image of the overall popularity of the OHVN's technical messages,[212] farmers, field agents and others identified a number of problems with the orientation of the program, and with specific themes in particular. In response to survey questions, nearly 70 percent of the OHVN field agents noted that either economic constraints (high purchase price of input vs low

[212] In their annual reports covering the five year period between 1989-1993, the OHVN cites adoption rates for 15 of their 17 technical themes that range from 100 percent to nearly 1500 percent above project goals (i.e., OHVN, 1992a; 1993a). Aside from the immediate question of how these project goals are set, there are other, more serious, questions pertaining to the way in which the data supporting these claims are collected. For example, the adoption rates for themes such as *parcs ameliorés* include structures that were constructed as demonstrations under the DRSPR/OHV research program, and which were given to specific individuals and villages after completion of the trials. Other themes, such as the use of animal manure for fertilizing fields, use of living fences, or construction of ridges, are longstanding traditional practices whose continued use can hardly be attributed to the efforts of the extension service. Furthermore, the promotion of such technologies as AT and the use of inorganic inputs (fertilizers, herbicides and pesticides) have benefited from the significant involvement of GOs and NGOs working in the OHVN zone, not to mention the commercial input suppliers.

sale price of produce, and lack of access to credit) or perceived shortcomings of certain aspects of the technical package, when compared with current practices, keep adoption rates low. A similar percentage of field agents reported difficulties in getting farmers to adopt the improved crop varieties being offered, citing problems such as poorer yields and taste, and higher levels of susceptibility to pests and weed pressures, when compared to local varieties. Economic analyses of the use of insecticides, ultra-low volume sprayers (Jago et al., 1993) and inorganic fertilizers in cereal production (King, 1986), the use of mechanical seeders (Jager, 1986), and the *parc amelioré* (McCorkle et at., 1993) show that these technologies are generally uneconomical for small-scale farmers in the Sahel, yet they continue to be strongly promoted through the current technical program.

Other recommendations within the OHVN extension program reflect significant internal contradictions. It is apparent, for instance, that with the addition of new themes on natural resource management, the older *Thèmes Classiques* have not been reviewed for their continued relevance and compatibility. For example, farmers for years have largely ignored the technical recommendation of flat plowing their fields. A recent study (SRCVO, 1992) tentatively confirmed that farmers' preferred practice of ridge plowing is more effective in conserving soil moisture (a major production constraint, especially in the northern half of the zone) than flat plowing. Furthermore, ridge cultivation requires less labor and, when used along the contour, helps to reduce soil erosion. The major emphasis in the OHVN technical program on encouraging farmers to increase their levels of mechanization (another of the *Thèmes Classiques*), including the use of mechanical seeders, poses additional inconsistencies. Farmers using these seeders are not only obliged to flat plow their fields, but must also remove the majority of crop stubble in order to keep the seeders from jamming and skipping.

Removal of crop residue, however, further reduces a field's soil and water conservation capacity, and removes a major source of soil organic matter.[213] In sum, the standing recommendation on mechanization and flat plowing, as currently extended, reflects serious incompatibilities with the newer themes on soil and water conservation.

Targeting. Despite the identification of recommendation domains and the development of a household typology by the DRSPR/OHV, there is no evidence that either of these tools have ever been used by the extension program in targeting its technical recommendations to specific farm-level conditions. In general, there is no recognition within the extension program of the range of, and differences in, the 'portfolio' of economic activities relied upon by households in various parts of the zone. Furthermore, most of the *fiches techniques* do not contain the type of information that would allow them to be targeted to specific areas or conditions, e.g., the *fiches* on varieties do not contain information on preferred soil types or rainfall requirements. A 1992 internal draft report on the extension program notes that "one can remark that in general the *thèmes* are disseminated without consideration to where they are pertinent (or expressed as needs by farmers)"(Anon., 1992). For example, the use of fertilizer is one of the most widely popularized *thèmes* and has been extended to a majority of the GVs in the zone, including 62 percent of those in the Banamba secteur. However, less than 5 percent of the farmers in each of the northern *secteurs* (Sirakorola, Banamba, Boron) have adopted the *thème*. For farmers in Boron *secteur*, neither the OHVN nor private banks provide production credit for the purchase of

[213] In addition to soil and water conserving attributes, crop residues also help to lower surface temperatures and ground wind speed, important factors during early crop establishment.

inputs because of the high risks involved. In addition, farmers in these areas produce very little cotton or maize, and the use of inorganic fertilizer on millet and sorghum in such high-risk environments has long been recognized as unprofitable (e.g., King, 1986; DRSPR/OHV, 1988a).[214]

With respect to those technical *thèmes* which do enjoy widespread usage (e.g., animal traction), the OHVN has needlessly limited itself in the scope of its intervention. For example, the technical recommendations on animal traction (AT) have been limited solely to the use of bullocks, whereas farmers in the OHVN zone rely upon both horses and donkeys, in addition to bullocks, in performing field operations (e.g., DRSPR/OHV, 1991a). In fact, in areas of the far North, the importance of these alternative forms of AT far outweigh that of bullocks. After nearly 30 years of intervention, neither the research nor extension service has broadened its conceptualization of AT to include other sources of draft power in promoting its potential.[215]

Under the First DHV project amendment (USAID, 1993)(see Appendix E), the OHVN has added an agri-business section to its programming. Although the production and export of fruit and vegetables to Europe has been a recurring theme in the *Haute Vallée* area since the early 1960's, there is no evidence that these current efforts will expand beyond the traditional garden market areas surrounding Bamako. The 'targeting' of farmers involved with this effort is largely determined by the type of

---

[214] It has been suggested that the early vegetative growth promoted by fertilizer use (in phosphorous deficient environments) increases the plant's moisture demands and may actually make it more vulnerable to drought damage caused by the common irregularity of the early rains. However, there is no agronomic data to support this claim.

[215] Through the mid-1970's, lightweight plows suitable for use with donkeys had been imported and sold to farmers in the Mopti area by the Catholic mission. Virtually all other plows made and sold in the country are of heavier construction, intended primarily for use with bullocks.

crops selected for export (e.g., mango's and green beans), and the transportation and transaction costs associated with their marketing (not to mention marketing and political contacts), rather than an explicit attempt to provide additional income-generating alternatives for farmers in a specific area of the zone. Unless a concerted effort is made to develop cash crop opportunities for farmers in the drier northern areas, as well as the more remote areas of the South, these farmers will continue to benefit little from the OHVN extension program, and from these new efforts in particular.

The T&V Approach

Criticism of the OHVN extension service for its failure to stimulate greater agricultural change within its zone of intervention dates to the beginning of USAID's investment (e.g., Bingen et al., 1994; RONCO, 1985; USAID, 1982). While such criticisms have identified serious shortcomings in the program's performance, it is also important to note that throughout its history the OHVN has received very little technical assistance (TA) for the development of its extension programs.[216] In the absence of innovative leadership, the OHVN has focused most of its attention upon increasing the level of regimentation in its programming and establishing tighter control over its field staff through the T&V system. In many respects, the hierarchical nature of the T&V system, and the authoritarian style with which it has been implemented,

[216] Under Phase I of the project, no TA was budgeted for extension. Under Phase II, while extension TA was budgeted, the first technical advisor left after a few months due to health reasons; the second person filling this position was asked to leave after a year (for both personal and professional reasons). Neither of these individuals were able to accomplish much in the way of helping the extension program improve its activities. Following the departure of the second extension advisor, the position was terminated, and the remaining TA funds were re-allocated to other areas.

is responsible for many of the shortcomings that the program has experienced in providing farmers with relevant technical assistance.

The Flow of Information. The effectiveness of the T&V approach depends largely upon the continued flow of new and relevant technological innovations from the research system to farmers, as well as a return flow of farmers' feedback and observations to researchers (Benor et al., 1984). Although the OHVN extension program has made great strides in streamlining its activities and monitoring the actions of its field agents, the program has continued to experience a number of difficulties in the preparation and distribution of new technical materials in support of its field staff. As of the 1992 season, the subject-matter specialists (SMSs), who are charged with the preparation of new *fiches techniques*, had developed very little new extension material since their installation in 1987 (the major exception being a collection of *fiches* on gardening, which had yet to be distributed to field agents). Apart from their ties with the DRSPR/OHV research program, there is no evidence that individual SMSs, or the extension program as a whole, make any use of other sources of information in attempting to improve the technical program. This includes any appreciation of farmers' extensive agricultural knowledge. On the contrary, farmers and their knowledge are generally perceived as one of the major obstacles in the advancement of the extension program, and in dire need of 'sensitization' to more 'rational' practices. One result of this underutilization of the available information resources is that the extension staff remain poorly informed about recent advances in their areas of specialization, and are unable to both improve the program by building upon farmers' wisdom, or make informed demands upon the research unit in developing new technical themes.

In addition, the availability of material on the existing technical themes is poorly managed; even the sector offices do not have complete sets of the *fiches techniques*. Out of six sector files examined, one contained no *fiches*, three contained approximately a dozen, one had nearly two dozen *fiches* on eight to ten themes, and another had quite an extensive collection. Most of the *Chefs sous-Secteur* have little or no written information on the technical recommendations. One agent responded in the questionnaire that "I deplore the total lack of *fiches techniques* on the different themes. Extension agents are asked to pass on the technical themes without anything written. In my opinion no one can know all about the themes without a minimum of documentation." A complete collection of the *fiches* could not even be assembled at the OHVN headquarters.[217]

There is little evidence that field agents communicate farmers' needs and feedback to researchers, or exchange experiences among themselves (nor is this a new problem; see, e.g., USAID, 1982; Ronco, 1985; Kagbo, 1986; Lebeau, 1986). In their questionnaire responses, over 45 percent of the field staff reported knowledge of a local variety or indigenous practice that, in their judgement, was superior to the technical recommendations being extended to farmers. Yet of these individuals, fewer than 12 percent (<7 percent of all field agents) reported passing this information on to others in the extension service, or to researchers.

The present administrative structure and prevailing organizational culture within the OHVN inhibits extension personnel from sharing their experiences and contributing to the development of the program. The program currently does not have the capacity to capitalize on extension agents' knowledge or creativity, either through an

[217] Over a year after these observations were made and reported to the OHVN and USAID, the situation had remained unchanged (e.g., McCorkle et al., 1993).

institutionalized channel of information exchange, or even in the basic recognition that such exchanges are a good and necessary part of the organization's development. As a 1985 evaluation of the program observed, "such innovation [on the part of field agents] is positively discouraged by the present heavy-handed, centralized system" (RONCO, 1985:98). The monthly planning meetings of the *Chefs Secteur* and the OHVN administration are a case in point, as well as a reminder that little has changed in how the organization is managed. These meetings often involve the open debasement of individual agents for their lack of progress in certain areas, and are in no way managed to solicit feedback from the field staff. In the words of one *Chef Secteur*, "these meetings block the advancement of the OHVN."

Rather than trying to understand why things are not working and attempting to make improvements in their technical messages, the OHVN administration places a premium upon reporting adoption figures that continue to support the image of a 'successful' program. For example, in reviewing the results of the 1991 agricultural campaign, the OHVN reported that the two themes with the lowest adoption rates would receive increased emphasis during the next year; however, no effort was made to examine why adoption rates were so low (OHVN, 1992a; Kingsbury, 1994). This singular focus on adoption rates prevents the organization from identifying the larger and more serious problems associated with the inability of the extension program to meet farmers' needs.

<u>Groupement de Vulgarisation</u>. Over 6,000 contacts were reported between field agents and members of the *groupement de vulgarisation* (GV) during 1991 (OHVN, 1992a), yet a majority of the *Chefs sous-Secteur* report considerable difficulty in convening GV meetings. When GV meetings are held, attendance averages six farmers, less than one-

half of the established upper limit for meetings (15 persons)(Anon., 1992). Moreover, the same farmers do not attend on a regular basis; GV membership tends to 'roll' as members attend a few meetings and then drop out. It is estimated that only 400 of the officially reported 538 GVs actually exist and hold regular meetings (Anon., 1992; OHVN, 1991a).[218] In support of this observation, farmers in five of the eleven villages visited in this study maintained that there was either no GV in their village, or that they had not seen an OHVN field agent in over a year. The GV attendance problems are closely linked to, and indicative of, the static and marginally relevant nature of the technical information being communicated through the extension program. Some of the *Chefs sous-Secteur* at older posts report that the lack of new extension material (*fiches techniques*, video, radio broadcasts, etc.) is one of the main reasons why they are unable to attract more farmers to GV meetings. The farmers who do attend do so as a precaution against 'missing out on something,' rather than due to any known or anticipated benefits.

Role of the *Animateurs*. Many of the 3,400 *animateurs* trained by the project to provide administrative support to the *Association Villageoise* (AV) feel that they are being exploited as unpaid OHVN employees, induced to assume the duties of the former *Chefs de Base*. In many cases the villagers themselves view the *animateurs* as part of the OHVN system and not as part of the village structure. Because of the position's significant time requirements and lack of remuneration, *animateurs* in several

[218] If six farmers attend each meeting, and there are only 400 GVs operating in the zone, then the reported 6,000 farmers contacted through the GV meetings in 1992 over-report the number by 150 percent (Anon., 1992; OHVN, 1992a). This, and other examples, speaks to the larger issue of the lack of reliability in the OHVN self-reported statistics on their accomplishments. The number of reported GVs rose by nearly 50 percent from 538 in 1991 to 754 in 1992 (OHVN, 1991a; 1992a).

villages plan to abandon their positions, and admit that it will be difficult to recruit replacements under the current conditions.

These problems are most acute in the 50 *auto-encadré* villages (OHVN, 1992a), where *animateurs* are responsible for managing the extension meetings, as well as the activities of the AVs. *Animateurs* from these villages are required to attend monthly meetings with representatives from other *auto-encadré* villages in their *secteur*, in addition to attending regular extension training meetings at the *secteur* offices. They also play central roles in the operation of their AVs, which require them to collect orders for input supplies, make several trips to Bamako to secure loan agreements, place purchase orders, supervise the distribution of goods and collect loan repayments. Where collective agreements are made between several AVs, the *animateurs* must attend additional meetings to organize these collective orders, and negotiate the frequent discrepancies that emerge between the amounts ordered and those received. In many cases, *animateurs* may be away from their fields for over two weeks each month during the growing season, and may not even be compensated for all of their basic travel expenses (transportation, food, lodging)(cf. Kingsbury et al., 1994). Although the *animateurs* from *auto-encadré* villages usually receive some compensation from the AV for their efforts, this is not true for *animateurs* from all villages, and rarely is this compensation viewed as adequate to make up for their lowered agricultural productivity.

The trend of growing dissatisfaction among *animateurs* has serious implications for the future of rural development in the OHVN zone, especially as a growing number of development programs are beginning to shift their emphasis to community-based initiatives. Given the small number of literate and numerate villagers, most of the NGOs and other governmental projects already look to the *animateurs* as their village representatives or counterparts.[219] Any additional demands placed upon these individuals may result in a complete breakdown of the AV system upon which much of the development work occurring within the OHVN now depends.

Multi-Media Usage. Beyond the GV meetings, the extension program makes virtually no use of available media options to reach farmers. The vast majority of technical recommendations have not yet been compiled and translated into *Bamanan* for widespread distribution to farmers through the functional literacy programs. The OHVN's use of regular rural radio broadcasts, successfully used in extension programs in other Sahelian countries, e.g., Niger, is infrequent. The programs aired are generally produced by the public radio agency with little OHVN involvement.[220] An individual formerly in charge of this program stated that the OHVN was by far the least interested and most difficult ODR to work with, and, as a result, never made full use of the available programming options.

Although farmers and field agents alike reported the tremendous value of farmer-to-farmer visits, the use of such visits by the OHVN has been very limited--less than half a dozen over the past five years. In addition, farmers who have participated in these visits complain about the lack of follow-up which, in some cases, has forced

[219] For example, the *Agrométéologie* program relies upon the *animateurs* to collect data on rainfall and cereals production, and to transport these figures into the sector offices every ten days. The FAO seed multiplication program also depends upon the AVs and their *animateurs* to organize meetings, manage the financial accounts, and market the seed.

[220] During the 1991/92 season, the government radio station broadcast general programs dealing with such topics as cotton production, use of herbicides (on maize and cotton), animal husbandry, and the importance of renewing hybrid seeds. The television station also covered functional literacy training in Oueléssébougou and a farmer 'field day' in Kati.

them to abandon their attempts at adopting the very technologies they were taken to see. For example, farmers from one of the northern *secteurs* visited a research trial of a millet-sorghum intercropping system, which featured a dwarf variety of millet that was protected from bird predation by the taller stalks of a traditional bird-resistant sorghum variety. However, seeds of the dwarf millet variety were never made available to these farmers, even though many were eager to test this system in their own fields. After failing for two years in their attempts to get seed stock of this dwarf variety, farmers gave up their efforts. Farmers in one of the southern *secteurs* reported similar frustrations resulting from their visit to the CMDT zone.

Several other extension activities have failed to meet expectations. Although most farmers enjoy the annual *journées agricole*, they tend to feel that the ceremonial features, with high profile visits from Bamako dignitaries, have largely replaced the field day's role as an educational experience. Due to the disappearance of equipment in transit, the OHVN has been unable to implement its planned audio-visual program. Yet at the same time, the OHVN has not taken advantage of the $2.1 million FAO/PNUD-financed Centre for Audio-Visual Production Services to generate extension material (FAO, 1992).

<u>Focus on Women</u>. Increasing the level of women's involvement in the extension program is one of the major themes of the DHV project (USAID, 1986). Yet, fewer than a dozen *animatrices* are responsible for working with women across the entire OHVN zone (the isolated northernmost *secteur* of Boron was still without an *Animatrice* in 1992). Compared to the 80 *Chefs sous-Secteur* who work with male

farmers, the ability of the OHVN to reach women farmers is extremely limited at best.[221] Women, in several of the villages visited, repeatedly mentioned that their requests for assistance go unheeded. For those who are contacted, the extremely high farmer-*Animatrice* ratio makes it impossible to provide quality services. With such limited personnel, the OHVN cannot expect to carry-out a successful program that responds to women's needs and interests, particularly if these initiatives geared towards women remain separate from the regular extension activities. As it now stands, the *Chefs sous-Secteur* focus virtually all of their attention upon the all-male GVs, and spend less than one percent of their time working with women (OHVN, 1990a). With the addition of the *Animatrice* positions, the *Chefs sous-Secteurs* may feel even less compelled to increase their contact with women.

<u>Collaboration with Development Partners</u>. In its annual reports, the OHVN continues to highlight its linkage with an array of governmental research units and other development projects (e.g., OHVN, 1991a; 1992a; 1993a). In reality, the degree of inter-agency collaboration is generally confined to an official recognition that these organizations are present and conducting development activities within the OHVN zone. Even with programs with which the OHVN has established working agreements, such as the Peace Corps, *Projet Agro-Ecologie* (PAE) and the FAO Seed Multiplication Project, there is very little active collaboration between field workers of the OHVN and those of these other organizations. The Peace Corps volunteers interviewed were unanimous in their dissatisfaction with the working relations between themselves and

[221] The claim that the 11 *Animatrices* maintained contacts with 10,483 women farmers during the 1991 agricultural campaign (OHVN, 1992a), a figure approaching double the number of contacts made by the 80 CSSs contacted, serves to further place in doubt the reliability of the OHVN statistics.

the OHVN. The inflexible nature of the T&V approach provides virtually no opportunity for volunteers to contribute to the program's objectives. In instances where volunteers have attempted to assist village groups by working through the OHVN bureaucracy, they have met with little success. The PAE is another example of a program whose attempts at working directly with the OHVN have been unsuccessful. Hoping to improve the OHVN's ability to work directly with farmers and communities on addressing their natural resource management problems, the PAE provided specialized GRAAP (*Groupe de Recherche d'Action et d'Appui à l'Auto-Promotion*) training, a highly participatory group planning approach, for the entire Oueléssébougou *secteur* field staff. This training has yet to be utilized by any of the field agents, ostensibly because of both the difficulty of integrating this approach into the regular T&V calendar, and the lack of support from the OHVN administration in allocating time for these non-official, non-remunerative activities. The FAO Seed Multiplication Program operates in a bit more independent fashion than do the other OHVN affiliates. However, the program officer has also experienced more difficulties with the OHVN than with the other ODRs participating in the program. OHVN field agents were often negligent in carrying out the relatively simple tasks of monitoring the program's activities, and had provided little assistance in helping to distribute the seed stock of improved varieties produced by farmers in the multiplication villages.

The DRSPR/OHV Research Program

In attempting to contribute to agrarian change in the OHVN zone, the DRSPR/OHV has concentrated its efforts in three general areas that warrant consideration. The first is the development and use of various tools and guides to help the research and extension units focus their efforts, including the identification and prioritization of research themes, and the characterization of production environments and household production systems to help target research efforts. The second area is the creation and strengthening of a number of communication linkages to enhance the exchange of information and experiences between the DRSPR/OHV and extension, farmers, and other research and development organizations in Mali and beyond. The final area is the over-arching objective of generating new and useful technologies with the potential of improving the productivity and economic well-being of farm families residing within the OHVN zone, as well as the recently added objective of assisting farmers in sustaining their natural resource base.

The Identification and Prioritization of Research Themes. A number of inconsistencies exist between how farmers rank their production problems and the way in which the research program has interpreted and prioritized these in its research agenda. For example, farmers identified problems with water supply (both rainfall and flood waters) as one of the two most critical constraints in the production of five of their seven major crops (the other critical constraint being weeds)(Yeboah et al., 1991), and, as outlined in Table 19, cited water as the second most important overall production constraint (DRSPR/OHV, 1991a). In the research program's three-tier hierarchy of research themes, however, water shortage is currently defined only in terms of "planting dates," and is relegated to second-order status (DRSPR/OHV, 1990b).[222] To date, this theme has received almost no research attention. Other themes that were low priority for farmers, such as disease and insect pests, have been given much

[222] Earlier research had been conducted on the use of tied-ridges as a means of conserving soil moisture. However, this was abandoned after farmers complained of the high labor demands associated with the technology. The proposed research of developing mechanical alternatives for the 'ridging' process was never carried out.

higher rankings by researchers. Themes such as problems with intercropping yields and animal husbandry were not identified as constraints by farmers at all, yet have been given first priority by the research program. Similarly, the second priority themes of crop storage and consumption-related issues, and all of the third priority themes, were not perceived as problems by farmers.

Despite these inconsistencies, the way in which the formal system has chosen to respond to the identified research themes poses even more serious concerns. As expected, the first priority themes have clearly dominated the agenda of the field trials that have been conducted since the research themes were prioritized (59 of the 73 agronomic variables tested, see Table 21). However, in the majority of cropping system trials (42 out of 62), the variable examined was a purchased input--various fertilizers and pesticides. Such an emphasis is neither consistent with the economic abilities of the majority of households in the zone, nor with the environmental conditions--highly variable rainfall and disparate soils--that are found across the different areas of the zone.

Table 21. Variables Examined by the DRSPR/OHV Research Program (1990-91; 1991-92; 1992-93).[223]

Variable Tested (priority)[224]	1990-1991 (# of trials)	1991-1992 (# of trials)	1992-1993 (# of trials)	Total
Fertilizer (1)	8	5	7	20
PNT[225] (1)	6	2	8	16
Animal Husbandry (1)	2	3	3	8
Herbicide (1)	2	1	3	6
Intercropping (1)	2	2	2	6
Manure (1)	2	0	0	2
Mechanical (1) Weeding	0	1	0	1
Insecticide (2)	2	2	0	4
Sources of Revenue (2)	1	1	0	2
Crop Storage & Consumption (2)	1	0	0	1
Timing of Sowing (2)	0	1	0	1
Variety (3)	4	0	0	4
Fallow (3)	0	1	1	2

Research Targeting & Appropriateness. Despite the efforts of the DRSPR/OHV in identifying recommendation domains and creating a typology for differentiating between the financial status of areas households, there is no evidence in the project's annual reports and planning documents indicating that the household typologies or

[223] Source: DRSPR/OHV, 1991a; 1992a; 1993a.

[224] Each DRSPR/OHV research trial commonly examines several variables, e.g., comparison of varieties, effect of various fertilizers, and the evaluation of manual versus chemical weeding. The data summarized in Table 21 includes all the individual variables tested in each of the field trials run during the three research campaigns examined.

[225] PNT = *Phosphate Naturel de Tilemsi*

recommendation domains have been used in the targeting of research (DRSPR/OHV, 1988a; 1989a; 1990a; 1990b; 1991a; 1992a). One result has been that, on economic grounds alone, the major thrusts of the research program are inappropriate for the financial and physical resources controlled by most of the farmers in the zone (McCorkle et al., 1993). As shown in Table 21, the preponderance of research themes revolve around the use of AT and purchased inputs (inorganic fertilizer, herbicides and insecticides). Yet, the DRSPR/OHV's own research indicates that less than 25 percent of the households in the zone have the financial means and equipment necessary to take full advantage of these types of technologies (DRSPR/OHV, 1993a). In order for poorer households to begin using higher input technologies, they would have to increase their exposure to financial risk significantly by taking out substantial loans through their village association, or directly from the input suppliers (or informal lenders). The frequency of 'poor' harvests due to erratic rainfall and pest outbreaks, factors which are acknowledged by the DRSPR/OHV (e.g., 1993c) but which are rarely included in their sensitivity analyses of the different technologies, make such exposure inadvisable. This failure to explicitly direct research toward technologies appropriate to the economic conditions of the majority of farmers, or to areas where the particular technologies offer a viable alternative, significantly limits the research program's impact.

The near complete lack of women's involvement in the research program is another issue which is in direct contradiction to the realities of the zone. Women participate in the majority of agriculture activities throughout the OHVN zone, and provide a major share of the agricultural labor. Yet as indicated in the latest program evaluation (McCorkle et al., 1993), women have neither been included in the major surveys collecting baseline data, nor have they participated in the majority of research

and *pre-vulgarisation* trials (as with the OHVN extension program, the DRSPR/OHV has attempted to address women's concerns through a separate set of studies). Furthermore, their views are not represented in the annual farmers' evaluations. The fact that half or more of the zone's farmers are excluded from participating in the primary research and development activities means that the research program has again needlessly limited its potential impact (McCorkle et al., 1993).

The Conceptualization and Characterization of the Production Environment. There is virtually no evidence that researchers use the different recommendation domains to help focus research efforts. In addition, the range and inherent qualities of the resources within each of these areas are also overlooked. For example, there is no apparent appreciation for the basic characteristics of the region's rainfall patterns--its high temporal and spatial variability--in the research program's approach to technology development. Research results from poor years are typically treated as aberrations when testing new technologies, instead of as a feature of the environment to which new technologies must be responsive. Economic sensitivity analyses of the effects of rainfall variation on technology suitability, either using actual data from years in which field trials are conducted, or data from past years in a modeling program, are generally not conducted. This underappreciation of the importance of intra- and inter-annual variations in rainfall misrepresents a critical feature of the environment, and one to which farmers' welfare is directly tied. The technologies which have received the greatest attention in the research program, such as the use of inorganic fertilizer, are not economically viable under conditions of highly variable rainfall, which may explain in part the low adoption rates for many of the technologies.

Similarly, the current efforts geared towards helping farmers make better use of the available rainfall, e.g., the *Pilot Agrométéologie* program, fail to account for the essential characteristics of local rainfall variability. The recommendations issued through this program are based upon the use of decentralized rainfall monitoring at the village level. However, due to the highly disparate nature of local rainfall, farmers' fields, which can be several kilometers distant from the centrally-placed raingauges, often experience very different rainfall patterns. When coupled with differences in topography and the moisture-holding capacity of different soil types, such a simplistic approach is hardly appropriate, and probably one of the reasons why none of the farmers interviewed reported following the recommended planting dates provided by the project.

On the whole, the issue of water conservation has not received sufficient recognition. Even those themes introduced as part of the initiative on natural resource management that have water conservation potential, such as the use of various types of rock barriers, have not been acknowledged or promoted for their moisture-conserving capabilities. These technologies have been viewed solely as soil conservation measures, despite their well-known abilities to conserve water, which, in water deficit environments, can increase crop yields from 35-55 percent (Matlon, 1990), and up to 80 percent in drought years (Reiji, 1991).

Soil quality variance is another critical factor that is not addressed in the research program. Despite the fact that virtually every agronomic decision farmers make includes reference to the characteristics of the soil type being considered--its suitability for producing a particular crop(s) or variety, and its need for particular management practices--neither the research program nor the extension service have developed any kind of strategy for characterizing, incorporating, or using soil heterogeneity in their programming. Even the technical recommendations that promote the use of improved varieties fail to mention soil types as an important variable. The research program has chosen to focus on fertility management through the use purchased inorganic inputs, viewing soil as essentially an undifferentiated medium, an assessment which is neither accurate, nor economical.

The important differences between the major soil groups of the northern and southern parts, as well as the numerous localized variances in soil types within each of these areas, are ignored. Past research efforts in Mali, most notably ICRISAT's use of a soil 'toposequence' approach in running its varietal and intercropping trials, have taken a more holistic approach in characterizing and exploiting the soil environment (ICRISAT, 1979; Mulla, 1989). Unfortunately, such an approach has not been adopted by the current DRSPR/OHV program. More recent research findings indicate that an even more dynamic appreciation of the soil environment may be required in order to optimize soil management in environments with highly variable rainfall (Brouwer et al., 1993). This research has shown that some soil topographic features exhibit an inverse relationship in terms of their crop-yield response to rainfall, i.e., the least fertile soils may support the highest yields under poor rainfall conditions. The use of fertilizer on cereal crops, when indiscriminately applied, has repeatedly been shown to be uneconomical in environments with frequent shortfalls in precipitation, whereas the judicious application of fertilizer on crops in certain soils, even in very poor years, may be economical.[226]

---

[226] Interestingly, the development of 'precision farming' techniques in the United States has allowed large-scale, mechanized farmers to replicate many of the same types of individualized management techniques that small-scale, hand-powered farmers in Mali rely upon. Using Global Positioning Satellite technologies, lasers, and a comprehensive data bank of soil analysis, these highly advanced systems can adjust the seeding rate, application of fertilizers and other inputs several times each second

Without an overall framework for understanding soil variability in the OHVN zone, and how to best exploit it, the research and extension programs have rendered themselves incapable of providing farmers with recommendations that could improve their current management practices. There is little wonder, then, that the research themes investigated by the DRSPR/OHV have failed to help farmers improve their use and management of specific land types, or to exploit common microenvironmental niches.

The artificial division maintained by the DRSPR/OHV between its research themes on natural resource management and cropping systems improvement is an issue which underlies several of the program's problems. The DRSPR/OHV expanded its research agenda to include natural resource management issues in response to pressure from USAID and the national government. Yet the program has had notable difficulties in balancing this new focus with its long-term research agenda, which emphasizes the overriding of local resource deficiencies through the use of external inputs. As a result, the newer natural resource management themes have neither influenced, nor been integrated into, the DRSPR/OHV's overall orientation towards addressing agricultural production practices in the zone, even though a biologically-oriented approach is more consistent with farmers' current practices and financial status. Adopting a more resource conscious approach would force the research program to pay closer attention to the major differences, and diversity, in environmental conditions found across the zone.

based upon yield goals, soil hydrology, slope, past cropping history and other significant factors--everything, short of making the adjustments in specific crops and varieties, that resource-poor farmers manipulate in their cropping systems.

The Conceptualization and Characterization of Farmers and Farm Households. By failing to appreciate the inherently diverse and variable qualities of the physical environment, or the need for farmers to utilize equally adaptive management practices, the formal system has prevented itself from acquiring an informed understanding of what it takes to be a good and successful farmer under the prevailing conditions. On the whole, farmer behavior is not an issue that has been critically examined by the research program. Although statistics are collected annually on a number of specific aspects of what farmers do, e.g., levels of equipment usage, areas planted to specific crops, as well as more detailed studies on household agricultural revenues and expenditures (e.g., DRSPR/OHV, 1992a; 1992c; 1993a), virtually no data have been collected on how or why farmers engage in any of these specific behaviors. There is no evidence in the project's documentation which suggests that their data collection efforts have either been guided by, or led to the development of, an over-arching understanding of farmers' behavior, individually or in terms of household investment patterns. Even the DRSPR/OHV's assessment of the various levels of 'risk-tolerance' associated with different household types (as defined in the DRSPR/OHV household typology) has not led to an improved understanding of farmers' behavior. At best, there exists an implicit appreciation among individual researchers that farmers are rational and highly efficient maximizers of resources. Yet this appreciation falls far short of an institution-wide understanding of the basic need for farmers to develop and maintain a flexible outlook in their approach to agricultural production--especially in terms of the types of technologies that they require.

Although the research unit's characterization of the four 'recommendation domains' and their household typology fail to reflect the larger patterns of economic opportunities around which households organize, the unit is closer to being able to respond to challenges and opportunities which household diversification presents than is the case in some of the other areas of its programming. The DRSPR/OHV has already amassed a considerable wealth of data on whole-farm revenue and expenditure streams (e.g., DRSPR/OHV, 1992a; 1993a). This information, if supplemented with additional data from other locations within the OHVN zone, could easily be used as a basis for redefining the organization's perception of household economic diversification, and in creating recommendation domains which reflect actual differences in household economic activities (e.g., household economic portfolio areas), as well as justification for expanding its level of attention to developing alternative sources of income generation. As currently conceived, however, the DRSPR/OHV's orientation towards household economic diversification is limited to the minor research theme on expanding women's economic alternatives. To date, research in this area has resulted in the investigation of only two alternative income-generating activities: soap making, and the substitution of soy for néré in cooking. The remainder of the research carried out in the name of revenue diversification has focused upon varietal trials and input use (fertilizers and pesticides)(DRSPR/OHV, 1992c), reflecting the same sort of biases towards research on input usage which have affected the program as a whole.

Linkages with Farmers. One of the major objectives of the DRSPR/OHV project was to establish and improve the working linkages between the research unit and its numerous development partners (USAID, 1984). With respect to the DRSPR/OHV's ongoing relationship with farmers, much of the emphasis appears to be on the recently established post-research feedback sessions, *evaluation paysanne*, which are now conducted annually in each research village (DRSPR/OHV, 1992b). While these sessions are carried out in a highly efficient manner, with the recording of farmers' reactions to specific trials, the fact that they are carried out only on an annual basis prevents them from serving as a forum for active researcher-farmer collaboration along evolving research themes. Farmers' input in the annual reports is limited to a very brief, generally favorable synopsis of their comments. Contrary to other field units,[227] the DRSPR/OHV does not appear to use collaborative farmer participation in developing new technologies, or in making adjustments to subsequent trials along continuing research themes. The nature of the existing financial and professional incentive structure, lack of supportive technical assistance, and lack of direct accountability to farmers may be largely responsible for the current situation.

In the few instances where farmers' knowledge and input have been incorporated into the research process, the results have been resoundingly positive. The *fiches technique* on using soy as a substitute for néré seeds in making soumbala, and the identification of superior, traditional soap-making recipes, are both based upon farmer input (DRSPR/OHV, 1993), and are some of the only *fiches* issued by the DRSPR/OHV that involved original research. Interestingly, these examples, which have been hailed as examples of "FSR/E at its holistic best" (McCorkle el al., 1993), are both from the minor research theme on women's alternative income-generating activities.

In cases where farmers' input has not been solicited, the results have been as equally resounding, but in the negative. For example, in its research village in Boron *secteur*, DRSPR/OHV researchers identified a hardy local tree species which seemed to prosper on highly eroded sites. A trial was designed to test the suitability of using

---

[227] The DRSPR/Mopti has made extensive use of farmers' knowledge and opinions in carrying out its program of field research, resulting in the development of a number of highly innovative improvements in local cropping systems based upon farmers' participation (see McCorkle et al., 1993).

this species for rehabilitating impoverished areas. Seedlings were planted in specially prepared half-moon micro-catchments to conserve surface runoff, and were protected from livestock by fencing. However, by the second year of the trial, the selected species was being overgrown by the emergence of 'volunteer' specimens of two other tree species. Not only were these other species faster growing than the one identified by researchers (having started from seeds outside of the specially prepared catchment areas), but farmers reported that they were also highly desirable for their use as fodder, fuelwood, and in the manufacture of traditional medicines. The tree species selected by DRSPR/OHV researchers was not used by villagers for any purpose, which may explain why they appeared to inhabit degraded sites. In any case, farmers had little interest in planting a species for which they had no intended use, which highlights the importance of involving farmers in the *ex ante* analysis of proposed technical solutions.

On the whole, researchers' contact with farmers appears to be minimal. The annually negotiated contract between the research program and farmers participating in the on-farm trials, while a necessary instrument for articulating each party's duties and responsibilities, has neither been constructed, nor used as a foundation for establishing an interactive partnership between researchers and farmers. Even though farmers are unquestionably the most knowledgeable regarding their local production environments and diverse production systems, the current approach used in the research program casts farmers as technology users rather than technology producers. Despite the use of a prioritization scheme based in part upon farmers' perceived constraints, farmers have virtually no 'voice' in setting the research agenda. The rationale for undertaking each research trial is that of the researcher, rather than the result of any focused farmer-researcher interaction. This process has been further biased by researchers' consistent selection of technical responses that involve purchased, inorganic inputs. In the research and *pre-vulgarisation* trials, farmers' participation is typically limited to the contribution of land and labor (e.g., DRSPR, 1990b; 1991c; 1992e), and in both cases researchers maintain needlessly tight control over the management of each trial (McCorkle, el a., 1993). Farmers reported that their contributions of opinions and ideas were limited to the post-trial evaluation sessions. This is particularly unfortunate in light of farmers' creative capacities, and their expressed interest and willingness to cooperate with researchers.[228] In sum, the DRSPR/OHV research program has neither built upon farmers' knowledge or practices, nor contributed to farmers' abilities to make adaptive responses on their own.

<u>Linkages with Extension</u>. The DRSPR/OHV and OHVN extension service both report highly effective and amiable relations with one another. Yet, when the substantive issue of technology generation is considered, the managers of both the extension and research programs admit that the communication of relevant information to extension is a major weakness impeding the success of agricultural development efforts in the zone (OHVN, 1992c; Sélingué, 1992). The same is true for the reverse flow of relevant information from extension agents to researchers. Less than seven percent of the extension field staff reported ever communicating their knowledge concerning problems with the technical program or observations on farmers' superior practices to

[228] In general, farmers have a far more positive view of their interactions with the DRSPR/OHV field personnel than they do of their relationships with OHVN extension agents. In fact, of the villages visited which hosted a DRSPR/OHV research program, farmers almost unanimously responded that they worked only with the DRSPR/OHV and not OHVN extension personnel. Comments included in the DRSPR/OHV's own annual farmers' evaluation echo these same sentiments (e.g., DRSPR/OHV, 1992b). These attitudes indicate the existence of a vastly underutilized potential for farmers' involvement in research trials.

resea
in th
colla
of p
rese
stat

Link

DRS
to b
serv
con
univ
con
tec
the
go
cu
cu
be
OH
be
the
DR
is a

researchers. In its day-to-day field operations, extension agents have little involvement in the research and *pre-vulgarisation* trials beyond assisting in the selection of collaborators, the occasional supervision of the application of inputs, and the collection of payments for those inputs supplied. The extension program's director notes that research is particularly poor in keeping local extension agents informed about the status and progress of research trials in their area (OHVN, 1992c).

Linkages with Other Institutions and the Existing Knowledge Base. The quality of the DRSPR/OHV's relationship with other ODRs and government research units appears to be mixed. Twelve of the 15 new *fiches technique* provided to the OHVN extension service by the DRSPR/OHV originated from other research on erosion control measures conducted in Burkina Faso and Niger, and which had been field tested in other DRSPR units. Yet, almost none of this prior research is cited or used as justification for conducting any of the DRSPR/OHV's own research trials involving the same technologies. A number of other technologies, such as various intercropping trials and the use of natural rock phosphate, technologies that have been the subject of various governmental and international research programs in Mali since the 1970's, are currently being investigated by the DRSPR/OHV without any indication of how their current research is building upon these previous efforts. Overall, the situation may be best summarized by the observations of the directors of both the DRSPR/OHV and the OHVN extension program, who noted that because of the "insufficiency in coordination between the different research structures," there has resulted "a plethora of tests on the same *thèmes*" being conducted within the OHVN zone (Sélingué, 1992). The DRSPR/OHV's best example of collaboration with another governmental research unit is again in the case of research done on developing alternative income generating activities for women. The DRSPR/OHV worked very closely with the national nutrition lab in developing the *fiche technique* on the substitution of soy for néré seeds in making soumbala (McCorkle et al., 1993).

Not all inter-organizational linkages have been beneficial for the DRSPR/OHV program. It has been suggested that the evident bias in the type of technologies selected by the DRSPR/OHV for its on-farm trials (i.e., purchased inputs) is the result of influence exerted by the other, discipline-based, research units in the IER (pers. com. McConnell; McCorkle et al., 1993). If, indeed, such influences are preventing the DRSPR/OHV from working more closely with farmers and developing solutions that both build upon farmers' knowledge and capacities and which are within farmers' financial means, the DRSPR/OHV will never be able to fulfill its potential as an applied research program.

Another important issue is the DRSPR/OHV's use of the literature and existing knowledge-base in carrying-out its research program. A recent evaluation (McCorkle et al., 1993) notes that the DRSPR, in planning and reporting on its research program, neither states which particular hypothesis is being examined, nor offers a rationale for why a particular technology was selected for testing. In most cases an *ex ante* analysis, or even a thorough review of the literature, is not done. Numerous examples from the research program indicate that the existing knowledge-base is not consulted in preparing the research agenda. For example, there are a number of technologies, both recent and old, which have been overlooked, yet hold promise in supplying farmers with additional management tools. These include: the use of run-on systems of water harvesting (e.g., Niemeiyer, forthcoming); *Zai* production systems for use in laterite encrusted areas (e.g., Gubbels, 1992); the use of living vegetative barriers such as vetiver grass for water conservation (investigated by ICRISAT's Sahelian program in the 1980's (ICRISAT, 1989), and widely promoted, e.g., World Bank, 1990; NRC, 1993); the use of extracts from the neem tree as an insecticide (NRC, 1992); the use of donkeys and horses in AT; and the use of a toposequence perspective in designing cropping trials (e.g., Stoop, 1987a; 1987b), among many others. One informant remarked that because of the need to analyze results and generate reports on each season's trials (much of the harvest data is not collected until October or November), as well as prepare the next season's research proposals for the annual IER *Commission Technique* meetings, typically held in March, there is simply not enough time to conduct literature reviews in preparing research proposals. Yet the result of not reviewing and making better use of the existing knowledge base, in terms of costs associated with redundant, outdated, and misguided research, suggests that this is one step in the research process that cannot be overlooked.

Generating New Technical Recommendations. The *raison d'être* of the DRSPR/OHV research program is the adaptation and generation of new and useful technologies relevant to the conditions faced by farmers in the various parts of the OHVN zone (USAID, 1986). Although it is difficult to determine the exact impact of any research program, and particularly so in the case of the DRSPR/OHV, which had not attempted to monitor its own progress prior to 1991, several indicators exist which hint at the program's influence on agricultural change in the zone.[229] In 1991 the DRSPR/OHV conducted a survey which identified farmers' adoption rates for a number of

---

[229] Kingsbury et al. (1994) rightly differentiate between the adoption of technologies by farmers, and the biophysical and social impacts of that adoption. Because of the relative newness of the DRSPR/OHV recommendations, little can be said at this point about their overall impact on either the physical environment of the economic welfare or households in the OHVN zone.

technologies (DRSPR/OHV, 1992a). Although the survey shows very favorable results, in terms of the adoption of recommended practices, the small sample size (n = 262) and unequal representation from the five villages surveyed (30 households in one village in the DRSPR/OHV's Northern Recommendation Domain vs 90 households from a single village in the Southern Recommendation Domain where higher input use is common) skew the results. The DRSPR/OHV claims that these results can be used as representative of adoption rates across the entire zone (e.g., Yeboah, 1993), yet because only farmers in its own research villages were sampled, the results cannot be used to generalize beyond this select group. In general, it would be erroneous to attribute many of the indications of agricultural transformation in the OHVN zone to the DRSPR/OHV research program. Although the DRSPR/OHV identified in its survey over 50 technologies, which it claims farmers acquired from research, the fact remains that the research program has only issued 15 technical recommendations to extension (DRSPR/OHV, 1993b), twelve of which are on natural resource management (including five on the various uses of rock lines, and six on tree planting), and many of these had not yet been extended to farmers. In addition, many of the technologies, such as the use of living fences, organic fertilizer (manure, mulch) and seeding guides, that were tallied in the survey are traditional farmers' practices. Others, such as the use of animal traction, have been a part of the *Thèmes Classiques* promoted in Mali since the 1930's. Further still, the reported adoption rates neither reflect the contributions of other programs,[230] nor the adaptations that farmers themselves have made in the technologies.

[230] Many of the technologies, such as pesticides, have been regularly distributed without charge during locust attacks in the northern parts of the zone (Kremer and Sidibé, 1991), or their purchase has been subsidized by ONGs working in various areas.

Finally, significant discrepancies arise among the various reports issued by the DRSPR/OHV and other organizations. In one report, the DRSPR/OHV claims adoption rates of 26 percent for improved sorghum varieties among farmers (DRSPR/OHV, 1992a). Other reports by the DRSPR/OHV and the OHVN list average adoption rates of improved sorghum varieties at nine and three percent, respectively (DRSPR/OHV, 1992d; OHVN, 1992a), which are fairly typical, if a little high, of adoption rates for improved varieties in West Africa as a whole (e.g., Matlon, 1990). Regardless, the entire discussion of varietal adoption rates is wholly misleading as the DRSPR/OHV has run only a very limited number of variety trials (on rice, soy and sesame) and can claim little credit for the expanded use of improved varieties of the major upland cereal crops.

In many respects, the bottom line is revealed through a review of the program's annual reports for the past six research campaigns (1987-88; 1988-89; 1989-90; 1990-91; 1991-92; 1992-93). The results of the *pre-vulgarisation* trials, those trials which are the final stage of verification before passing new technologies on to the extension system, show that none of the technologies examined produced statistically significant results when compared with farmers' standard practices (DRSPR/OHV, 1988a; 1989a; 1990a; 1991a; 1992a; 1993a). In essence, while the DRSPR/OHV research program has adopted a number of technologies from other research programs, it has not developed any alternatives that are superior to farmers' existing practices through its own research. In addition, when selecting 'traditional practices' for use as controls in the on-farm trials, there is no indication that the selected practices represent farmers' 'best practices.' As shown by the DRSPR/OHV's research on identifying superior traditional soap-making recipes, local practices can vary significantly.[231]

Chapter Summary

Agricultural research and extension activities in the OHVN zone have received sustained and generous financial support over the past decade and a half. Unfortunately, these investments have not led to significant improvements in farmers' productivity and economic welfare. Farmers' perceptions, presented in Chapter VI, and the review of the formal system's own records, as well as direct observations and other sources presented in this chapter, indicate that in general the formal system has made few contributions to the overall improvement of local production systems and household economic well-being. Several features associated with the orientation, organization, and modes of operation of both the T&V extension program and FSR research unit can be identified which have prevented these organizations from having greater success.

It is clear, for example, that neither research nor extension has adequately responded to the challenges presented by the major characteristics and specific details of the physical resource systems that comprise farmers' production environments. The *thèmes techniques* contain little new or useful information, and are conceived and presented to farmers as static sets of recommendations, wholly unresponsive to the dynamic conditions under which farmers must function (between, as well as within, locations, and in the same location from one year to the next). The extension service has neither attempted to target its technical messages to areas where each *thème* is most appropriate, nor, as currently written, do most of the *fiches* contain the type of

[231] One of the traditional recipes investigated was found to be twice as profitable as others.

information that would enable them to be effectively targeted.

The research currently being conducted in the zone appears to be equally unresponsive to variations in both the physical environment and farmers' financial resources. The research themes do not appear to be targeted to specific areas, nor are technologies designed to be used across a range of conditions. There is a major bias in the research program towards testing high input technologies, which, even if successful, would on economic grounds be inappropriate for a majority of the households within the zone. The more recent focus on natural resource management issues, which may provide some lower-cost management alternatives for farmers, have not been integrated into the principle crop production research themes. On the whole, the research conducted thus far builds little upon farmers' current practices, and fails to improve farmers' abilities to respond to their problems. The lack of professional incentives, institutional and technical support, and any sense of accountability to farmers' needs, may be preventing researchers from becoming more involved in collaborative activities. Similarly, the focus on extension efficiency, via the T&V approach, rather than on the development of farmer capacity, has largely prevented the extension service from providing more beneficial services.

Finally, in addition to making virtually no attempt to utilize farmers' knowledge, or to enlist their communication skills or creativity in identifying problems and developing possible solutions, the research and extension system has made very little use of the existing knowledge base. Furthermore, other than the minor research theme on alternative revenue sources for women (the only part of the research program with significant involvement of women), no attention has been given to expanding the range of economic options, or improving the profitability of farmers' current portfolio of activities. In order for the formal research and extension programs to begin making fuller use of these and other neglected resources and opportunities, a more detailed understanding and deeper appreciation for the capacities of the informal system will be required. In addition, the development of a conceptual framework on the dynamics and processes of change in local agricultural systems will be needed to guide more responsive development activities.

Chapter VIII. Towards a Conceptual Framework for Understanding the Internal Dynamics and Processes of Local Agrarian Change

This dissertation has used the grounded theory approach (Glaser and Strauss, 1967; Strauss and Corbin, 1991) to examine the case of the OHVN in order to help broaden and sharpen our understanding of the internal processes and relationships involved in agricultural change at the local level. The material and observations presented thus far have focused almost exclusively upon the context of farmers in the OHVN. The present chapter takes the next step in the inductive research process, linking the field observations and case study analysis back to the extensive knowledge base on human behavior and social interactions which, to date, have been little used in assisting agricultural development activities.

This chapter presents a synthesis of the theoretical concepts and postulates from a number of behavioral science disciplines (psychology, sociology, and anthropology) that both helps to interpret the observations from the OHVN case study in broad theoretical terms, and provides an entry point for utilizing the extensive behavioral science literature to better understand and build upon the social and individual processes involved in agricultural change. The conceptual perspectives used in this chapter were drawn from the literature of cognitive psychology, cultural anthropology, personal construct theory, social learning theory, and the sociology of knowledge, as well as the writings of a number of contemporary development scholars. The chapter is divided into three parts, beginning with a general theoretical overview of the relationships between culture, society , and individuals, and the basic structure of local knowledge systems. This is followed by an examination of some of the major characteristics of local knowledge, and the different states and forms that knowledge takes. Finally, a basic model for understanding agricultural and cultural change is introduced--one which emphasizes the dynamic interplay between cultural traditions and the processes of individual creativity and communication which enable cultures to evolve and sustain themselves.

The Relationships Between Culture, Society, and Individuals

As observed in the case of the OHVN, there are obvious differences between the world views and perceptions of reality held by rural farmers and members of the formal research and extension system. Farmers' world views, for example, include the existence and involvement of 'devils' in land degradation, and the interpretation of dreams and the cycle of the moon as guides for when to undertake certain agricultural practices, such as plowing. Such explanations and sources of guidance are vastly different from those recognized as valid by members of the formal system, and are indicative of the underlying differences in socialization, cosmological perspectives, types and levels of education, and the various patterns of reinforcements active within these two groups.[232]

[232] In many cases, the division between cultural perspectives is not so distinct. Some individuals working in the formal research and extension system may be part of what George Axinn of Michigan State University (pers. com.) has termed the 'Third Culture.' Because of their personal histories, these individuals' connections to their indigenous culture and knowledge system has eroded, yet because of the lack of resources and other barriers, they have not become fully integrated into other systems of belief and behavior. As a result, epistemologically they reside somewhere in between two different world views.

Viewed in broader social terms, individuals do not exist in isolation, but are active participants in the rich drama of creating, maintaining, and re-constructing the patterns of social relationships, institutions, and shared knowledge that constitute a group's cultural heritage. The resulting sense of identity and security that arises from cultural membership is based upon the accumulated experiences and collective knowledge of the group. In helping to preserve a group's identity, social institutions, as the "complex of norms and behaviors" of the group (Uphoff, 1986:6), provide individuals with two important services: the positive and negative reinforcement of acceptable behavior; and as an influence on "the process of individual learning," a process which "consists of adopting highly specialized attitudes toward reality...so deeply implanted that it never occurs to the individual that there might be any others" (Towner, 1980:171). These 'attitudes,' embedded in the codified symbols and language of the group, provide some of the basic templates and guides through which individuals interpret and impart meaning to the sensory information which they encounter. Although individuals do not hold identical visions of what reality is, through the interplay between the individual and group "there is an ongoing correspondence between *my* meanings and *their* meanings," such that there develops a perception that "*we* share a common sense about...reality" (Berger and Luckmann, 1966:23).

The cultural-centric perspective that develops as part of the socialization process reinforces the need for a multi-cultural approach in identifying and addressing development problems. A diagrammatic tool, the 'Johari window,' borrowed from the study of personal awareness in psychology (Luft and Ingham, n.d.), is modified in Figure 22 to demonstrate how individuals from different social systems and 'realities' possess different knowledge, and, in fact, have a limited awareness of each other's knowledge. In contrasting the knowledge held by researchers and farmers, this figure illustrates that while certain things are known to both groups, other elements are known only selectively, and some are known to neither. The obvious implication from a knowledge systems perspective is the long argued position that both researchers and farmers have unique contributions to make, and that neither knowledge 'system' can fully replace the other.

Figure 22. The Intersection of the Informal and Formal Knowledge Systems.

		Researchers	
		Known	Unknown
Farmers	Known	Commonly held Knowledge	Unique Local Knowledge
	Unknown	Unique Scientific Knowledge	Unknown

The Social and Personal Constructions of Reality

The results of group and individual interviews with farmers in the OHVN zone illustrate elements of both broadly shared knowledge and knowledge that is more personal in nature. Two contrasting sociological and psychological theories illustrate these different sets of knowledge. In the social constructionist view, reality is a normatively defined and socially replicated perspective, based upon the postulate that the definition and belief of something as real leads to it becoming "reality as subjectively experienced by the members of that society" (Thomas, 1923). This view is neither oriented towards making a commentary on the existence or nature of an ultimate reality, nor on the theories that attempt to explain it. Rather, it focuses on the way in which reality is jointly defined and experienced by social groups at a particular point in time. Examples of this type of knowledge from the case study include the spiritual interpretation of certain events, such as 'devils' causing the degradation of specific sites, and the acquired understanding of the many signs that accompany the changing of the seasons--in short, knowledge that is never questioned and is assumed that everyone holds.

In many respects the social constructionist position is the social, or shared, counterpart to the 'personal construct' psychology proposed by Kelly (1955). The central premise of Personal Construct Theory is that individuals function as their own 'personal scientist,' driven by the desire to understand and predict--"to devise conceptual templates (personal constructs) that permit them to interpret, anticipate, and appropriately respond to the events with which they are confronted" (Neimeyer, 1985: 2). In this view, human understanding is primarily fueled by individual inquisitiveness and creativity, and not social conformity. Examples of this type of knowledge are found in the specific activities of individuals, such as the selection of a particular intercropping pattern, or the preference of one variety over another. These elements of belief and knowledge are not widely shared, yet are used by individuals as guides in making many of their daily decisions.

By taking a further look at the underlying architecture of knowledge within society, it is possible to combine both the personal and social construct perspectives into a more holistic interpretation of the local knowledge system. Every society can be said to consist of a 'social pool' of collective knowledge, composed of the total stock of knowledge held by a society's members (Berger and Luckmann, 1966). By definition, this 'social pool' far exceeds the personal stock of knowledge held by any individual, or collection of individuals, within a society. The 'social pool' in turn contains a core, or 'common stock' of socially shared knowledge, held by nearly all members of a society, and defined literally as commonsense knowledge (Berger and

Luckmann, 1996; Holzner and Marx, 1979). This commonsense knowledge provides the medium for social intercourse evident in the normal rhythms of everyday life. It is, in effect, "believed to represent reality itself" (Holzner and Marx, 1979:259), or, in terms of the social constructionist view, the normatively agreed upon and jointly accepted understanding of reality. In addition to this common stock of shared knowledge is the knowledge shared among members of sub-groups within a society, as well as the unique knowledge holdings of individuals. These added dimensions of knowledge differentiation can be explained by the various 'social frames of references' with which individuals are involved, and the personal knowledge biography that every individual amasses during the course of her or his lifetime.

Social Frames of Reference and Individual Biographies

The recurrent patterns of individual responses obtained during the interviews indicated the existence of sub-groups within the local population, which are best understood through the identification of different 'social frames' (Gurvitch, 1971), or joint 'frames of reference,' with which groups of individuals are involved (Holzner and Marx, 1979). These social frames represent the various sub-divisions within society, and their associated rules and norms that influence individual patterns of behavior. Social frames define the various roles and expectations by which individuals identify themselves and manage their social relations within the larger society. These roles range from the relatively 'closed' (ascribed) aspects of family, gender, class and ethnic divisions, to the more 'open' or achieved levels of social status associated with such factors as age and wealth.[233] By influencing an individual's access to resources and relegating the performance of specific tasks, the combination of social frames with which an individual is associated serves to delimit her or his personal horizon of opportunities and real-life experiences, and consequently her or his acquisition of experientially-derived knowledge. Viewed in such a way, a social frame perspective is not only a tool for understanding some of the dynamics involved in knowledge formation, but is also an orderly way of explaining some of the overall commonalities found within the knowledge holdings and interpretive meanings of individuals from similar backgrounds. For example, women from poor, ethnic minority households draw upon vastly different sets of experience, meaning and sources of information, based upon their gender, poverty and ethnicity, than do males from rich, ethnically-dominant households. The influence of social roles leads individuals to acquire knowledge about different things, or different aspects of the same things, or to interpret and organize the same information in different ways (cf. Norem et al., 1989). Thus individuals, even from the same locality, possess different knowledge (e.g., Swift, 1979) and perceptions, an observation which highlights the importance of talking with a range of different individuals in data collection.

The findings presented in Chapter V provide ample evidence illustrating the social differentiation of knowledge holdings, as well as individual differences among those from similar social backgrounds. Certain differences are obviously related to the social frames of gender, age, ethnicity, and wealth, as well as the less obvious yet still notable influences of family, class, and others. Yet, the field data also highlight the

---

[233] This list of roles is a synthesis of Gurvitch's 'social frames,' which are drawn along structural lines, and Holzner's and Marx's 'frames of reference,' which are amenable to a broader interpretation, to include, for example, the general social outlook shared by individuals of common gender (e.g., Norem et al., 1989).

existence of important individual differences in knowledge based upon personal experiences (e.g., travel), as well as individual variances in skill, creativity, and motivation, among members of similar social frames.

The structural perspective represented by the concept of 'social frames of reference' is a useful starting point in identifying the different knowledge sub-systems embedded within a society. However, in order to avoid imbuing the social frames perspective with "the determinism of existing general theories of social change" (Long, 1984:3), the type of theories which Johnson (1972) finds have "unintentionally contributed to a cumulative distortion in our image of the practice of traditional agriculture" (Johnson, 1972:151), "what is needed is to combine structural analysis [i.e., a social frames perspective]...with an actor-oriented approach [i.e., personal biographies]" (Long, 1984:7)(cf. Bebbington, 1994). In other words, a perspective needs to be developed which views individuals as 'situated-actors' (Bebbington, 1994), possessing knowledge that is based not only upon their socially influenced range of experiences and opportunities, but also as a product of their individual attributes of inquisitiveness and intellectual abilities.

The concept of "individual biographies," introduced by Berger and Luckmann (1966), helps to define and provide a temporal dimension to the subjective differences in personal constructs and elements of individually held knowledge encountered during the various interviews conducted for this research. Viewed in this way, each individual's knowledge represents a 'biography,' or living record of one's life history, composed of the unique combination of life experiences, reinforcements, genetic attributes, and varying levels of motivation in meeting various needs. Whereas the socialization process tends to produce a general, shared outlook or consensual understanding of what reality consists of (as articulated through the beliefs and values of a society's members), each individual's personal knowledge develops as an outgrowth of her or his life experiences, interpretations, and insights. Such a view is consistent with the broader theoretical notion of 'reciprocal determinism,' as outlined in Bandura's Social Learning Theory (1977). In this theory, "human functioning neither casts people into the role of powerless objects controlled by environment [of which social forces are a part] nor free agents who can become whatever they choose. People and their environments are reciprocal determinants of each other" (Bandura, 1977: vii). In individual interviews with farmers in the OHVN, certain types of discussions, such as general land use practices, were greatly facilitated by talking about the subject in relation to real life events (e.g., such as the downturn in rainfall in the late 1960's and the struggles individuals underwent in attempting to adapt their planting practices).

The Nature and Organization of Knowledge

Because knowledge is one of the essential elements of culture--the complex of human values, beliefs and behaviors that defines a way of life and renders each group distinct from its neighbor--the temptation is to accord cultural knowledge with a high degree of uniformity and orderliness. However, as the preceding discussion illustrates, the portrayal of local knowledge as a singular, highly organized system is misleading in that it implies a greater degree of homogeneity in individual knowledge and fluidity in information exchange than often exists (e.g., Johnson, 1972; Scoones and Thompson, 1992). While the social differentiation of individual knowledge could lead one to question the very existence of local knowledge 'systems' altogether, the implication that a systems view should be applied solely to Western science is flawed in its exaggeration of the differences between local and formal knowledge. As the examination of formal research institutions reveals, a differentiation of individual knowledge appears to be part of the nature of knowledge, even within the formal scientific community (e.g., Knorr-Cetina, 1981). For example, knowledge is differentiated by disciplinary views, increasingly divergent schools of thought, the organizational culture of each research facility, and successive revolutions in scientific thinking involving what, and how, knowledge is agreed upon. Thus, in terms of the differentiation of individual knowledge and clusters of shared perspectives, the differences between the formal and informal systems is one of degree rather than kind.

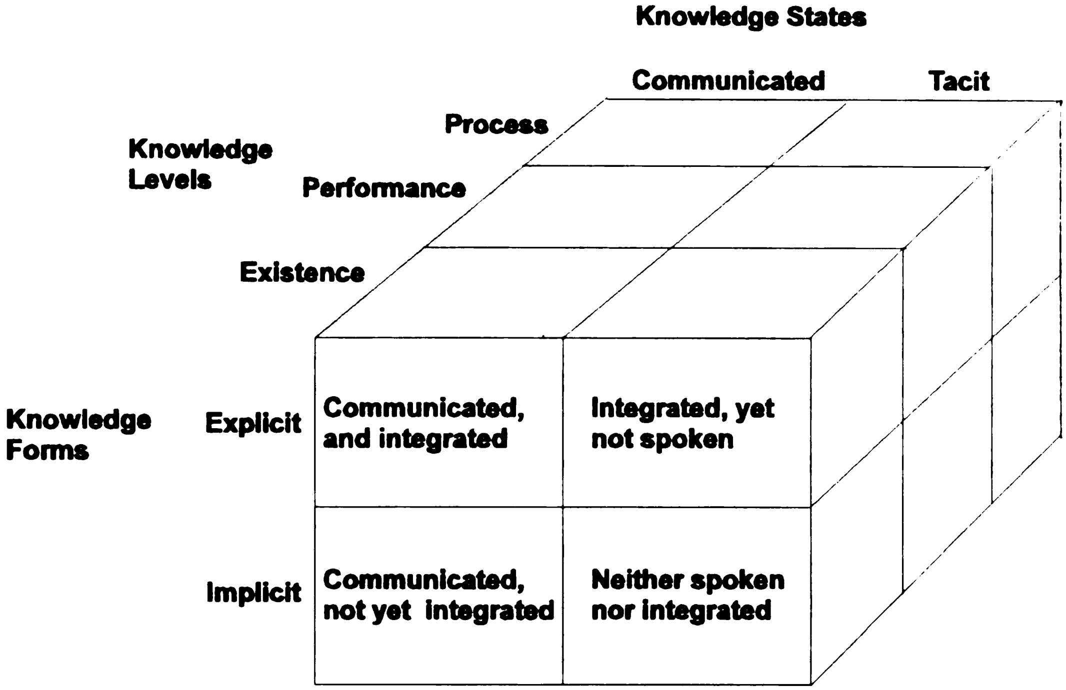
One area where the two systems do show a great deal of divergence is in the organization of knowledge--in particular, the extent to which technical knowledge is separated from the rest of the knowledge holder's beliefs and activities. Members of the formal system, for example, are employed specifically to operate an explicit (normative) system of rules and procedures in generating new information. These individuals, however, are generally not the intended end-users of the information that they produce. Their immediate livelihoods and well-being, and that of their families, are not dependent upon the utility of the knowledge that they generate in terms of practical application. In other words, the knowledge system of their profession is separate from the rest of their activities. Members of the informal system, on the other hand, generate and utilize different sets of 'practical knowledge' (Sternberg and Wagner, 1989; 1986) that are essential to their immediate survival. In this way the elements of technical knowledge that farmers utilize are inextricably linked to a range of social processes, such that the technical "knowledge system does not appear as an empirically separate aspect of the social structure" (Holzner and Marx, 1979:175), but is a central part of the "...continuing [social] adaptation and survival of the group in the ecological setting in which its members find themselves" (Berry and Irvine, 1986:271).

Even though farmers and scientists may use similar approaches in conducting their research (e.g., Potts el at., 1992), no explicit rules govern the generation of knowledge by members of the informal system. Information is validated through its utility in practice. From a knowledge user's perspective, the immediate relevancy of knowledge in the successful performance of specific activities is of greater importance than is the overall comprehensiveness or fit of that knowledge as part of a universal explanatory system.

Forms, States, and Levels of Knowledge

Apart from its relationship with specific activities, knowledge within the human consciousness can be said to reside in a number of forms and states, and to exist at several levels of inclusiveness. The two basic forms which knowledge takes are explicit knowledge (conscious, or integrated), and implicit knowledge (subconscious, or unintegrated)(Cleeremans, 1993). Knowledge also resides in one of two different states, tacit (unspoken), and that which is openly communicated, and occurs on a number of levels, ranging from knowledge 'of,' or existence knowledge, knowledge 'how,' or performance knowledge, and knowledge 'what,' or process knowledge (adapted from Scoones and Thompson, 1992). Figure 23 illustrates the different dimensions of personal knowledge in terms of the forms, states, and levels that knowledge can take. For example, the simple fact that we often "know more than we can tell" (Polanyi, 1966:4) illustrates both the existence of implicit/tacit knowledge and helps to explain the difficulty some farmers have in articulating knowledge that has not yet been fully integrated into their world view. This situation is diametrically opposed to that where we possess bits of explicitly-held knowledge which we could pass on to others, but choose not to (explicit/tacit)(Berger and Luckmann, 1966). These different dimensions illustrate the necessity of employing a number of research methodologies in actively working with farmers to identify and integrate both tacit and implicit knowledge.[234]

Figure 23. The States, Forms, and Levels of Personal Knowledge.



The different forms, states, and levels of knowledge, when combined with individual differences in access to information, life experiences, as well as intellectual capacities, underscores the point that individual knowledge biographies are "fragmentary, partial and provisional in nature...never fully unified or integrated in

[234] When applied in a developmental sense, the process of 'naming the world,' advocated by Freire (1970) and others (e.g., Fals-Borda and Rahman, 1991), is an empowering one, directed at breaking the 'culture of silence' and helping adults to move non-communicated and implicit knowledge into a conscious, communicable, and action-enabling form.

terms of an underlying logic or system of classification"...and are..."always in the making" (Scoones and Thompson, 1992:4). The important lesson here is that individually and jointly, knowledge holdings are continually evolving.

Cultural Change

Change within cultural knowledge systems begins with the individual. All knowledge, even that which is culturally shared, "is first acquired by individuals" (Towner, 1980:171). The construction of individual knowledge biographies takes place through a combination of processes involving the acquisition of pre-existing information[235] via various channels of communication, observation, and the generation of new information through personal experimentation and discovery. When viewed over time, or as in the case study of the OHVN, by collecting data covering various time periods, the maintenance and evolution of culturally shared knowledge can be seen as a process fueled by individual creativity and inter-personal communication (including intra-generational, within and between different groups of the same culture, and with individuals from other cultures). The creation, exchange and diffusion of information and materials can be described as taking place among three main sources.[236] These sources--individual, cultural, and external--are shown in

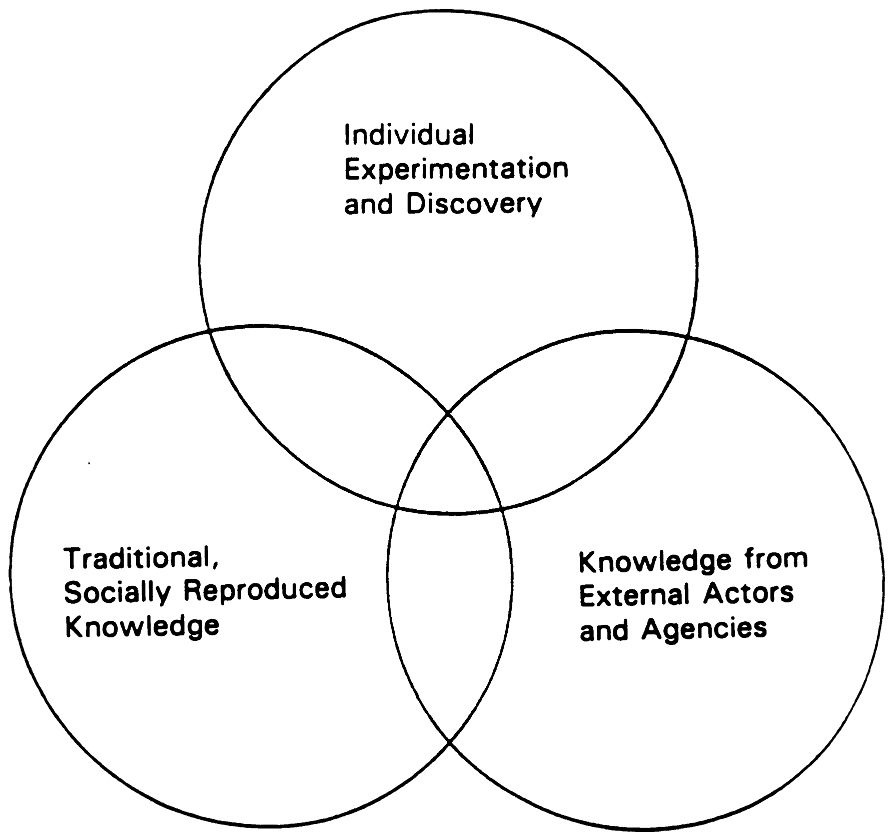
---

[235] As noted by Mundy and Compton (1995), knowledge and information are not synonymous with one another. Knowledge is a personal construct, and "it cannot be communicated but is created in the minds of individuals as a result of the person's perceptions of the environment or through communication with others" (Mundy and Compton, 1995:112).

[236] Niamir (1990:16), in her description of traditional pastoral management systems, describes these sources as "1) accumulated cultural knowledge 2) knowledge modified through contact with other cultures, and 3) progressive learning of the environment." Other authors have identified similar or closely related relationships and sources, e.g., Knight, 1974; McCorkle et al., 1988; Barnett, 1953.

Figure 24, which represents a simplified model of the major interfaces among the different reservoirs of knowledge and sources of information. The degree of overlap between these three spheres of knowledge varies from person to person, depending upon the extent and breadth of their interpersonal linkages, experiences and insights. Each individual, for example, draws upon, helps to preserve, revises, and contributes to the collective knowledge pool of her or his culture, as well as the knowledge pools of groups outside of her or his immediate locality. As seen in some of the examples presented in Chapter VI, cultural traditions change as innovations, developed by individuals within the culture or brought in from the outside, become widely diffused and integrated into the current practices and are passed on to subsequent generations. Broader culture to culture exchanges occur through such avenues as mass media campaigns, educational programs, and the re-shaping of the economic and political playing fields via policies that affect the opportunity sets of entire segments of a society *en masse*.

Figure 24. <u>Sources of Information and Frontiers of Interaction in the Evolution of Local Knowledge Systems</u>.



The evolution of technical knowledge is characterized by an inherent "conflict between the freedom to vary, which makes advance possible, and the value of retaining the cultural accumulation" (Campbell, 1965:35). This continual interplay between tradition and individual variation underscores the notion that "change is internal to tradition," and that through the continual reconstruction of cultural traditions in people's daily lives, traditions embody a "living past" (Zaretzke, 1982:91).

The central force in the maintenance and evolution of the cultural knowledge system is learning. Learning involves both the creation of new knowledge through innovation and discovery, and the transfer (communication) of existing information and skills from one individual to another, and one generation to the next--the process whereby today's innovations become tomorrow's traditions (Wilson, 1984).

Individual Learning Through Experimentation

In the behavioral sciences, the number of theories about learning are legion. In the present discussion, however, attention will focus upon the types of learning associated with individual creativity and innovation described in this dissertation. At some point, "those who concern themselves with innovation begin with, or come to accept, one of two antithetical propositions relative to human inventiveness. It does not matter whether their point of view is founded upon general impressions or careful study; in either case they find themselves impelled to believe that [all] human beings are fundamentally creative, or that they are not" (Barnett, 1953:17). The observations drawn from the OHVN case study unequivocally support the proposition that individuals <u>are</u> creative beings. Other authors (i.e., Biggs and Clay, 1982) suggest that, in fact, the very nature of such processes as natural selection require that farmers be 'creative' in order to continually adjust to the evolving gene pool with which they interact. Such an argument can also be applied to the evolution of other environmental factors, as well as the social, political and economic systems.

As seen in the OHVN case study, innovation is a creative response arising from the necessity of, desire to, or curiosity about, change. Change within the cultural system, as previously noted, is "initiated by individuals" (Barnett, 1953:39), and is based upon the view that "human beings are fundamentally creative" (ibid, 1953:17), facing no two stimuli that are exactly alike, and responding to no two situations in exactly the same way (ibid, 1953:19). Thus, innovation can be conceived as a psychological process, with social consequences related to the acceptance or rejection of an innovation's technical and social impacts by the larger social group (ibid, 1953:1). The movement of ideas, materials, and innovations through the three spheres (individual, cultural, external) depicted in Figure 24 constitutes the essential social processes involved in the technical and social evolution of agricultural systems.

The moment of an innovation's conception has been likened to a 'lightning bolt' of insight (Knorr-Cetina, 1981); previously ordered concepts and empirical evidence are recombined to form new results, or are extended in taking the next 'logical' step (often guided by intuition), or are transferred from one social frame and applied within another.[237] Other times, innovations arise in the form of exceptions to normal outcomes which are isolated and then exploited for their uniqueness and inherent advantage[238], or through serendipitous discovery (Barnett, 1953; Knorr-Cetina, 1981:61; Rhoades and Bebbington, 1988). The various examples of farmers' innovations in the OHVN, described in Chapter V, illustrate many of these different types of innovative processes at work.

Most learning theories emphasize the importance of the learning environment, or the person-environment interface, as the primary place where learning takes place (and as noted previously, this interface is strongly influenced by the various social frames with which an individual is associated). This interface not only provides the opportunity for individuals to make observations and discoveries which build and reform their (explicit) explanatory theories and concepts about reality (Towner, 1980),

---

[237] Kuhn (1970), for one, notes that many major breakthroughs in science are made by people who are young and/or new to their fields, whose thinking is not bound by the standard perceptions and who may bring knowledge from other areas to bear on the problems at hand.

[238] Richards (1985; 1986), for example, describes the practice among rice farmers in Sierra Leone of 'roguing' unique rice cultivars from their fields for separate experimentation, in order to identify their potential as new varieties.

but the continuous interaction between the individual and her or his physical and social environment also provides the opportunity for the acquisition of an implicit understanding of how the world works (Holzner and Marx, 1979). Farmers' lifelong, intimate contact with their local environments provides ample opportunity to develop extensive stores of both types (explicit and implicit) of knowledge.

Communication and the Diffusion of Information

The observations from the OHVN clearly indicate that individuals are linked with, and learn from, one another through a variety of communication channels. Many of the ascribed and achieved social frames of reference discussed previously not only shape individuals' opportunities for observation and personal experience, but also strongly influence interpersonal lines of communication, e.g., who talks to whom. Individuals acquire knowledge from others through overt instruction and demonstration, as well as through the tacit transfer of specific skills and competencies through periods of guided experiential learning and careful observation (Holzner and Marx, 1979).[239]

As a process, knowledge transfer is always imperfect, conveying less or interpreted differently than the communicator or receiver desires. Thoughts are often poorly expressed, contain incomplete information, or lack the contextual detail necessary for their full comprehension. This is especially true of knowledge that is just emerging from tacit storage, or implicit cognition which has not previously been articulated and opened to social commentary (Cleeremans, 1993). Conversely, information is also imperfectly received in terms of both content and meaning,

---

[239] In Bandura's Social Learning Theory (1977), for example, most social behavior is conceived of being acquired through the modeling of observed behavior.

dependent upon the attentiveness, interpretive skills, and personal biographies involved, as well as the embedded authority and credibility of the source (Wilson, 1982; Havelock, 1973). The communication process has been described in terms of a 'demi-arc' model, proposed by Haray and Havelock (1977). In this model, the arc of information transfer is defined as a 'meshing' of the sending and receiving halves. The sender determines what and how selected information is to be encoded, while the receiver must decode and interpret this information, "forming connotations with schemata and memorized experiences and relating it to knowledge he or she already has" (Mundy and Compton, 1995:112).

Communication pathways are the medium through which knowledge systems are maintained and evolve over time. Not only do the various pathways serve as vehicles for individual learning and socialization, but they also serve as the means by which existing knowledge is preserved (i.e., inter-generationally), especially in situations where written records and other more permanent systems of storage do not exist. The continual transfer and exchange of information and experiences between individuals also helps to reaffirm and reinforce cultural identity, relationships, and social roles.

The major features in the social differentiation of knowledge, detailed in Chapter V and conceptualized by the notion of social frames of reference, are also useful as descriptors of the principle communication pathways or channels through which individuals exchange information and materials with one another. The notion of social frames used thus far is analogous to what Rogers (1983) terms 'homophilous' conditions, which denote the degree of similarity between individuals' social experiences and the likelihood that these similarities will serve to facilitate the exchange of information between like individuals. The maintenance of long-distance relationships, such as in the case of the OHVN where women and others visit their villages of origin, constitutes what Rogers (1983) terms a "strong 'weak' link," bridging the gap between different social groups. The link's 'strength' comes from the nature of the pre-established relationship (e.g., kinship ties, where separation may actually strengthen some kinds of exchanges), while its 'weakness' stems mainly from the infrequency of contact. Interpersonal relationships at the local level play the essential role of moving information and materials across the different interfaces. In addition to the observations from the OHVN case study, investigations from other regions show that, for rural villagers and post-industrial applied scientists alike, interpersonal contacts and informal lines of communication are among the most important sources of information regarding practical details (Holzner and Marx, 1979; McCorkle et al., 1988; Nazhat and Coughenour, 1987; Richards, 1994).

Social learning theory recognizes two types of diffusion: the acquisition of new information, and the adoption of that information into practice (Bandura, 1977). In diffusion theory (Rogers, 1983), these two aspects are viewed as a single process in the spread of ideas, from 'innovators' to the 'late majority adopters' and, lastly, to the 'laggards.'[240] 'Peaks' in the local knowledge topography represent individuals whose levels of skill, creativity, and knowledge are widely recognized, and who serve as important sources of information and models of behavior (e.g., Box, 1988).

Recently, some authors (e.g., Scoones and Thompson, 1994) have adopted a power-based interpretation of knowledge differentiation and social change. Such a view harkens back to Sir Francis Bacon's equating of knowledge with power, where

---

[240] This view has been criticized for its assumption that the relevancy of innovations is uniform across all local actors. The varying needs and costs of making adaptations in the innovation before it can be implemented by various actors is also overlooked.

"knowledge itself does not give special powers: only exclusive knowledge" (Freidson 1973:28). Other authors (Fairhead and Leach, 1994) have noted the use of 'declarations of difference' by certain local producers, in which individual differences in knowledge holdings are overstated as part of a strategy to capture a larger share of the perceived or potential benefits from development interventions. While a power-based perspective of information diffusion can explain the initial selective channeling of benefits from recent innovations, the inherent 'leakiness' of social relations due to overlapping social frames, as well as the multiple sources of information and highly observable nature of most innovations, prevents these power relations from permanently deforming the local knowledge landscape with regard to any single innovation. When viewed over time, however, some individuals, because of their interpersonal linkages with key information sources (especially external sources),[241] may be able to consistently capture the benefits of new information long before others gain access. In instances where interventions by the formal system plan to use local knowledge in helping to direct development activities, it will be important to remember that <u>whose</u> knowledge is consulted may largely determine <u>who</u> ultimately benefits. Methodologically, approaches will need to be used that involve a broad base of participants and their knowledge in order to ensure that social inequities are not being reinforced or created.

Finally, with reference to the Johari window depicted in Figure 22, in instances where actors from different social groups or cultural contexts attempt to exchange their knowledge, an additional set of parameters comes into play at the 'exchange interface' (see Long, 1989). Chambers (1983), for one, has long noted the many

---

[241] Specific social factors, such as wealth, can greatly influence an individual's access to diversified sets of information sources (Rogers, 1983).

biases affecting relationships between 'insiders' and 'outsiders' in the standard approaches to rural development. Other factors, such as linguistic nuances (e.g., Stolzenback, 1993) and radically different world views, can confound even the most careful attempts at interacting with individuals from other cultures. Such factors highlight the need for a greater degree of sensitivity to local people's perspectives, and, at least initially, the need to adopt a slower pace to allow for inter-cultural learning than is common in most development approaches.

Summary

The theoretical interpretations of the research findings presented in this chapter not only help to improve our understanding of many of the internal individual and social processes involved in local agrarian change, but also hold a number of important implications for agricultural development activities. Taken as a whole, the concepts on individual and social behavior, drawn from the behavioral science literature, form the beginnings of a framework for interpreting the process of change at the local level. This emerging framework highlights a number of important features in the structure and dynamics of local knowledge systems: social frames of reference; individual knowledge biographies; different states, forms, and levels of knowledge; and the essential role played by individual experimentation and informal lines of communication. Methodologically, the recognition of differences between the world views of members of the formal system and farmers, as well as differences both among individuals and members of sub-groups within local populations, is a crucial starting point for formal research and extension institutions interested in utilizing local knowledge. Not only do these features of the local knowledge system speak to the need for including multiple individuals from different social frames (or at least a conscious recognition of which social frames are represented or excluded), but the different forms, states, and levels of knowledge will require the use of different approaches for accessing information from these different stores.

At a more fundamental level, a deeper appreciation for the central role played by individual creativity and communication in the process of local social change opens the door to new ways of approaching research and extension. The formal research system may be able to build upon farmers' creative capacities and develop technologies that are 'loosely packaged,' designed specifically to allow local producers to use their knowledge, skills, and creativity in making the necessary adjustments and adaptations that their particular circumstances require. Similarly, extension may be able to build many of its activities around the central theme of strengthening local traditions of experimentation and information exchange. Such alternatives, however, are contingent upon the adoption of a more dynamic view of the capacities for change within the local cultural systems.

Chapter IX. Summary, Recommendations, and Conclusions

This chapter is concerned with three basic tasks: to summarize the major findings of the research; to identify recommendations for improving the contributions of the formal and informal systems to sustainable agricultural production and the improvement of rural livelihoods within the OHVN zone, and for future research; and to present some concluding observations regarding the research methods.

Summary of the Research Findings

The motivation for conducting this research arose from a basic concern over the lack of success that the conventional, centralist approaches to agricultural and rural development have achieved in improving the welfare of the rural poor. In addition, the under-developed conceptual framework supporting the alternative Farmer First approach led this research to focus upon various aspects of the internal processes of local change. In order to explore the dynamics of local agrarian change within the context of the OHVN case study, the data collection for this dissertation was organized around four major questions: what changes have taken (and are currently taking) place in farmers' production systems, and how? What have been the contributing sources of those changes (the formal or informal system)? How have the information, ideas, and materials supporting the observed changes been communicated? What adjustments in the formal system's approach could be made which would improve both the formal and informal system's ability to contribute to future agricultural development efforts? The exploration of these areas was influenced by several additional interests, most notably: the significance of the physical environment in influencing human behavior; the patterns of individual adaptations and household diversification in responding to the physical and social environments; and the role played by both local and non-local systems of knowledge, communication, and innovation in the transformation of local production systems.

In this section the major findings of the research are summarized. These findings are organized around three general themes: the natural resource systems of the OHVN zone (Chapter III); the major characteristics of the human management systems (Chapters IV-VI); and the responses of the formal institutions of research and extension (Chapter VII). The first two themes focus upon those features of the natural environment and human activity that are of particular importance to development efforts aimed at improving the agricultural productivity and economic well-being of farm households. The final theme summarizes the major weaknesses of the formal research and extension programs that have prevented their making more significant contributions to agrarian change in the OHVN zone.

The Natural Resource Systems

Throughout much of the OHVN zone, farmers are faced with a complex and constantly changing mosaic of physical resources to which their management efforts must respond in order to meet their nutritional and economic needs. The essential characteristics of the major resource systems (rainfall, soils, vegetative) provide a number of important lessons for both understanding farmers' behavior and for the organization of assistance activities. In the OHVN zone, for example, soils lie in two distinct soil regions, neither of which offers farmers exceptional production opportunities. However, within each of these regions, regular and random influences of topography, moisture regimes, parent material, and vegetative communities, among other factors, contribute to the development of a range of variations in local soil conditions which farmers exploit. In terms of rainfall, the OHVN zone has experienced a marked decline in annual rainfall levels since the late 1960's. This decline has contributed to an increasingly variable (spatially and temporally) pattern of local rainfall. When combined with the varying levels of fertility and water-holding capacity of different soil types, the uncertainty in local rainfall creates a wide array of conditions to which farmers must respond. Overlaying this landscape are vegetative communities which directly influence the adjacent croplands and provide a number of important economic benefits to area households. The positioning and composition of these communities reflect both the conditions of the physical environment and past management decisions. Agricultural production in such complex, diverse and risk-prone environments places a premium on knowledge, both of the major characteristics and specific details of each site, as well as the agroecological processes which govern the viability of each management alternative.

The Human Response System

Having evolved from within such a *milieu* of extreme variability, farmers' management systems in the OHVN are characterized by flexibility, adaptiveness, and attention to detail. Changes in both the physical environment and the availability of household resources require that farmers continually make adaptive modifications in their management practices, as well as undertake improvisational responses as the need arises. Farmers' abilities to successfully meet the demands of each season depend largely upon their intimate knowledge of the production environment and their ability to creatively respond. These behavioral patterns are characterized in this dissertation as 'linked agricultural performances' (cf. Richards, 1989).

At the household level, farmers defray risk and exploit the available opportunities by diversifying their investment of scarce resources across a wide range of economic activities. These activities include agricultural, value-added processing, and on- and off-farm non-agricultural employment. The exact pattern of investitures for any household in any given year depends upon the existing constraints and perceived alternatives, and are continually in flux in response to signals from both within and outside of the household. Similarities in large-scale environmental and market conditions, as well as transportation infrastructure, and other factors, allow the characterization of at least five, and possibly as many as eight, distinct household economic 'portfolio' areas.

Over time, the management practices and economic alternatives associated with these portfolios have changed significantly. Farmers identified changes in virtually every aspect of their production systems that they have made since the 'time of their mothers and fathers.' These changes include: the diffusion of varieties and the introduction of new crops; adaptations to cultural practices; the increased use of soil fertility and water conservation practices; and the development of new agroforestry and horticultural systems, among others. Many of the changes were undertaken in direct response to fluctuations in the physical environment, most notably the sharp decline in regional rainfall levels and declining soil fertility. Other changes represent responses to emerging market opportunities, such as the sale of horticultural crops and an increased investments in livestock.

Recent changes to local production systems come from several different sources. On the whole, however, the majority stem from farmers' own innovations, as well as their adaptations of technologies developed by the formal system. Only a limited number of technologies produced by the formal system have been adopted outright on a large scale. Farmers' experimental activities can be classified into three basic types: those aimed at making adaptive changes in their current practices; those aimed at integrating new material and practices obtained elsewhere into their current production systems; and the exploration of their own ideas and curiosity.

The knowledge, new information, and materials supporting these experimental activities are acquired by farmers primarily through their personal experiences and local channels of communication. Although much of farmers' general knowledge about the physical environment is broadly shared, farmers' more specific technical knowledge is largely acquired through personal experience, and is deeply meshed with the other aspects of their daily lives. A number of social factors, including gender, age, kinship ties, class, and ethnicity, among others, exert important influences over an individual's life experiences, access to resources, and opportunities to interact with others. These same social factors also strongly influence the principle lines of communication through which individuals exchange information. Farmers indicated that these informal lines of communication are the major means by which they acquire new genetic material and management information. On the whole, local knowledge, and the informal processes of innovation and communication, have served as the virtual 'lifeblood' of local agrarian change in allowing farm households to adapt to the evolving set of environmental and social conditions.

The Institutional System

Despite a high level of sustained financial support for agricultural research and extension activities in the OHVN zone, a number of critical issues can be identified within the orientation, organization, and objectives of the formal research and extension programs that have prevented them from playing a more significant role in the evolution of local production systems. Many of these issues are directly linked to the major features of the physical environment, farmers' management systems, and local producers' knowledge and creative capacities that have been described thus far.

In its orientation, the research and extension programs have seldom acknowledged or attempted to respond to either the dominant characteristics or more detailed attributes of the major natural resource systems influencing agricultural production within the zone. For example, sensitivity analyses on the impact of rainfall variation on new technologies are not routinely performed by the research program, despite the fact that for most technologies, such variations determine their overall profitability and ultimate viability. Virtually no attention has been given to the soil conditions under which new technologies are tested, contrary to farmers' practices of matching cultural techniques and genetic material to the specific environmental conditions. There is no indication that the research or extension programs recognize the need for farmers to maintain an adaptive outlook in their production activities, or to diversify their household economic activities, either as a means of fully exploiting the available resources, or in providing household economic and nutritional security.

The research agenda in particular fails to reflect the differing needs of farmers within specific locations of the zone, e.g., the need for various water conservation measures in the semi-arid northern areas. Although the formal system's research program is based upon a partial prioritization of farmers' perceived constraints, the translation of these constraints into actual research themes and specific field trials shows a strong bias towards the use of purchased inputs. In most cases this bias is ill-suited for both the physical conditions and the financial resources of a majority of the farm households in the zone. Furthermore, the newly added research themes on natural resource management, which may offer farmers more affordable means of mediating some of the vagaries of their production environment (such as using rock and vegetative barriers to improve moisture conservation, thereby reducing the problems associated with highly variable rainfall), remain artificially separated from the traditional research themes on crop and animal production.

In addition to the technical shortcomings related to the research program, the organization of the extension program has failed to respond to farmers' needs in a number of ways. The extension service has shown no signs of targeting its efforts towards assisting farmers in specific areas, or specific types of households (e.g., those with or without animal traction). Nor, as currently written, do the *fiches techniques* contain the type of information that would allow them to be effectively targeted. The core of technical messages upon which the OHVN's technical program is based are outdated, inconsistent with the newer recommendations on natural resource management, and incompatible with many of the conditions with which farmers are faced. As a result, the majority of technical recommendations extended are largely irrelevant to farmers' needs and major concerns.

A more grievous shortcoming of the extension program relates to the basic objectives of its service delivery orientation and use of the T&V approach. The T&V approach was designed, and is currently being used in the OHVN, as an efficiency measure for getting technologies quickly into the hands of as many farmers as possible. As noted above, however, the technologies developed and extended thus far are largely ineffective, outdated, and in general represent static responses that are inappropriate to the dynamic circumstances in which farmers find themselves. While improved technologies have a definite role to play, in CDR environments such as the OHVN zone, the development of an improved capacity of farm managers to respond to evolving, site-specific sets of conditions will play an equally, if not more, significant role in the future of agricultural development in the zone. Farmers not only need improved 'tools,' relevant to their conditions and major concerns, but also an improved ability to further adapt and refine these new and existing tools to meet their continually changing, highly specific needs.

In general, the orientation of the research and extension programs are towards the development of static technologies that are extended as blanket recommendations, irrespective of local conditions, and missing entirely the needs of farmers attempting to manage dynamic and highly diverse production environments. Aside from the minor attention to increasing women's range of income-generating opportunities, the research and extension programs have done little to improve the profitability of farmers' current activities, or to increase the overall range of options from which farmers' in various areas can choose.

Despite major efforts of the DRSPR/OHV to improve its working relationship with various partners, the principle linkages within the formal system (research-farmers, extension-farmers, research-extension, formal system-knowledge base) continue to suffer from major weaknesses. Of principle concern is the poor use made by the research and extension programs of farmers' detailed knowledge and skills. Outside of supplying land and labor, farmers are little involved in the development, evaluation, and redesigning of new technologies. The limited consultations with farmers both prior to initiating and after completing research trials are superficial, and have failed to result in any notable changes in the research program, either in its overall orientation or with respect to any individual technologies. Women in particular have been excluded from the majority of research and extension activities. With the OHVN's decreased involvement in credit, input supply, and marketing, coupled with a stagnant technical program, farmers have few reasons to maintain contact with the extension program's field agents.

Several institutional factors within the research and extension programs are largely responsible for creating the conditions which have allowed such poor relations with area farmers to prevail. Within the research program, for example, there is no incentive structure for encouraging or rewarding researchers for becoming involved in collaborative research with farmers. In fact, becoming more involved in field research activities brings with it a number of disincentives, including physical hardships, and with the more participatory styles, the added difficulty of having to work around the different educational levels and worldviews of farmers. Unlike other sections of the DRSPR, the TA provided thus far to the OHV, has not been oriented towards improving researchers abilities to take a more farmer-oriented approach in their field work. As a result, researchers in the OHV are poorly positioned to begin taking advantage of the growing, but still limited, professional and publication opportunities associated with FPR field approaches. Lastly there is no established, or implicit, mechanism for ensuring research's accountability to farmers' needs or in making tangible contributions to farmers' welfare. These same factors are present within the extension service, if not in a more pronounced form, and are exacerbated by difficulties in securing logistical support and per diems, and by the organizational culture of the OHVN which views farmers as generally uneducated and stubborn.

The overall effectiveness of development efforts within the OHVN zone has been further hampered by the non-productive relationships between the research and extension services, and their potential development partners, as well as the poor use of the existing formal knowledge base. Few, if any, of the results from the many research trials conducted annually in the OHVN zone have found their way to the extension service. Conversely, little 'feedback' and observations from the OHVN field staff, which could benefit the various research programs, are being communicated to researchers. When coupled with the poor use of the literature, and the limited (and in the case of the extension program, dysfunctional) relationships with other development organizations (e.g., Peace Corps, DED, FAO), the research and extension programs have largely isolated themselves from other possible sources of information and collaborative assistance.

In sum, the formal system's failure to account for the major characteristics of natural resource systems, and the nature of human responses that these systems necessitate, combined with the underutilization of the existing human and information resources, has rendered the research and extension programs almost incapable of dealing with the complexity of conditions found in the OHVN zone. Neither program seems to appreciate what is required to be a successful farmer under the prevailing conditions, and are thus poorly positioned for providing the kind of technical support that farmers need.

Recommendations for Improving Future Development Efforts

Based upon the findings of this research, a number of recommendations can be made which hold promise in helping the OHVN extension program and DRSPR/OHV research unit improve their assistance to area farmers. Although the following recommendations are directed primarily towards these two institutions in the OHVN zone of Mali, many of the underlying messages contained in these recommendations are relevant to other development efforts within the region and, at a more general level, contribute to discussions on agricultural and rural development approaches on a broader scale. The recommendations presented here are organized along the same general themes identified in the research.

The Physical Environment and Farmers' Performances

Belloncle's observation that "if African farmers as a whole have not yet adopted the practices recommended to them, the reason is not that they are too complicated for them; on the contrary, they are too simple to solve farmers' problems" (1989:39) speaks volumes in the case of development efforts in the OHVN. As a precondition for other improvements, a greater effort will need to be made in increasing the research and extension programs' ability to address the complexity and diversity of the principle resource systems which farmers manage. This effort will need to include not only a more detailed accounting of the general and specific attributes of the individual resource systems, e.g., rainfall and soils, but will also need to reflect certain aspects of systems interactions, such as the implications for different management strategies of highly variable rainfall patterns occurring across a number of locally occurring soil types. At a minimum, all development efforts should reflect a basic compatibility with the variability and diversity of the major resource systems. For example, new technologies should be subjected to a sensitivity analysis on the effects of fluctuations in rainfall similar to those with which farmers must contend. Research, and any technical messages extended, should also reflect a basic appreciation for the differences in soil types that farmers manage. Attention will also need to be directed at determining the ability of various management practices to buffer the vagaries of the environmental conditions and conserve resources, while increasing the productivity/profitability of local production systems.

Fortunately, a number of conceptual models and specific techniques exist which are capable of responding to the high levels of resource diversity found within environments such as the OHVN zone. As mentioned previously, ICRISAT has developed a soil 'toposequence' approach for use in targeting field trials to specific, locally occurring soil types. Such an approach could greatly help both research and extension in effectively targeting their efforts to the actual land types that farmers recognize and manage in their production systems. In the case of local variance in rainfall, simple field techniques for assessing soil moisture in relation to the specific moisture-holding capacities of different soil types have been developed for use by farmers in semi-arid areas of Australia, and may require little modification for use in Mali. Such techniques would greatly aid the current practices which ignore soil differences, and measure moisture availability using centrally placed, village rain gauges.

In addition to shaping the research program around a more realistic appraisal of the important features of resource diversity and variability found in the OHVN zone, the research and extension programs need to explore ways of helping farmers reduce or mediate the uncertainty resulting from certain types of variability. As a first step, the artificial separation between the so-called natural resource management (NRM) and more traditional production-oriented research themes needs to be eliminated. All of the NRM practices introduced to date produce agronomic benefits. These benefits, such as the yield response to water conservation associated with rock lines, not only need to be identified and emphasized when promoting these technologies to farmers, but also should be used as the basis for conducting additional research, e.g., exploring possible changes in cropping practices to take full advantage of the improved moisture conservation potential.

In some cases the formal system will need to broaden the conceptual horizon of alternatives for each technology. For example, if the construction of rock barriers effectively improves the infiltration of surface runoff, thus leading to higher yields, then other means of barrier construction should be examined (such as the use of vetiver grass hedges), particularly when in some locations sufficient quantities of rock are not available, or may not be the most efficient alternative. Developing technologies for use with a wider range of draft animals, e.g., donkeys and horses, is another example. Other areas, such as investigating the role of genetic diversity within the context of whole-farm production systems, will need to be started from scratch.

The research and extension programs must come to recognize that farmers are, and in such variable environments, need to remain, capable of making corrective adjustments in nearly every aspect of their agricultural production activities. The conceptualization of agriculture as a dynamic performance, introduced by Richards (1989) and built upon in this dissertation, offers an excellent starting point from which the formal system can begin to re-orient its field activities. One way of operationalizing this perspective is through the creation of technical recommendations that allow farmers to improve their ability of adaptively responding to changes in their physical environment and socio-economic circumstances. Because of the wide range of environmental and household conditions, technologies that are developed as discrete, static recommendations, such as one fertilizer application rate or one intercropping arrangement, are far less useful than tools or sets of sliding recommendations that can be used by farmers across a range of conditions (e.g., Okali et al., 1994). Better yet, 'loosely' packaged technologies, or the creation of management guidelines, that are specifically designed to allow farmers to mix, match, and adjust technologies to meet their unique circumstances may prove to be the best alternative. Another alternative, oriented specifically towards enhancing farmers' decision-making capabilities, involves the development of expert information systems, based upon the combination of the best of both local and formal knowledge (e.g., Walker, et al., 1991). Such systems can be designed to allow farmers to obtain useful input on emerging problems in an 'if...then' format, related to the parameters of their specific situation (e.g., Guillet et al., 1995; cf. Walker et al., 1991). Although technologies involved in this type of approach are still in their infancy, they hold the potential of providing the added benefits of creating a framework for the integration of formal and informal knowledge, as well as a basis for establishing and sustaining productive working relationships between farmers, researchers and extension field agents. Such approaches build directly upon farmers' adaptive and innovative capacities, and would require an entirely new outlook in agricultural research and the provision of technical support.

Household Economic Performances and the Identification of Portfolio Areas

A second area around which recommendations for the research and extension programs can be based is the formal system's conceptualization and characterization of household production systems. In light of the nature of the physical environment and the diversity in household resources, it is obvious that no single innovation or change will be capable of stimulating widespread economic growth across all households within the entire OHVN zone. Economic growth will continue to come from a diverse set of sources, with benefits accruing unevenly across households, depending upon their current circumstances, objectives, and abilities. In order to turn the pervasive diversity of household production systems into a positive theme around which specific actions can be planned, the formal system will need to redefine its characterization of recommendation domains and the differences in household types to reflect the variation in household opportunity sets. At least two immediate benefits can be gained from adopting a more holistic, whole-farm appreciation of household economic diversification. First, such a view would provide a framework for viewing individual agricultural enterprises as part of a whole-farm production system. Vandemeers (1989) and Schultz (1984), for example, have identified strategies of allocating resources between higher producing monocrop systems and more secure intercropping patterns that maximize both farmers' economic returns and overall security (cf. Sterns and Bernsten, 1994) . Such strategies are far different from the current practice of viewing each enterprise in isolation from others. A whole-farm perspective would also provide the context for understanding differentiations in tasks, access to resources, constraints and opportunities that affect various household members. In terms of gender differences, this would allow women's activities to be treated within the central focus of the research agenda, i.e., the whole-farm production system, and not as a separate stream of ventures that is easily isolated and marginalized.

A second potential benefit of adopting a diversified, whole-farm perspective lies in the re-characterization of research and recommendation domains in order to more closely match the overall constraints and opportunities experienced by households in various locations of the zone. As suggested in Chapter IV, a characterization based upon the portfolio of economic activities exploited by households in different areas is one such option. As a planning tool, adopting a portfolio outlook would allow researchers to quickly scan the breadth of principle enterprises which households rely upon in different locations and identify points of leverage where existing activities can be improved and new alternatives developed--in effect, using portfolio descriptions as a basis for conducting rapid sectoral-type assessments of each enterprise, across the range of enterprises in which households of different areas are engaged (an approach which is reminiscent of those advocated in the early period of the farming systems research movement).

A re-characterization of the OHVN zone along household economic portfolio lines would also provide a framework for the extension service to begin customizing its programming, in order to meet the diverse needs of farmers in specific areas within the zone. The decentralization of technical planning to respond to the needs of separate portfolio areas would provide OHVN field agents and subject matter specialists with a new range of tasks and, in the case of field agents, would for the first time bring their creative capacities into the development process. Any such move would necessitate a major reworking, or discarding, of the current T&V model.

The Orientation of the Institutional System and Farmers' Role in Development

In light of the rapidly changing institutional landscape of the national research system in Mali, the recommendations in this section are of a more general nature. Two areas which require immediate attention are the strengthening of working relationships between the various development partners, and an improved utilization of the existing formal knowledge base. Acceptance of a multiple source of innovation perspective, such as proposed by Biggs (1989a), would offer a highly workable conceptual orientation for organizing the formal system's inter-institutional relationships, as well as for planning around the increased inclusion of farmers and other potential partners in development activities. The extension program in particular could benefit from a complete overhaul of its relationship with such development partners as the PAE, Peace Corps, functional literacy program, village economic development initiatives, and the potentials of collaborating with a number of NGOs working in the zone. In addition, both research and extension could benefit tremendously by increasing their use of the existing formal knowledge base. In addition to those techniques already mentioned, a number of others can be found in the literature and elsewhere (not to mention farmers' own innovations) that may need only minor adjustments in order to benefit farmers in a number of different locations within the OHVN zone. The adaptation of many of these technologies may require only the comparatively 'light' involvement of the OHVN subject matter specialists, with occasional support from individual researchers, rather than the 'heavy' involvement of the DRSPR/OHV on-farm research program.

Prior to initiating any specific improvements in their performances, the research and extension programs would be well advised to begin with a broader evaluation of many of the fundamental underpinnings of their respective efforts. Such an evaluation should include not only a re-conceptualization of the natural resource and household production systems, as already suggested, but also a thorough review of how well existing technologies correspond to these systems, and more importantly, a reconsideration of the longer term objectives of what a more 'developed' OHVN zone would look like. In doing so, the formal system will have to consider the ideal level of involvement of farmers in their own development, and the range of services that the formal system, is capable of providing in order to meet this objective.

The final group of recommendations suggested by this research pertains to the re-evaluation of farmers' roles in the development process. If rural people's knowledge and creative capacities are ever to become anything but "the single largest...resource not yet mobilized in the development enterprise" (Hatch, 1976), then it will be incumbent upon the research and extension services to take the lead in providing the opportunity for farmers' increased involvement. One of the central objectives of a revised approach to agricultural and rural development should be in improving the capacities of farmers and farmer groups to provide more of the 'engine' for local development. There are at least three basic ways through which the resources of the formal and informal systems can be integrated to improve development efforts: the incorporation, or direct utilization, of rural people's knowledge in problem identification and solution testing; the collegial interaction of researchers and farmers, along the lines of one or more of the many Farmer Participatory Research (FPR) approaches; and through supporting and strengthening the informal processes of innovation and communication by providing farmers with basic information, material, and occasional advice, and then tracking developments that farmers are able to generate through their own creativity (cf. Biggs, 1989b).

With reference to the first type of systems integration, e.g., making use of rural people's extensive knowledge, one of the clearest examples is through the incorporation of indigenous soil typologies into a toposequence research approach, which can then be used as a guide in designing future trials. The second, and perhaps most problematic, type of systems integration concerns that of farmer-researcher collaboration. A number of examples drawn from both industry and agriculture (e.g., Haverkort et al., 1991; Gamser, 1988; deBoef et al., 1993) show that if the debilitating biases held by members of the research community concerning farmers can be overcome (see Bentley, 1994; Chambers, 1983), the potential gains appear to be substantial. In Mali, some of the most successful research initiatives undertaken by the different DRSPR field units illustrate the significant benefits that the involvement of technology users in the development process can bring (see Kingsbury et al., 1994;

McCorkle et al., 1993). First, however, a number of institutional barriers will have to be removed. At a minimum, the incentive structure and provision of technical assistance will need to be consistent with any new goals. In the long term, mechanisms for ensuring the accountability of formal development structures to farmers' needs will have to be established if such an approach is to succeed.

Recommendations for exploring the third type of interaction, involving the 'feeding' of the informal systems of innovation and communication, include the explicit effort to build directly upon farmers' creativity and ability to exchange information. Examples of this kind of interaction, albeit entirely unplanned, can be seen in many of the observations on agrarian change described in Chapter VI, and are the subject of a rapidly growing body of literature on indigenous experimentation and communication (e.g., Alders et al., 1993; Fujisaka et al., forthcoming; Haverkort et al., 1991; Hiemstra et al., 1992; ILEIA, forthcoming). The successful use of RRA methodologies in this research demonstrates how easily farmers' innovative activities can be monitored with a minimal investment of resources. Perhaps the greatest challenge, at least initially, in attempting to use these approaches may lie in determining under what conditions one approach (drawing upon, working with, or contributing to farmers' own efforts) should be used over another, and when it may be more effective to rely upon more traditional research designs.

Of particular importance to the extension program will be the tapping into the informal communication channels. Mundy and Compton (1991; 1995) have developed a simplistic model (Figure 25) which could easily be used as a heuristic planning device by the extension program in optimizing the dissemination of various types of information. In addition to the existing focus on extension meetings and demonstrations, a combination of approaches, such as a vastly increased use of farmer-to-farmer visits, regularly scheduled farmers' radio programs, the creation of audio video tapes of farmers' experiences with various technologies, the creation of innovator 'clubs' or groups, and the development of farmers' 'best ideas' into technical *fiches* as part of the functional literacy program, would all help to revitalize the extension program.[242] In addition, specific 'nodes' in the local communication pathways could be used to facilitate the diffusion of information. The creation of simple information booths at the regional market places, the placement of message boards near traditional places of conversation (i.e., the proverbial village shade tree), where improved extension messages can be posted, and the use of existing lineage, clan, age-set, or traditional work groups as the basis for communicating information are just a few examples. Such a diversified approach would require additional training for field agents, as well as close supervision, in order to ensure that social inequities are not being increased.

Figure 25. Communication Channels and Types of Knowledge.[243]

		Types of Knowledge	
		Exogenous Knowledge	Indigenous Knowledge
Types of Communication Channels	Exogenous Communication	Technology Transfer	Indigenous Knowledge-Based Development
	Indigenous Communication	Diffusion; Co-opting of Folk Media	Cultural Continuity and Change

[242] See Bingen et al., 1994, for a more detailed set of recommendations specific to the OHVN extension program.

[243] Source: Mundy and Compton, 1991.

A deeper theme, which runs through many of the preceding recommendations that call for the increased involvement of farmers, relates to one of the chief observations of Chapter VIII--that the processes of change observed in the OHVN are in fact central to cultural evolution and survival. Clearly, one of the hypotheses to emerge from this research is that many of the potentials for sustaining rural development lie in the ability to stimulate, encourage, and facilitate these internal processes of social change within local communities themselves, rather than solely attempting to supply a discrete range of services from the outside. Nor is such a perspective new. Earlier in this century, Gandhi regarded rural development in terms of the moral and intellectual development of the individual, where the development of individual creative intelligence, won through the identification and solution of problems of immediate relevance, was seen as the central engine of rural development (Herrera, 1981:21). While such a view is supported by the theoretical interpretations of case study observations, it is almost at complete odds with the current service delivery philosophy driving the formal system.

Several alternative models of extension have begun to emerge that appear capable of developing the problem-solving capacity of local producers. These models focus much of their attention upon extension-education by establishing a more interactive and responsive relationship with farmers. As an added benefit, such approaches provide an expanded and meaningful role for field agents--something that has been entirely lacking to date in the T&V approach used by the OHVN. Many of the Participatory Rural Appraisal (PRA) techniques, as well as the 'third generation extension' (e.g., Rogers, 1993), GRAAP, and RAAKS (e.g., Engel et al., 1994) models provide examples of promising approaches. These models seem to have achieved a balance between acknowledging the ability of farmers to contribute to development activities, yet avoiding a romanticized notion of populist development. They do, however, suggest that a larger, even major, share of development efforts should be focused upon developing rural capacities through engaging rural people in active, real-life problem solving efforts. In the end, this may not only contribute to 'better science,' as noted by Richards (1989b), but also a more sustainable form of rural development.

Future Research

Due to the conditions under which this research was carried out, certain time dependant features of farmers' behaviors, such as the intimate details of farmers' within-year adaptive performances and the year-to-year changes in household investment patterns, could not be thoroughly explored. The point has been reached, however, where less research is needed on farmers' knowledge and capacities, and more on how to effectively put into practice that which is already known. In this sense, the basic tenets of action-research--the twin goals of knowledge generation and social change--may provide a more useful paradigm for conducting future research efforts in this area. The conceptual themes on the dynamics of the local systems, presented in Chapter VIII, provide an ample theoretical basis from which a number of research-change interventions can be drawn. Based upon the findings from this research, an overarching hypotheses on the need for human potential maximization (in terms of knowledge, creativity, and communication) among farmers, extension workers, and researchers, could be used as the general orientation for future investigations. Specific attention paid to various features of the local social system to facilitate the diffusion of information, and the ability of farmers to become more explicitly involved in different types of experimental activities, hold particular promise in advancing research methods and extension practices.

Some Conclusions on the Research Process

On the whole, the methodologies used in this research--the grounded theory approach and rapid rural appraisal data collection techniques--were able to meet the many challenges of exploring a poorly understood subject under tight time constraints, and across a wide range of environmental and social conditions. In particular, the ability to adjust the principle lines of inquiry to reflect a growing understanding of the issues under investigation, and the use of multiple data collection techniques and subjects (triangulation), were critical features in the success of this research. In covering the breadth of thematic and physical territory addressed in this research, use of the 'constant comparative method' and the ability to visit a number of research sites were also major factors in its success. The ability to explore emerging areas of importance during the research process allowed a number of themes to be developed which had not been part of the original intent of this study. Examples of these include the characterizations of household economic portfolio areas, and the identification of different social influences on knowledge acquisition and information exchange.

The rapid nature of data collection, and especially the inability to make repeated visits with specific individuals and communities, did, however, limit the depth to which certain issues could be explored. Detailed studies, for example, of farmers' adaptive performances, the patterns of year-to-year household adjustments, and the documentation of experimental processes used by different farmers would all require sustained contact with a group of respondents over an entire production cycle, if not longer. Regarding the use of the grounded theory approach, the relatively short time frame for field research, also precluded the full development and testing of hypotheses while in the field. As a result, the development of 'grounded theory' in this research ended with the beginnings of a conceptual framework for understanding the processes of local agrarian change in terms of human behavior, presented in Chapter VIII. Any future use of the grounded theory approach should explicitly provide for multiple contacts with farmers over as broad a timeframe as possible.

In summary, the more significant contributions of this research may lie in using the grounded theory approach to link together the major facets of local change--knowledge, innovation, and communication--within the context of a single case study, and using this as the basis for developing a conceptual framework on the patterns of individual and social behavior involved in agrarian change. The findings presented in this dissertation provide the foundation upon which further research can build, and recommendations for numerous improvements in the formal system's ability to contribute to the welfare of the rural poor.

APPENDICES

APPENDIX A

Appendix A. Terms of Reference

ANALYSIS OF SERVICE DELIVERY SYSTEMS TO FARMERS AND VILLAGE ASSOCIATIONS IN THE ZONE OF THE *OFFICE DE LA HAUTE VALLEE DU NIGER*

A. BACKGROUND AND RATIONALE FOR THE ANALYSIS

For over 13 years, USAID/Mali has been providing support for farmers in the zone of the *Office de la Haute Vallée du Niger* (OHVN). This support has been channeled through a number of GRM agencies, notably the OHVN, DNAFLA and Travaux Neufs. In addition, technical assistance has been provided by two institutional contract firms (Louis Berger International Inc. and Experience Inc.), as well as by the National Cooperative Business Association (NCBA/CLUSA).

The emphasis of the current phase of USAID support is toward the establishment of self-managed village associations. Success in this area has resulted in an ever-increasing number of village groups that are willing and capable of contracting directly for a variety of agricultural services, including supply of agricultural inputs, transport of produce and marketing. The access that these village groups have to commercial bank credit further enables them to pursue a variety of economic activities.

As farmers' needs, abilities and organizational structures and competence evolve in the zone, the question of how best to respond to the needs of different kinds of farmers and farmers' organizations becomes critically important, as do the derivative questions of institutional sustainability, both of outside service agencies (e.g. OHVN and CLUSA) and local farmer organizations and village associations. For example, if farmers and village associations increasingly are capable of performing and contracting for marketing functions, but not extension functions, how will extension services continue to be provided (given that they are currently financed out of the profit margin on OHVN's marketing functions)? If some village associations, but not all, are capable of independently contracting for both marketing and extension, what are the implications for those less capable village associations which may continue to need OHVN or a similar agency for marketing and extension services?

This review will look at the participating organizations, from the farmers' perspective, to determine which ones provide the most effective services for farmers, and whether extension services might be obtained though more direct farmer-to-private operator arrangements. This study will examine the relationships of the development organizations in the Haute Vallée zone, to analyze the quality of services they are providing to farmers, and to suggest the most appropriate options for farmers, GRM agencies, cooperative organizations, and USAID.

B. OBJECTIVES

The specific objectives of this prospective analysis are as follows:

- to assess the performance, in terms of the quality of services provided to farmers, of the various agencies and organizations working in the OHVN zone;
- to identify the range of options available to the GRM and USAID for assisting farmers in the OHVN zone, presenting the advantages and disadvantages of each option;
- to determine how realistic is it to expect farmers and/or village associations to pursue their activities in a fashion that is more independent of a rural development organization, such as the OHVN;
- to determine whether the private sector can be counted on to play a greater role in agricultural extension.

C. STATEMENT OF WORK

The review of agencies and organizations working in the OHVN zone will provide answers to the following questions:

1. Technology Assessment

   a) What are the various (modern and indigenous) agricultural production, storage and processing, and other income-generating technologies used at the household level in the area?

   b) What are the significant non-agricultural production, income-generating activities in the zone?

   c) Are there any indigenous crops that could be used to enhance the incomes of households in the zone?

   d) What are the organizational mechanisms, if any, used by farmers to share information concerning agricultural technology? Are these organizations among those recognized as operating in the OHVN zone?

   e) What organizations are responsible for the development of new or improved agricultural technologies? How do these organizations account for the use of indigenous knowledge?

   f) What is the degree of integration of the indigenous and formal agricultural research and extension systems? Based on their current practices, do farmers have the opportunities, and do they seek changes in the technology packages that are promoted by the formal research and development organizations?

2. Technical Services Needs Analysis

   a) What are the kinds of services required by farmers in the zone, and what is their likely evolution over the next 5 to 10 years?

   b) What are the differences in the technical needs of farmers and farmer organizations, taking into account the fact that some village associations have progressed to the point where their needs are minimal, while other farmers are still very reliant on extension services?

   c) Are these service requirements identified by the farmers themselves, or do problems of a technical nature need to be brought to their attention by technicians?

3. Identification of Organizations and their Contributions

a) What specific benefits have each of the organizations operating in the project zone contributed to the general welfare of the farmers in the OHV zone? What are the roles and relationships of each of these organizations (both formal and informal)?

(1) OHVN
(2) CLUSA
(3) Peace Corps
(4) PVO/NGO community
(5) Community development organizations
(6) USAID
(7) Participating institutions from other GRM agencies (DNAFLA, Travaux Neufs, DRSPR, etc.)

b) What has been the contribution of these organizations to farmers' current production levels and standard of living?

c) Are there other sources of extension services (e.g. the World Bank's Training/Visit Extension Project), now or likely to arrive in the future, outside of the OHVN? If so, how would farmers access these services? Would farmers be willing to pay for such services on a fee-per-service basis?

d) What services are being provided by the *Compagnie Malienne des Textiles* (CMDT) to farmers and village associations in its zone of intervention? Are there any lessons from the CMDT program that could be transferred to farmers and village associations in the OHVN zone?

4. Organizational Dynamics

a) Which village associations now have the capacity to manage agricultural input supply, transportation, marketing, credit and extension needs on their own, without the assistance of a rural development organization? What proportion are most likely to develop this capacity in the future?

b) Are extension programs and other services which are developed for farmers by the OHVN a response to an expressed need?

c) How are the needs of the rural populations transmitted to the OHVN, DNAFLA and CLUSA? What structures exist for assessing and meeting these needs?

d) Are there built-in organizational incentives or disincentives for organizations working in the OHVN zone to undertake innovative activities, explore new options, or plan future programs?

e) What is the effect of the restructuring of the OHVN on its organizational efficiency? At what pace should the restructuring continue?

5. Political Context

a) Are there situations where the institutional priorities of the OHVN are in conflict with the development goals of a village association? How are these issues resolved?

b) In what political and legal contexts do village associations operate? Is this context changing as a result of the recent *Etats Généraux* conferences with farmers? Will village associations have an enhanced political and economic role to play as a result of the adoption of the *Shéma Directeur du Secteur, Développement Rural*?

c) In what political context does the OHVN operate? Does this context constrain or enhance organizational behavior and effectiveness, particularly in relation to the supply of services to farmers?

d) How are the changing policies regarding rural organizations in Mali affecting village associations in the OHVN zone?

e) What changes, if any, has the recent change of status of the OHV from an *Opération* to an *Office* had on its ability to provide farmers with extension services?

6. Organizational Constraints

a) What factors constrain village organizations from further development? What changes in their structure would enhance their effectiveness in increasing agricultural production and involvement in other economic activities?

b) What factors constrain the OHVN from effectively fulfilling its own mandates? The analysis should look at the following possible constraints:

(1) human resource capability and availability
(2) financial resources (under various scenarios given differing relations with village associations)
(3) non-human resources
(4) gender-related issues
(5) socio-cultural constraints
(6) communications
(7) decision-making processes

APPENDIX B

Appendix B. Research Instruments

ANALYSE DES SYSTEMES DE FOURNITURE
DE SERVICES AUX PAYSANS ET AVS
DE LA ZONE
DE L'OFFICE DE LA HAUTE VALLEE DU NIGER

ETUDES VILLAGEOISES--GROUPES DE VULGARISATION ET FEMININE

Zone: Date:
Village:
Approx. Pop.:
Group Type:
Gender of Group:
Attendance:
Session Facilitator(s):
Village Officials and OHVN Personnel Present:

PART I

Group History (year of OHV intervention; formation of GV; membership)

I. Describe the agricultural system(s) used in the time of your fathers/mothers.

-varieties (local?) -intercropping -rotations -fallow

-number of fields/systems

Bush	Crop	Varieties (No./ Chrct)	Intercropped
Year 1			
Year 2			
Year 3			
Year 4			
Year 5			
Year 6			
Year 7			
Year 8			

Fallow Length (why):

-cultural practices -equipment -animals -trees page 2

II. What production systems are now being used?

-varieties -intercropping -rotations -fallow

Bush	Crop	Varieties (Chrctrs)	Source	Difference	Intercropped W/
Year 1					
Year 2					
Year 3					
Year 4					
Year 5					
Year 6					
Year 7					
Year 8					

Fallow Length (why):

-cultural practices (% using animal traction) -equipment -livestock -trees (why important)

What were the major agricultural problems during the time of your fathers/mothers?

What are the major problems today?

-striga -fertility -erosion -pests -birds -storage

-livestock -spare parts

What changes have you made in your practices in the last two years (why, in response to what problems)?

-stopped old practices -started new -crops -varieties

-rotation -fallow -planting -others?

Where did the ideas or materials for these changes come from?

Where do you most often talk about agriculture with other people?

-fields -village -Group -market

From whom do you get information about agricultural practices? What? How often?

-family members/relatives -friends -sources outside of the village

-ONG's -field days -trials -radio -publications(Bambara)

What sort of agricultural information (seeds) do you share with your friends, relatives?

Rank sources by importance and Match with major problems mentioned above.

In the last year or two have you conducted any experiments? Where did ideas and or material come from?

-varieties -planting -rotations -intercropping

Have you heard of others in the village who have? Who? What? (beyond the group)

Who is the local millet expert? Sorghum? Maize? Niebe? Arachide? (beyond the group)

If you were able to talk to a researcher and demand some technical information what would you ask for?

-types of varieties -solution to which problems

Rank the crops you now grow in terms of their importance as food crops (good year, bad year) (specific varieties) (hungry season crops; gathered crops; fonio)

Rank the crops in terms of their importance as economic sources (good year, bad year)

What did your fathers/mothers do during the dry season to earn money?

What do you do during the dry season to earn money?

-wage labor elsewhere -hunt -fish

RESOURCE MAP

Location of different soil types; forest; water sources; other features

Location of different types of fields

Location of specific innovations
-anti-erosion dams -living fences -animal park -tree plantings

Location of fields of local "experts" (beyond the group)

Location of trials or experiments

*Plan route to visit sites with "guide"

Specific Sites

-History, where ideas and materials came from

-what took place -modifications -future plans

Specific Fields:

-source of seeds -cultural practices -problems

-fertility -erosion -sources of assistance/knowledge

"Best" Farmers:

-What are they doing -how different from others

-who do they talk to, where -sources of information

How many farmers are there in the Group?

Are these always the same people? If not, why?

Are there any women members? If not, why?

What do you do as a group? How do you work together? How different since intervention of OHVN?

What is the name of your Chef Sous-Secteur?

When does he come to the village? How often do you see him?

What does he do when he's here? What does he talk about?

Do you take your agricultural problems to him? What?

Has he been able to help? If not, what happened?

Have you had any difficulties in relations with agents of the OHV?

What have been your greatest benefits in working in the Group? W/ the OHV?

What would you like to see from the OHV in the future? (technical assistance)

Fiche Technique
Chef Secteur: Chef Sous-Secteur

ANALYSE DES SYSTEMES DE FOURNITURE DE SERVICES AUX PAYSANS ET AVS DE LA ZONE DE L'OFFICE DE LA HAUTE VALLEE DU NIGER

Questionnaire
Encadrement OHV
(Chefs Secteurs, Chefs Sous-Secteurs,
Chefs ZAFs et Animatrices Actions Feminines)

A completer et remettre au Chef Secteur pour envoi à Simpson, s/c DCDR, Bamako **avant 31 juillet 1992**.

Poste: (Mettez une croix devant le groupe de secteurs auquel vous appartenez.)

_____ Koulikoro, Kati, Sirakorola, Banamba, Boron
_____ Gouani, Ouélessébougou, Dangassa
_____ Bancoumana, Kangaba

Nombre d'années avec l'OHVN: _____

Periode de temps dans le poste actuel: _____

OHVN - MISSION, RESTRUCTURATION

Quelle est la mission de l'OHVN?

Quelles sont, d'après vous, les effets de la restructuration de l'OHVN?

Quelle est la contribution de l'OHVN à l'amélioration des conditions de vie des paysans?

Quelles sont les conséquences du changement de statut de l'OHVN en Office sur sa capacité de fournir des services aux paysans?

Y a-t-il des facteurs qui empêchent l'OHVN d'accomplir efficacement ses fonctions? Si oui, lesquels?

PROGRAMME DE VULGARISATION

Quelles difficultées avez-vous constatées avec les themes techniques au niveau du paysan? Préciser.

Comment peut-on améliorer le programme de vulgarisation 9y compris les themes techniques)?

Le programme de vulgarisation qui est mis au point à l'intention des paysans par l'OHVN reflète-il un besoin exprimé? Préciser.

Y-a-t-il une évolution dans le programme de vulgarisation? Préciser.

RELATIONS RECHERCHE-VULGARISATION

Y-a-t-il la recherche agricole dans le secteur et/ou les sous-secteurs? Si oui, quelle est l'importance de cette recherche?

RELATIONS VULGARISATION-PAYSANS

Comment les besoins des villagois sont-ils transmises à l'OHVN?

Identifier les questions techniques posées par les paysans auxquelles vous avez rencontrés des difficultés à repondre?

Quelles sont les difficultés OHVN-paysans?

Quelles sont les difficultés dans la vulgarisation de nouvelles varietés?

Identifier les variétés de mil, sorgho et maïs adoptées pour votre sous-secteur. Identifier les variétés cultivées par les paysans (variétés diffusées par OHVN et variétés locales)?

Connaissez-vous des "paysans-chercheurs"? Si oui, quels sont les objectifs de leurs recherches?

Identifier les variétés locales et/ou les pratiques culturales des paysans qui sont mieux adaptées aux conditions des paysans que celles vulgarisées par l'OHVN.

Si vous avez parlé avec d'autres paysans en ce qui concerne ces variétés ou pratiques, citez des cas.

Avez-vous parlé avec d'autres cadres de l'OHVN ou avec des chercheurs en ce qui concerne ces variétés our techniques? Si oui, quelle a été la suite de vos conversations?

Connaissez-vous de paysans qui ont modifie les thèmes techniques en fonction de leurs conditions. Quel changement? Commentez.

SITUATION AVs

Existe-t-il des situations où les priorités de l'OHVN sont en conflit avec les objectifs de développement d'une association villageoise? Comment résoud-on ces problèmes?

A quelles conditions toutes les AVs pourront-elles prendre entièrement en charge les programmes de développement de leur village?

RELATIONS OHVN-ADMINISTRATION

Quel est le rôle du comité et des conseils de développement?

Comment sont conçus et executés les programmes des comités de développement?

Quel rôle joue les conseils développement? Quels sont leurs rapports avec le comité de developpement?

Preliminary Reconnaissance Guidelines (Demo)

Date:_______________

Contact(s):_______________________

Level:
Source:
Method:
Specific informational needs:
Primary Questions for Source/Methods:

Additional Questions:

Verifying Questions:

Comments:

APPENDIX C

Appendix C. Transcript of an Interview with Owenemen Diarra, May 27, 1991

"The way the rainy season approaches in these parts, there are signs that we use which let us know that the rains are not far off. What things? Well, there is a certain grass which grows in the bush lands called *musowa*. The hot weather that comes before the rains makes this grass sprout new leaves. The cattle feed on these leaves. This grass sprouts before another that we use to make granaries from, called *cékala*. When you see that all of the *cékala* has sprouted, the rains will have arrived. Whatever you do, you should be planting then. If you've planted by then you won't get left behind. That's what we know about that, at least that's what comes to mind today.

What we know about birds, well, that's something that everyone knows. So if I skipped over that in the first place, it's because it's common knowledge. There is a bird that comes around here called *baninkono*. When you see the *baninkono* in the treetops, you should take your axe and go clear your field. God willing, you should be able to finish before the rains have arrived. If it turns out that you've cut the trees from your field by the time the *baninkono* arrives, then you'll be able to get a good burn. But the old men warn us that "the millet in the granary can be used up between the time the *baninkono* shows up and the proper time for planting." They say that "the millet in the granary can be used between the first sighting of the *baninkono* and the start of the rains." It's when it comes to build its nest that your planting should be done. You need to see the *baninkono* gathering millet stalks to take them up in the trees to build their nests and settle down. When they've built their nest, you'll find us planting.

By the time the rains are ending, around the tenth month, a lot of the *baninkono* will have left. Where they go we don't know, but there is another bird with a white chest that comes from the river when the rains are about to arrive. Quite a lot of them show up here. When we see them around, we know that it's time to get to work. The old men tell us that when we see these birds we should tell the kids that it's time to get to work. If you need to clear your field, you should take your axe and go clear your field. If you need to hoe your field, you should take your hoe and go work your field. When these birds start flying around in the treetops our young blacksmiths, who make our tools--our hoes with the curved handles, and especially the blades for them--they drop whatever else they're doing and get to work making our farm tools. If this is done as it should be, we'll be able to buy the blades and put them in without getting behind in cultivating. These young blacksmiths live here, right here in our village--there are quite a few of them. When it comes to farm tools, well, even if you go to them and tell them you need a hoe tomorrow, they take care of you. That's how it's done around here.

We see the *baninkono* and the old men tell us to get up and hitch up our britches. But it's just a bird, and about all you can count on is that when it comes the rains aren't too far off. In order to be more precise, we watch the way it acts. It comes in between the fifth and sixth months. Some come at the end of the fifth, some at the beginning of the sixth month. But when you see it you hitch up your britches, pick up your tools, and get your field ready. Clear and cultivate your field so you'll have enough millet to feed your family. When one person gets up early to eat his porridge, and others see him leaving the village early in the morning, they'll say to each other, "Hey, let's drop this--don't you see that farmer heading out with his plow," they'll take theirs and head out too..." (McConnell, 1993: Appendix A).

APPENDIX D

Appendix D. The Emergence of an Integrated Approach to Rural Development in Mali

In the decade leading up to Mali's independence in 1960, the emerging political leaders became increasingly polarized around alternative communist and socialist political ideologies (e.g., Jones, 1976). With the election of Modibo Keita, the socialist *Union Soudanaise Rassemblement Démocratique Africain* (USRDA) candidate, it was no surprise that Mali's first five-year national development plan, unveiled in 1961, articulated a form of 'rural socialism' (Bingen, 1985; USRDA, n.d.), termed by one observer as a "conciliation between Marxism, Islam and traditional communalism" (Megahed, 1970). While much of this plan was oriented towards decolonialization, achieving economic independence, and arousing a sense of political consciousness among the rural poor,[244] as Jones points out,

> "[w]hen the Plan began, the Malian government was obliged, to a considerable extent, to make do with a continuation of French colonial policies for rural development...if only because alternatives were not available. The only existing

[244] There can be no question that the new Malian government saw agricultural and rural social development as the primary vehicle for achieving its political objectives. The government sought to create a 'new man in the countryside' (Bingen, 1985) through a series of initiatives, which included the establishment of farmer cooperatives, collective fields, local and regional agricultural schools, all mixed with local party representation. These initiatives were oriented towards increasing agricultural productivity needed to achieve the national goals of food self-sufficiency, import substitution, commodity export and the establishment of an industrial base (featuring agro-industries)(e.g., Bingen, 1985; Jones, 1976; USRDA, n.d.). "[I]nstead of pursuing economic and social policies to transform peasant...production into socialist production units such as state plantation, the Keita regime believed the state had only to revitalize the productive forces of the traditional village economy" (Bingen, 1985:16-17). The problem lay in the fact that there were not enough trained civil servants and financial backing to carry out these plans and, as a result, few ever achieved wide-spread use (Jones, 1976; Megahed, 1970).

> plans for investment in the rural sectors were those conceived and drawn up by the French [and French speaking Marxist economists and planners, e.g., Samir Amin (pers. com. Bingen)] (1976:268)

The French policies, upon which the new government was to elaborate, consisted of investments in both large irrigation schemes, such as the *Office du Niger*, and smaller, more localized water control systems, called 'polders,' as well as the extension of new technological 'packages' directed at improving rainfed agriculture and the production of export crops (Bingen, 1985; Jones, 1976). The new government built upon these initiatives by continued investments in the *Office du Niger* and polder development, and by creating a national extension service to help popularize modern agricultural practices throughout the country. Compared with the investments in the various irrigation systems, those directed at establishing an extension service to promote rainfed agriculture (which accounts for the vast majority of agricultural production in the country) were kept to a minimum. New administrative structures, local political party representation, and collective work groups and demonstration fields at the village level were intended to assist the extension service in spreading the new production systems throughout the country (Jones, 1967). Although the Plan mentioned a concern for establishing an independent food supply, through the increased emphasis on food crop production, how this was to be achieved was not addressed (in Jones, 1976: 272). Most, if not all, of the Plan's focus upon agricultural development was directed at the expansion of cash crop production, which was viewed as the basis for achieving national economic independence and moving towards industrialization.

The Technological Basis

Aside from the *Office du Niger*, established in 1932, the French had never invested heavily in Mali's rural development. Nevertheless, a French agronomist, Viguier, developed two important technical 'packages' for increasing the productivity of traditional agriculture that were to have a lasting effect upon Mali's agricultural development. One package, based upon research begun in the 1930's, involved the construction of polders, engineered systems of levies designed to gain partial control over the rise and fall of annual flood waters, necessary to improving local rice production (Viguier, 1939; Gallais, 1967). The second technical package, also originating from work initiated by Viguier in the 1930's, was oriented towards the production of upland crops, and involved a specific rotation of cotton (fertilized with manure)-sorghum-peanuts-fallow (using *Stylostanthes gracilis*)(Jones, 1976). This system of upland crop production was referred to as the *M'Pesoba* method, after the agricultural school which Viguier established and where the system was first perfected (Viguier, 1952). Elements of the *M'Pesoba* system have exerted a great deal of influence upon agricultural development in Mali through the different rural development organizations.[245]

---

[245] One example of this is the continued fixation on the use of *Stylostanthes* in planted fallows. Both the second five-year Plan, 1974-1978, and early USAID planners for the *Haute Vallée* project, promoted the use of planted fallows with this species (Steedman et al., 1976), although nothing much came of their attempts because of several technical oversights. This technology was still being doggedly promoted by the OHVN extension service into the 1990's, albeit with very little success--only .25 ha. was planted by farmers during the 1991-92 cropping season (OHVN, 1992a).

The Institutional Framework

Accompanying these technological developments were a series of equally important institutional changes. By the mid-1960's a trend emerged among national planners to promote the creation of separate commodity-based agricultural 'programs' and 'actions' (e.g. *Programme Arachide; Action Tabac*) within the national Ministry of Agriculture (Diallo, 1990; Min. de la Production, n.d.). However, this first attempt at promoting a regionalized approach to rural development failed to achieve the desired results, primarily due to a cumbersome national bureaucracy, lack of funding, and shortage of trained personnel. As a result, in 1967 the government initiated a new approach. Impressed by both the economic success of the *Compagnie Française pour le Développement des Fibres Textiles* (CFDT), a French parastatal created in the late 1940's to expand the commercial production of cotton in southern Mali, and the organizational precedent set by the *Office du Niger*, a state-run, self-contained development project, the government began to create a number of separate, semi-autonomous *'opérations'* to promote national rural and economic development objectives. These *opérations* were centered around the promotion of specific agricultural systems, for the production of key economic crops within defined geographic areas. The *opérations* were given a *carte blanche* to "reorganize, coordinate and rationally utilize all of the means available to enable them to obtain their fixed objectives, within specific zones fixed by the government" (*l'Arrêté* No.573 SEER/CAR, June 20, 1967, in Min. de la Production, n.d.). Under this new approach, the future role of the Ministry of Agriculture was envisioned as being supervisory, presiding over a growing number of *opérations* and governmental agro-industrial *sociétés* (e.g. *Société des Conserveries du Mali*, SOCOMA) (Min. de la Production, n.d.).

From the outset, the *opération* 'formula' of rural development was conceived as "an integrated approach to development," aimed at undertaking a range of "social actions" necessary to improve farmers' conditions (Min. de l'Agriculture in Diallo, 1990:73). Farmers and village groups were given access to a number of services that were considered essential to the specific production objectives of each *opération*: technical advice, credit, chemical inputs, seeds, and commercial outlets for their produce (Min. de la Production, n.d.).

One of the intentions behind the creation of these semi-autonomous development schemes was to attract external donors who could help with their financing (Min. de la Production, n.d.). In fact, the identification of external funding was one of three criteria established for creating a new *opération* (*ibid.*). The remaining two criteria, the creation of a trained *cadre* of Malian professionals to staff and manage the *opérations*, and the establishment of a budgeting system independent from that of the funding source, were designed to keep these *opérations* from becoming neo-colonial enterprises of exploitation, one of the principle concerns of the new government (*ibid.*).

In 1972, following the 1968 *coup d'état* and a period of economic recovery, the second post-independent Malian government elevated its commitment to the *opération* approach to a new level, by making *Opérations de Développment Rural* (ODR) its official strategy of rural development (Bingen, 1985). The ODRs were founded upon the same principles of administrative and financial autonomy, and the same mandate to pursue their development objectives 'through any means available.' The planning documents of the second five-year Plan, 1974-78, clearly illustrate how central the ODRs were to meeting national development objectives (CNPER, 1972). Under the second Plan, the country was partitioned into 11 rural development zones, each of which roughly corresponded to the location of an ODR.[246] By the mid-1970's there were at least 18 agriculture ODRs and their smaller cousins, the *Actions*, functioning within the country (Diallo, 1990).

From an institutional standpoint, the creation of rural development zones, and the growing number of ODRs, marked an important turning point in the administration of agricultural and rural development in Mali. First, this initiative moved the majority of administrative responsibilities out from under the highly centralized, bureaucratic structures that had previously ground development efforts to a halt. Secondly, from a programmatic standpoint, the rural development zones and ODRs were established largely along agroecological lines. In determining their boundaries, the ODRs grouped together villages with similar agroecological conditions that could be easily serviced through a single development structure. By identifying areas with fairly homogeneous conditions, the ODRs responsible for commodity development in these areas could focus their efforts on exploiting the potential of a single set of conditions, rather than diluting their efforts by attempting to develop technical recommendations for a wide range of environments.

In terms of attracting external funding, the ODR approach was highly successful. By the early 1970's, nearly 90 percent of the financing for the different *opérations* came from foreign sources (e.g., European, French, among others)(Min. de la Plan, n.d.). *Opérations* which did not have external funding tended to exist on paper only (Steedman et al., 1976), as nearly all the available government funding was used to meet the matching fund requirements of the donor financed programs. Through a

[246] The correspondence of ODRs to the development zones was only approximate, as the ODRs had their own boundaries. In some cases they covered parts of more than one zone, or overlapped with other ODRs within a single zone (e.g., Bingen, 1985).

pricing structure known as a *bareme*, the ODRs were supposed to become increasingly able to generate their own revenues. This system of subsidies and price controls, established through the governmental monopolies on input supply and marketing channels (e.g., *Société de Crédit Agricole et d'Equipment Rural* (SCAER); *Société Malienne d'Import Export* (SOMIEX); *Office des Produits Agricoles du Mali* (OPAM)), allowed the ODRs to capture commissions on the marketing of agricultural commodities which they controlled, as well as through input sales.

Unfortunately, the unique characteristics of each ODR contributed to increasingly disparate rates of growth in the different rural development zones. Due to the combination of differences in the level of external funding, the profitability of the particular commodities being promoted, and the success of individual development approaches, each ODR has experienced its own trajectory in economic growth. Their independence from governmental support and dependence upon external financing have posed problems for the ODRs' longevity, as in cases where external funding has been withdrawn (i.e., the demise of the OACV). By establishing a new set of organizational divisions--*zones, secteurs, secteur de base*--the ODRs introduced an administrative system completely independent from that established by the first Malian government.[247] This financial and administrative autonomy of the ODRs has led to conflicts between the ODRs and the comparatively poorly-funded development efforts undertaken by the local governmental ministries (Bingen, 1985). Overall, such a strong

---

[247] As one of its first administrative acts, the first national government abolished the old colonial *cantons*, which had effectively preserved the traditional political structure of the Malinké *Kefu* (Leynaud and Cisse, 1978), replacing them with a new administrative structure comprised of *regions*, *cerles*, and *arrondissements*. This action reflected the Marxist approach of the first regime, which called for the destruction of the traditional peasant base in order to build a new 'collective spirit' at the village level (see Bingen, 1985:16).

reliance on external funding and planning so soon after the colonial period, while providing a short road to economic growth, also further delayed the development of a national capacity for conceiving and carrying out autonomous development plans.

APPENDIX E

Appendix E. The Evolution of the OHVN Extension Program

Phase I: The *Opération Haute Vallée* (OHV) Project

Following the decline in French and European funding in the mid-1970's, USAID took over the financing of a new *Opération Haute Vallée* (OHV) project in 1978. This project was a large, highly ambitious, integrated rural development program. The project's overall goal was to "increase the income and improve the quality of life of the rural poor," and was to be achieved largely through increased agricultural productivity and marketing (USAID, 1978). The project was designed around the major technical assumption that, aside from lack of irrigation, the limited use of animal traction (AT) was the major impediment to agricultural growth in the area. Farmer credit and an improved road system were seen as critical factors in allowing farmers to invest more heavily in AT technologies and in getting their increased produce to market. The project was composed of seven thematic areas: animal traction--promotion, training and research;[248] modifications in the agricultural credit program, in order to allow farmers to increasingly invest in AT and inputs; rehabilitation and expansion of 640 ha. of irrigated rice in the Bancoumana polder; road construction and improvements to facilitate the marketing of increased agricultural produce; a rural health care program

[248] Originally, the project paper called for the establishment of AT training centers as a way of promoting AT. These were later dropped, and attention shifted to the creation of demonstration farms as a way to spread improved AT techniques. Both of these measures are highly reminiscent of an early attempt by the first National Development Plan to use these same approaches to justify lowered investments in the creation of a national extension service. There were no funds in the OHV project specifically allocated for improving extension.

to improve labor efficiency; a functional literacy program to improve farmers' ability to access information; and administrative and technical support of the OHV in providing services to area farmers (USAID, 1978). In addition, minor components, such as a blacksmith training program to increase the local capacity of manufacturing and repairing of AT equipment, were added to the project. The combined impact of these seven components was expected to rapidly transform agriculture in the OHV zone.

Shortly after the OHV project was established, the *Compagnie Malienne pour le Développement des Textiles* (CMDT),[249] active throughout the more fertile and well-watered areas of Southern Mali, ceded its westernmost areas to the OHV, following slumps in the world market price for cotton. This transfer of land introduced cotton production as an important economic crop in the OHV's program. By 1980, the last and most significant addition to the OHV geographical range of coverage had taken place.[250] With both the crash of the world peanut market, and donors' refusal to come to its aid, the *Opération Arachide et Cultures Vivières* (OACV) folded. Subsequently, a substantial portion of the OACV's former area was transferred to the OHV. This transfer in effect tripled the OHV's size and doubled its client population, without adding any new economically viable commodities to its portfolio (as peanuts were no longer an economically viable cash crop). The addition of this new, semi-arid territory (rainfall in these northern areas was under 800 mm annually, compared to over 1,200 mm in the extreme South) meant that the OHV was no longer an area with

[249] The CMDT, originally the *Compagnie Française pour le Développement des Textiles* (CFDT), was established in the Koutiala area in 1952 to promote and extend the commercial production of cotton in Southern Mali. The CFDT was nationalized in 1974 and renamed the CMDT.

[250] None of these added territories were covered under the original OHV project design (RONCO, 1985)

fairly homogeneous agroecological conditions, but now contained a wide variety of physical conditions and an increasingly broad range of programmatic themes.

The Eighth Project Amendment

After some stinging critiques of the project's early performance (e.g., USAID, 1982; RONCO, 1985), substantive steps were undertaken to reform and improve the project's management and financial operations. Originally designed as a ten-year effort, funded under an initial five-year grant, the OHV project was extended and amended several times before it reached USAID's ten-year statute of limitation on project funding, and had received nearly 20 million dollars in total financing. Any success that the project experienced during the latter period of Phase I is directly attributable to the conditions imposed by the Eighth Project Amendment. This agreement essentially redesigned the OHV project, reducing the seven thematic areas to five: credit; functional literacy; road construction; on-farm research; and the administrative support of the OHV. The health and Bancoumana polder rehabilitation components were dropped completely, while the emphasis on animal traction research and training was replaced with a more general research focus on farming systems.

Despite the measured improvements which came from these changes, several major issues remained which the Eighth Amendment did not address. First, the inability of the OHV to cover its recurrent operating costs through the *bareme* system became an increasingly significant area of discussion. The position held by USAID, including the language of the Eighth Amendment, was that the focus of the OHV must be on food crop production. However, following the crash of the peanut market and the impending liberalization of the cereal markets, the OHV was increasingly being forced to turn to cash crop production (cotton and tobacco) in order to secure its operating revenues. This was further encouraged by the Government of Mali, which, after the financial failure and dissolution of the OACV, was urging all the ODRs to achieve higher levels of financial security in their operations. Yet the OHV's ability to increase its level of self-financing was limited. The tobacco market was fairly stagnant, and cotton production was only viable in a fraction of the newly-expanded zone.

A second major issue was that neither the original project paper nor the Eighth Amendment addressed the need, or provided technical assistance, for improving the performance of the extension service. The early evaluations of the project (USAID, 1981, in RONCO, 1985; 1982) were highly critical of the extension service's performance, calling it "inefficient and ineffective " (USAID, 1982). Subsequent reviews (RONCO, 1895; USAID, 1986; Lebeau, 1986) continued to comment on the *opération's* weak extension service, but increasingly began to focus upon the closely related issue of the 'tired, old' extension themes and the lack of relevant, technical information. As Lebeau (1986) pointed out, the "limits on available technology limits the impact of extension." These problems were taken up in the project's redesign, under a second phase of funding.

Phase II: The Development of the *Haute Vallée* (DHV) Project[251]

As part of Mali's acceptance of the structural adjustment policies introduced by the World Bank under an Economic Policy Reform Program, the World Bank commissioned the *Société d'Aide Technique et de Coopération* (SATEC) to undertake a study on the reorganization of Mali's ODRs. The recommendations of this study, which was completed in 1985, called for the transfer of greater rural development

[251] Much of the material in this section is based upon an earlier version presented in Bingen et al., 1993.

responsibilities to the private sector (input supply companies, banks, and marketing structures) and to rural village organizations (SATEC, 1985). Phase II of USAID's investment in the *Haute Vallée* area built upon these recommendations in designing the new Development of the *Haute Vallée* (DHV) project, which redefined the role of the OHV as primarily an extension and planning organization. The DHV project was to address three main areas: "OHV restructuring, involving the gradual withdrawal from credit, input supply and marketing functions, accompanied by significant reductions in OHV staff and a strengthening of the OHV extension function; rural enterprise and rural institutional development, involving village-based farmer cooperatives, private business firms, and intermediate financial institutions; and expansion of the rural road network, to stimulate markets and private enterprises in the *Haute Vallée*" (USAID, 1988:6). Under this plan, USAID was to continue financing the credit, rural roads and functional literacy efforts begun under Phase I. In addition, new efforts were aimed at overhauling the OHV administrative structure, improving the OHV extension service, and establishing rural village associations and providing them with economic development assistance.[252]

In improving the extension (*vulgarisation*) program, the primary measures included: a reconfiguration of the OHV administrative structure and significant cuts in field staff; redefined jobs and improved technical support for extension field agents; and an increased transfer of extension responsibilities to rural villages (see OHVN, 1988). As part of this restructuring process, the OHV increased the number of administrative sectors (*secteurs*) from six to ten, and replaced its four-tiered extension

---

[252] Only those elements of the DHV program that have a direct technical impact upon farmers' agricultural activities are covered here. A review of the broader programmatic themes can be found in Bingen et al., 1994.

organization (headquarters, *secteurs, Zone d'Expansion Rurale (ZER), secteur de base*) with a three-tiered structure (headquarters, *secteurs, sous-secteurs*). This reorganization was matched with a nearly 50 percent cut in the number of extension field staff. At the same time, the OHV added a new women's program and created the position of *animatrice* to coordinate the new program's activities in each *secteur*. The OHV was also elevated to the status of an *Etablissement Publique Administratif* and became the *Office de la Haute Vallée du Niger* (OHVN), allowing it greater economic freedom. One of the hopes of the DHV project was that by reducing operating costs, through a reduction in staff and the transfer of a number of activities to the private sector, and by increasing agricultural productivity, the OHVN would become financially solvent (USAID, 1988).

During the latter half of the Phase I OHV project, the OHV had begun experimenting with a group approach for extension activities. Under Phase II, the OHVN increasingly applied, and eventually formally adopted, a Training and Visit (T&V) system of extension (see Benor et al., 1984). The major responsibility for agricultural credit, marketing and input supply was transferred from the purview of the extension service, and field staff jobs were redefined to focus solely on extension of technical information to farmers. A *Division de Vulgarisation* was created, as were seven new Subject Matter Specialist positions (SMS).[253] The SMS are located at the headquarters level to support and strengthen the training and technical backstopping of field agents, and to act as the primary link between the OHVN and various research programs. The OHVN research program, and position of research coordinator, were

[253] The SMS replaced the position of Research Coordinator. These seven new positions are divided between two sections: Crop and Animal Production (agronomy; animal husbandry; crop protection; irrigation and mechanization; tobacco) and Vulgarisation and Women's Activities (extension; women's activities).

phased out, as USAID undertook the financing of a separate farming systems research project in the OHVN zone (USAID, 1984). Field agents increasingly worked with village extension groups (*groupements de vulgarisation*)(GV) and contact farmers (*paysans de contact*), many of whom also served as *animateurs* in their local village association (*Association Villageoise*)(AV). Under the new governmental objective of increased "*responsabilisation du monde rural,*" the OHVN began to increasingly target the creation of self-managed extension villages (*villages auto-encadré*) as a major goal in its programming. According to the OHVN, these villages, some of which were selected in the mid-1980s, have achieved the level of technical skills necessary to meet their own extension needs.

The First DHV Project Amendment

In 1993, the first DHV project amendment was issued which extended the life of the OHVN project for an additional four years, and increased total spending on Phase II from 17 million to 29 million dollars (USAID, 1993). In addition to continuing support for the training of village associations, functional literacy training, credit scheme and rural roads construction, this amendment added a family planning and AIDs awareness component, provided for an expanded emphasis on natural resource management through the OHVN extension program and the addition of a pilot community-based forest management initiative, and added an agribusiness and marketing unit to the OHVN's operations. The new marketing unit was charged with developing commodity export and domestic valued-added processing markets for farmers in the OHVN zone, as well as providing technical and managerial training for local business entrepreneurs. The notion of exporting fruits and vegetables produced in the OHVN zone to Europe is not new, having been attempted under both the first and second regimes during the 1960's and 1970's. The Amendment also recognizes the incapability of the OHVN to become self-financing, and calls for the gradual transfer of support of the OHVN's operating costs to the Malian government over the course of the project extension (USAID, 1993).

APPENDIX F

Appendix F. Other Governmental Programs, Projects, and Organizations Working in the OHVN Zone.

Governmental Programs

There are a number of governmental units which operate in the OHVN zone, such as the *Service National de la Protection des Végétaux* (SNPV), *Recherche sur des Eaux et Forets*, and *Recherche Zootechnique, Forestière et Hydrobiologiques*. Yet, these programs operate in near complete isolation of the OHVN. The SNPV, for example, operates primarily in response to severe attacks of migratory insects. With limited assistance from the OHVN and a system of village brigades, the SNPV intervenes in the northernmost *secteurs* of the OHVN zone, Banamba and Boron, to control grasshoppers and blister beetles. The SNVP has the responsibility for national plant protection policy, but its program tends to be driven largely by the availability of external funding for emergency pest control. In response, other agencies, like the *Institut d'Economie Rurale* and some private firms, conduct their own plant protection and research activities to deal with non-migratory and chronic pest problems that trouble farmers throughout the OHVN zone. These agencies devote some time to the study or use of integrated pest management techniques (Kremer and Sidibé, 1991).

The *Centre Feminin d'Animation Rurale* (CFAR) in Oueléssébougou supports a wide variety of small-scale women's projects, primarily in the Oueléssébougou sector (see Traore, 1986). The CFAR incorporates a "training of trainers" approach in most of its projects. Instead of simply soliciting support from village women, the CFAR trains volunteers to assume responsibility for implementing selected activities, such as functional literacy or gardening. Moreover, CFAR emphasizes the functional contribution of its supported activities. For example, its functional literacy program is designed to help village women maintain birth records, and the gardening program is designed specifically to help women fulfill their household responsibility to supply condiments.

Projects Supported by Foreign Governments and International Agencies

Several small development projects supported by national governments also provide services to farmers in the OHVN zone. With support from Canada, the *Projet Micro-Réalisations* sponsors village-level projects in the Banamba and Boron *secteurs*. In the Banamba *secteur*, the project maintains contact with the Forestry Service in its support of a village reforestation project. In the Boron sector, the project makes loans available for the purchase of agricultural equipment and works with the SNPV to help villages respond to migratory pest infestations. A FAO/Netherlands Local Forestry Project (*Projet d'Aménagement Forestier de Banamba*) is completing the second phase of its work with ten villages in the Banamba *secteur* to promote the adoption of agroforestry and village woodlot management practices. With support from the National Cooperative Service (CAC), the project offers loans to AVs to finance the purchase of seeds and the preparation of tree nurseries. The project also supports village functional literacy training with its own locally-recruited *animateurs*. All project activities are run independently of any OHVN programs.

Another village forestry project, *Projet d'Aménagement Forestier Villageois de Koulikoro*, promotes anti-erosion measures and small reforestation efforts in the Koulikoro, Banamba and Dioïla *Cercles*. An ILO/Norway project, in collaboration with the CAC, promotes the establishment of cooperatives in about 60 villages throughout the Kita, Koulikoro and Kangaba sectors. In addition to supporting functional literacy and cooperative management training, the project provides individual and group credit through the AVs for agricultural supplies and equipment and for cereals marketing. Finally, there are a number of other projects supported by the governments of Italy, France, Germany and Switzerland that are active in providing village and agricultural services to a limited number of villages, primarily in the southern half of the OHVN zone.

Non-Governmental Organizations

From 20 to 30 national and international non-governmental organizations (NGOs) carry-out a wide variety of economic and social service programs throughout the OHVN zone. Neither the private NGO Coordinating Committee (CCA/ONG), funded by USAID, nor the government's *Cellule de Suivi des ONGs*, an earlier effort financed by the World Bank, maintain accurate and complete records of the NGOs or their programs.[254] The OHVN operated a NGO office under Phase I of the project. However, this was closed as a result of the restructuring of the OHVN at the beginning of the Phase II DHV project. Although a number of NGOs contribute directly to the delivery of OHVN functional literacy services, in general there is no collaboration or contact between the OHVN and the NGOs operating in the zone. Most of the NGO programs deal with quality-of-life concerns and can be partitioned into two broad types

[254] A visit to the offices of the *Cellule de Suivi des ONGs* revealed that only one NGO had registered with them, even though in principle this was required by all NGOs working in the country. This requirement is being outright ignored by many NGOs; others are by-passing the requirement by obtaining "sponsorship" from one or another GOM office, which transfers the monitoring and reporting requirements to that office. The *CCA-ONG* has faired a little better in terms of tracking NGO activities, as it serves as a center of information exchange and hub for local hiring. Yet still their records of NGO activity were out-of-date and far from complete.

projects. The first type are those projects which focus on improvements to village infrastructure and which usually depend upon contributed labor and/or financial donations from villagers in the construction of: village wells and water supply, including the introduction of solar-powered pumps; the construction of health units, maternities, primary school rooms and functional literacy centers; and the construction or improvement of small-scale irrigation and water-control facilities. A second type of project addresses an extremely diverse range of small-scale economic activities. These projects, which may also involve some labor and/or financial contribution from villagers, include, among others: the establishment of cereal banks; the installation of woodlots; assisting the improvement of beekeeping practices; small-scale gardening and fruit tree programs; and the introduction of animal traction. Several NGOs also focus special attention on supporting women's small-scale economic activities.

APPENDIX G

Appendix G. The Evolution of Agricultural Research in the OHVN Zone

The technical programs for rainfed agriculture used by the *opérations* in their early period of agricultural development relied heavily upon the *M'Pesoba* system, developed by Viguier (see Appendix D). During the early period of development in the *Opération Haute Vallée*, use of the *M'Pesoba* system included the extension of a highly regimented system of food and cash crop (cotton) rotations, calling for crops to be planted in parallel bands laying perpendicular to the *harmattan* winds (Min. de la Production, n.d.).[255] Shortly after independence, the *Institut d'Economie Rurale* (IER) was created within the Ministry of Agriculture to direct the majority of the national agricultural research programs. However, the rural development organizations (ODRs) continued to draw virtually all of their technical support for the development of improved technological packages from a number of French research programs. The most prominent of these French institutions, part of the *Groupement d'Etudes et de Recherches pour le Developpement de l'Agronomie Tropicale* (GERDAT), included the *Institut Français de Recherches Fruitières Outremer* (IFAC), *Institut de Recherches Agronomiques Tropicales et des Cultures Vivières* (IRAT), which, in addition to the *Institut de Recherches du Coton et des Textiles Exotiques* (IRCT), and the *Institut de Recherches pour les Huiles et Oléagineux* (IRHO), worked directly with many of the ODRs. In addition, most of the research sections within the IER that dealt with issues

---

[255] This recommendation is similar to the *'couloir'* system of agriculture, promoted during the colonial period by the Belgians in present-day Zaire (Ruddle and Manshard, 1981).

of food crop production were headed by *expatriate* French researchers on loan from one of these major French research institutes (USAID, 1984). This pattern of reliance upon both the French research system and researchers continued until the late 1970's, when a growing *cadre* of trained Malian professionals, in collaboration with several regional and international research programs, began to take a more active role in leading Mali's national research and development programs. In 1979, the *Division de Recherche sur les Systèmes de Production* (DRSPR) was formed within the IER to adapt research to farmers' conditions, and to direct future research efforts in meeting national development goals. In the same year, the regional Semi-Arid Food Grain Research and Development project (SAFGRAD), funded by USAID, began conducting on-farm varietal trials in Mali in collaboration with IER scientists, and the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), also supported by USAID funds, began actively collaborating with IER researchers in developing breeding and agronomy programs (Schilling et al., 1989).[256] The separation of Malian research programs from their French predecessors marked an important turning point in Malian agricultural research, and fueled the growing capacity of the country to design and carry-out its own research agenda. The IER now boasts one of the largest national research systems in West Africa, with over 130 trained researchers (ISNAR, 1990).

Preceding these developments within the national research structure during the late 1970's, a few ODRs, including the *Opération de la Haute Vallée* (OHV), which were not closely aligned with any of the commodity programs receiving research support from the French, began to develop their own independent research units.

[256] Although ICRISAT had been present in Mali since 1976, it did not begin its breeding and agronomy programs in earnest until the 1979 cropping season (ICRISAT, 1979).

When USAID began financing Phase I of the OHV project in 1978, a research component was created which focused on issues related to advancing AT technologies. By "using the assistance of Peace Corps Volunteers and two American agronomists...to test plows, plant spacing, varieties, planting dates, weeding techniques, etc.," the research program gradually evolved into a larger on-farm testing and demonstration effort (RONCO, 1985). This research and demonstration effort was considered to be "a critical element of the project because it [was] the only component which [would] eventually enable the...program to move beyond its initial focus on animal traction" (USAID, 1978). In 1983, the Eighth Project Amendment began to shift the emphasis of the OHV research effort towards a broader farming systems research and extension (FSR/E) approach. To assist the OHV, separate contracts were negotiated with the DRSPR and SAFGRAD to respectively undertake socio-ecological studies and conduct varietal trials within the project zone that would help the OHV to target its extension activities more effectively, and deliver higher-producing, new varieties to farmers. The position of a Research Coordinator was added to the OHV administration to help coordinate the OHV's own research efforts with those of the DRSPR and SAFGRAD, as well as the growing number of other Malian research divisions that were beginning to conduct research in the zone (e.g., SRCVO; SRCFJ; CEM)(Kagbo, 1986). Despite these efforts, a series of problems led to major delays in the initiation of the DRSPR's contracted research, which, in addition to a number of administrative problems, contributed to the failure of developing an FSR/E perspective within the OHV project.

The SATEC study on the restructuring of the ODRs, presented in 1985, had a major impact on the future of agricultural research within the OHVN (SATEC, 1985). The study strongly recommended that ODRs, such as the OHVN, which managed their own research programs, should terminate these efforts in order to reduce needless repetition and to concentrate research expenditures at the national level where all of the country's development programs could benefit (SATEC, 1985). In 1986, USAID funded the creation of a new section (*volet*) within the DRSPR, the DRSPR *Volet* OHV (DRSPR/OHV), to work exclusively on agricultural improvements in the OHVN zone.[257] This heralded a change from earlier attempts to increase the research capacity within the OHVN. In 1988, with the debut of the DHV project and the restructuring of the OHVN extension service, the OHVN officially closed its research section and established the position of Subject-Matter Specialists (SMS) to serve as liaisons between the OHVN and the DRSPR/OHV and other governmental research organizations. Thus ended the period of the OHVN's direct involvement with on-farm research and testing. From this point forward the OHVN would become entirely dependent upon other agencies and institutions for the development of new technical information and extension messages. Chief among these sources of information was the new DRSPR/OHV farming systems research program.

[257] The DRSPR program both originated and had been working exclusively in the CMDT zone under Dutch and Canadian funding.

BIBLIOGRAPHY

Bibliography

Adesina, A.A. 1992. "Village-Level Studies and Sorghum Technology Development in West Africa: Case study from Mali." In *Diversity, Farmer Knowledge, and Sustainability*, Moock, J.L. and R.E. Rhoades (eds). Ithaca: Cornell University Press.

Agriculture and Human Values. 1989. "Building on Local Agricultural Knowledge." *Agriculture and Human Values* Vol.VI(3).

_________________. 1991. "Indigenous Agricultural Knowledge Systems and Development." *Agriculture and Human Values* Vol.VIII(1/2).

Ahn, P.M. 1970. *West African Agriculture. Volume 1 West African Soils* (Third Edition). London: Oxford University Press.

Akasaka, M. 1973. "Ouelésébougou, A Village in Southern Mali, Its Characteristics as Market Settlement." *Kyoto University African Studies* Vol.VIII: 118-149.

Alder, C., B. Haverkort, and L. van Vleduizen. 1993. *Linking with Farmers: Networking for low-external-input and sustainable agriculture*. London: Intermediate Technology Publications.

Allan, W. 1965. *The African Husbandman*. London: Oliver & Boyd.

Altieri, M.A. 1987. *Agroecology: The scientific basis of alternative agriculture*. Boulder: Westview Press.

________. 1990. "Why Study Traditional Agriculture?" In *The Ecology of Agricultural Systems*, C.R. Carroll et al. (eds). New York: McGraw-Hill.

Altieri, M.A. and S.B. Hecht (eds). 1990. *Agroecology and Small Farm Development*. Boca Raton: CRC Press.

Anon. 1992. "Regenerating West African Soils." The Soil Management Collaborative Research Program. *Newswire* (August) 1992:1.

___. 1993. "Pest and Pesticide Management Practices and Policies in Africa: Opportunities for success in integrated pest management, Mali (Draft)." Systems Approach to Regional Income and Sustainable Resource Assistance (SARSA). Washington, D.C.: USAID.

Aubert, G. and B. Newsky. 1949. "Note on the Vernacular Names of the Soils of the Sudan and Senegal." In *Proceedings of the First Commonwealth Conference on Tropical and sub-Tropical Soils*, Commonwealth Bureau of Soil Science (1948). Technical Communication No.46. Harpenden: Commonwealth Bureau of Soil Science.

AZANIA. 1989. "Special Volume on the History of African Agricultural Technology and Field Systems." *Azania Journal of the British Institute in Eastern Africa* Vol.XXIV.

Bailleul, P.C. 1981. *Petit Dictionnaire Bambara-Français Français-Bambara*. England: Avebury Publishing Co.

Bandura, A. 1977. *Social Learning Theory*. Englewood: Prentice-Hall Inc.

Barker, D. 1979. "Appropriate Methodology: An example using a traditional African board game to measure farmers' attitudes and environmental images." *IDS Bulletin* Vol.10(2):37-40.

Barlett, P.F. 1980. "Adaptive Strategies in Peasant Agricultural Production." *Annual Review of Anthropology* Vol.9:545-573.

Barnett, H.G. 1953. *Innovation: The basis of cultural change*. New York: McGraw-Hill Book Co.

Batterbury, S. 1993. "Roles For Farmers' Knowledge in Africa." Overseas Development Institute Agricultural, Administration (Research and Extension) Network. Network Paper 42b. London: ODI.

Batie, S.S. 1983. "Soil Conservation Policy for the Future." In, *The Farm and Food System in Transition: Emerging policy issues*, Cooperative Extension Service. East Lansing: Michigan State University.

Bureau d'Études de Conseils et d'Interventions au Sahel (BECIS). 1991. "Project de Développement de l'Operation Haute Vallée. Rapport Final. Octobre, 1991." Bamako: BECIS.

Bebbington, A.J. 1994. "Composing Rural Livelihoods: From farming systems to food systems." In *Beyond Farmer First: Rural people's knowledge, agricultural research and extension practice*, Scoones and Thompson (eds). London: Intermediate Technology Publications.

__________. (Forthcoming). "Knowledge, Practice, Organization: Theory and relevance in indigenous agriculture." In *Rethinking Social Development: Theory, research, and practice*, D. Booth (ed). Harlow: Longmans.

Becker, L.C. 1990. "The Collapse of the Family Farm in West Africa? Evidence from Mali." *The Geographical Journal* Vol.156(3):313-322.

Bell, M. 1979. "The Exploitation of Indigenous Knowledge, or the Indigenous Exploitation of Knowledge: Whose use of what for what?" *IDS Bulletin* Vol.10(2):44-50.

Belloncle, G. 1989. "Proposals for a New Approach to Extension Services in Africa." In *Agricultural Extension in Africa*, N. Roberts (ed). A World Bank Symposium. Washington, D.C.: The World Bank.

Benor, D., J.Q. Harrison, and M. Baxter. 1984. *Agricultural Extension: The training and visit system*. Washington, D.C.: The World Bank.

Bentley, J.W. 1989. "What Farmers Don't Know Can't Help Them: The strengths and weaknesses of indigenous knowledge in Honduras." *Agriculture and Human Values* Vol.VI(3):25-31.

________. 1992. "Alternatives to Pesticides in Central America: Applied Studies of Local Knowledge." *Culture and Agriculture* Fall 1992 Number 44:10-13.

________. 1994. "Facts, Fantasies, and Failures of Farmer Participatory Research." *Agriculture and Human Values* Vol.11(2/3):140-150.

Berger, P.L. and T. Luckmann. 1966. *The Social Construction of Reality: A treatise in the sociology of Knowledge*. New York: Anchor Books, Doubleday.

Bergeret, A., with J.C. Robot. 1990. *L'Arbre Nourricier en Pays Sahélien*. Paris: Editions de la Maison des Sciences de l'Homme.

Bernsten, R.H., A. Rochim, H. Malian, and I. Basa. 1980. "A Methodology for Constructing an Agro-Economic Profile of Cropping Systems Sites." Manual prepared for the CRIA Cropping Systems Economics Training Program, June 2-14, 1980. Mimeo.

Berry, J.W. and S.H. Irvine. 1986. "Brocolage: Savages do it daily." In *Practical Intelligence: Nature and origins of competence in the everyday world*, Sternberg, R.J. and R.K. Wagner (eds). Cambridge: Cambridge University Press.

Berry, J.W., S.H. Irvine and E.B. Hunt (eds). 1988. *Indigenous Cognition: Functioning in cultural context*. NATO ASI Series D: Behavior and Social Sciences No. 41. Dordrecht: Martinus Nijhoff Publishers.

Berry, S.S. 1984. "The Food Crisis and Agrarian Change in Africa: A review essay." *African Studies Review* Vol.27(2):59-112.

Biggs, S.D. 1989a. "A Multiple Sources of Innovation Model of Agricultural Research and Technology Promotion." Overseas Development Institute, Agricultural Administration (Research and Extension) Network Paper No.6. London: ODI.

______. 1989b. "Resource-Poor Farmer Participation in Research: A synthesis of experiences from nine national agricultural research systems." OFCOR Comparative Study Paper No.3. The Hague: ISNAR.

Biggs, S.D. and E.J. Clay. 1981. "Sources of Innovation in Agricultural Technology." *World Development* Vol.9(4):321-336.

Bijker, W.E., T.P. Hughes and T.J. Pinch (eds). 1987. *The Social Construction of Technological Systems: New directions in the sociology and history of technology*. Cambridge: MIT Press.

Bille, J.C. 1977. *Etude de la Production Primaire Nette d'un Ecosystème Sahélien*. Paris: Travaux et Documents de l'ORSTOM.

Bingen, R.J. 1985. *Food Production and Rural Development in the Sahel: Lessons from Mali's Operation Riz-Segou*. Westview Special Studies in Social, Political, and Economic Development. Boulder: Westview Press.

Bingen, R.J. and Simpson, B.M. 1993. "Technology Transfer, Agricultural Development and Democracy in West Africa: Challenges and opportunities in Mali."Paper presented at the "Technology Transfer and Public Policy Symposium," October, 1993. Ames Iowa: Iowa State University.

Bingen, J., A. Berthé and B. Simpson. 1993. "Analysis of Service Delivery Systems to Farmers and Village Associations in the Zone of the Office de la Haute Valleé du Niger." Washington D.C.: Development Alternative Inc.

Bingen, J., B. Simpson, and A. Berthé. 1994. "Analysis of Service Delivery Systems to Farmers and Village Associations in the Zone of the Office de la Haute Valleé du Niger." Department of Resource Development Occasional Report. East Lansing: Michigan State University.

Bishop, J. and J. Allen 1989. "The On-Site Costs of Soil Erosion in Mali." Policy Planning and Research Staff, Environmental Working Paper No.21., Environment Department. Washington, D.C.: World Bank.

Box, L. 1988. "Experimenting Cultivators: A method for adaptive agricultural research." *Sociologia Ruralis* Vol. 28(1):62-75.

Bradley, P.N. 1977. "Vegetation and Environmental Change in the West African Sahel." In *Landuse and Development*, O'Keefe, P. and B. Wisner (eds). African Environment Special Report 5. London: International African Institute with Environment training Programme UNEP/IDEP/SIDA.

______. 1983. "Peasants, Soils and Classification: An investigation into a vernacular soil typology from the Guidimaka of Mauritania." Department of Geography Research Series No.14. Newcastle Upon Tyne: University of Newcastle Upon Tyne.

Brokensha, D., D.M. Warren, and O. Werner (eds). 1980. *Indigenous Knowledge Systems and Development*. Washington, D.C.: University Press of America.

Brokensha, D. and B.W. Riley. 1986. "Changes in Uses of Plants in Mbeere, Kenya." *Journal of Arid Environment* Vol.11(1):75-80.

Brouwer, J., L.K. Fussell, and L. Herrmann. 1993. "Soil and Crop Growth Micro-Variability in the West African Semi-Arid Tropics: A possible risk-reducing factor for subsistence farmers." *Agriculture, Ecosystems and Environments* Vol.45:229-238.

Campbell, D.T. 1965. "Variation and Selective Retention in Socio-Cultural Evolution." In *Social Change in Developing Areas: A reinterpretation of evolutionary theory*, Barringer, H.R, G.I Blanksten, and R.W. Mack (eds). Cambridge: Schenkman Publishing Co.

Carroll, C.R., J.H. Vandermeer, and P.M. Rossett. 1990. *Agroecology*. Biological Resource Management Series. New York: McGraw-Hill.

Carter, S.E. and H.K. Murwira. 1995. "Spatial Variability in Soil Fertility Management and Crop Response in Mutoko Communal Area, Zimbabwe." *Ambio* Vol.24(2):77-84.

Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD). 1980. *Memento de l'Agronome*. Paris: Ministere de la Cooperation.

Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT). 1980. *Planning Technologies Appropriate to Farmers: Concepts and procedures*. CIMMYT: Londres.

Chambers, R. 1980. "Lesson No.1 for Rural Developers: The small farmer is a professional." *Ceres* Vol.13 (2):19-23.

_______. 1983. *Rural Development: Putting the last first*. Harlow: Longman Scientific & Technical.

_______. 1990. "Microenvironments Unobserved." *Gatekeeper Series* 22. London: International Institute for Environment and Development.

Chambers, R., R. Longhurst and A. Pacey (eds.). 1981. *Seasonal Dimensions to Rural Poverty*. London: Frances Pinter Publishers.

Chambers, R. and B.P. Ghildyal. 1985. "Agricultural Research for Resource-Poor Farmers: The farmer-first-and-last model." *Agricultural Administration* Vol.20: 1-30.

Chambers, R., A. Pacey, and L.A. Thrupp (eds). 1989. *Farmer First: Farmer innovation and agricultural research*. London: Intermediate Technologies Publications.

Chamber, R. and C. Toulmin. 1991. "Farmer-First: Achieving sustainable dryland development in Africa." In *Rural Households in Emerging Societies: Technology and Change in sub-Saharan Africa*, Haswell, M. and D. Hunt (eds). Oxford: Berg Publishers.

Charreau, C. 1974. "Soils of Tropical Dry and Dry-Wet Climatic Areas of West Africa and Their Use and Management." Department of Agronomy, Mimeo 74-26. Ithaca: Cornell University.

Charreau, C. and P. Vidal. 1965. "Influence de l'*Acacia albida* Del. sur le Sol, Nutrition Minerale et Rendements des Mils Pennisetum au Senegal." *l'Agronomie Tropicale* Vol.67:600-625.

Chevalier, A. 1900. "Les Zones et ces Provinces Botanique de C.A.O.F.C.R." *Acad. Sci.* (Paris) 130:1205-1208. In *Plant Ecology in West Africa: Systems and processes*, Lawson, G.W. (ed) 1986. Chichester: John Wiley and Sons.

Comité Inter-états pour la Lutte contre la Sécheresse au Sahel (CILSS)/Club du Sahel and Ministry of Rural Development. 1978. "Integrated Rural Development Projects and Improvement of Agricultural Production Systems." Bamako Seminar Synthesis, February 20 - March 1, 1978. Bamako: Club du Sahel and Ministry of Rural Development.

Cleeremans, A. 1993. *Mechanisms of Implicit Learning: Connectionist models of sequence processing*. Cambridge: Bradford Books MIT Press.

Cochemé, J. and P. Franquin. 1967. "An Agroclimatological Survey of a Semi-arid Area in Africa South of the Sahara." The World Meteorological Organization, Interagency Project on Agroclimatology. Technical Note No.86. Geneva: FAO/UNESCO/WMO.

Conable, B.B. 1991. "Africa's Development and Destiny." Address to the 27th Session of the Organization of African Unity (OAU), Abuja, Nigeria, June 4, 1991.

Conklin, H.C. 1957. "Hanunoo Agriculture in the Philippines." FAO Forestry Development Paper No.12. Rome: FAO

________. 1972. "Folk Classification: A topically arranged bibliography of contemporary and background references through 1971." Department of Anthropology. New Haven: Yale University.

Coughenour, C.M. and S.M. Nazhet. 1985. "Recent Changes in Villages and Rainfall Agriculture in Northern Central Kordofan: Communication process and constraints." Report No.4 INTSORMIL CRSP. Dept. of Sociology. Lexington: University of Kentucky.

Coulibaly, B. 1988. "Tests en Milieu Paysan: Expériences, Observations et Impressions des Paysans. (rappot d'une enquête d'évaluation, "feed-back" des paysans) des zones Nord et Sud de l'OHV Campagne 87/88." Bamako: DRSPR (Volet OHV).

Coulibaly, O.N. 1987. "Factors Affecting Adoption of Agricultural Technologies by Small Farmers in sub-Saharan Africa: The case of new varieties of Cowpeas around the agricultural research station of Cinzana, Mali." Masters Thesis. Department of Agricultural Economics. East Lansing: Michigan State University.

Creevey, L.E. (ed). 1986. *Women Farmers in Africa: Rural development in Mali and the Sahel*. Syracuse: Syracuse University Press.

Cross, N. and R. Barker (eds). 1991. *At the Desert's Edge: Oral Histories from the Sahel*. London: Panos Publication Ltd.

Dabin, B. 1951. "Contribution a l'Éstude des Sols du Delta Central Nigérien." *l'Agronomie Tropicale* Vol.VI (No.11-12):606-637.

Davy, E.G., F. Mattei, and S.I. Solomon. 1976. "An Evaluation of Climate and Water resource for Development of Agriculture in the Sudano-Sahelian zone of West Africa." World Meteorological Organization, Special Report No.9. Geneva: UNEP/WMO.

Day, J.C. 1989. "Soil and Water Management in West Africa: An economic analysis." Resources and Technology Division, Economic Research Service, United States Department of Agriculture. Staff Report No. AGES 89-35. Washington D.C.: USDA.

de Boef, W., K. Amanor, K. Wellard, with A. Bebbington. 1993. *Cultivating Knowledge: Genetic diversity, farmer experimentation and crop research*. London: Intermediate Technology Publications.

de Schlippe, R. 1956. *Shifting Cultivation in Africa: The Zande system of Agriculture*. London: Routledge and Kegan Paul.

de Wit, J.M. and J.R. Harlan. 1971. "The Origin and Domestication of Sorghum bicolor." *Economic Botany* Vol.25(2):128-135.

Dennett, M.D. 1987. "Variation of Rainfall: The background to soil and water management in dryland regions." *Soil Use and Management* Vol.3(2):47-51.

Denzin, N.K. 1978. *The Research Act: A theoretical introduction to sociological methods* (2nd ed.). New York: McGraw-Hill.

Diallo, A. 1990. "Participation Paysanne et Dévelopment Rural: Le cas de l'Opération Haute Vallée (OHV) du Niger au Mali." Thèse doctorat. Department des Sciences Sociales Aplliquees aux Developpment. Laboratoire d'Anthropologie et de Sociologie (LAST). Tours: Universite Francois-Rabelais de Tours.

Diallo, D. 1991. "Etude des Classifications Paysannes des Sols au Mali: Cas du Djitoumou." Atelier sur les Approches et Priorites de Recherches en Appiu a la Lute Communicutaire Contre la Desertification, 9-11 Septembre, 1991. Dakar: Centre de Recherche pour le Developpment International, Bureau Regional pour l'Afrique Centrale et Occidentale.

Diallo, D. and D. Keita. 1992. "Projet de Recherche sur les Classifcations Paysannes des sols au Mali." Sythèse des Résultats Obtenus dans la Zone Agroécologique du Djitoumou (HBN2). Présentée au Comité Technique Régional de la Recherche Agronomique, Bamako 24-28 Mars, 1992. Bamako: Laboratoire d'Agropédologie, et Institut Polytechnique Rural de Katibougou.

Diarra, N. 1975. "Le Jardinage Urban et Suburbain au Mali: Le sac de Bamako." *Journal D'Agriculture Tropicale et de Botanique Appliquée* XXII No.10-12:359-364.

Diouf, J. 1990. "The Challenge of Agricultural Development in Africa." *Annual Report 1990*. Technical Centre for Agricultural and Rural Cooperation (CTA).

Diop, M. 1971. *Histoire des Classes Sociales dans l'Agrique de l'Ouest: 1. Le Mali. Testes à l'Appui*. Paris: François Maspero.

Djibo, H., C. Coulibaly, P. Marko, and J.T. Thomson. 1991. "Decentralization, Governance, and Management of Renewable Natural Resources: Local Options in the Republic of Mali. Volume III, October 1991. Final Report." Studies on Decentralization in the Sahel. OECD Contract No. 90/52. Burlington: Associates in Rural Development, Inc.

Doenges, C.E. 1988. "The Sahel as a Place: The evolution of an image." Department of Geography Discussion Paper No.94. Syracuse: Syracuse University.

Dommen, A.J. 1989. "A Rational for African Low-resource Agricultural in Terms of Economic Theory." In *Indigenous Knowledge Systems: Implications for agricultural and international development*, Warren, D.M., L. J. Slikkerveer, and S.O. Titilola (eds). Studies in Technologies and Social Change No.11. Ames: Iowa State University.

Eicher, C.K. 1989. "Sustainable Institutions for African Agricultural Development." ISNAR Working Paper No. 19. The Hague: ISNAR.

Engel, P.G.H., M.L. Salomon, and M.E. Fernandez. 1994. "Strategic Diagnosis for Improving Performance in Extension." Version 5.0. The Netherlands: Wageningen.

Fairhead, J. and M. Leach. 1994. "Declarations of Difference." In *Beyond Farmer First: Rural people's knowledge, agricultural research and extension practice*, Scoones and Thompson (eds). London: Intermediate Technology Publications.

Falconer, J. 1990. "The Major Significance of 'Minor' Forest Products." FAO Community Forestry Note 6. Rome: FAO.

Fals-Borda, O. and M.A. Rahman (eds). 1991. *Action and Knowledge: Breaking the monopoly with participatory action-research*. New York: The Apex Press.

Farmer, G. and T.M.L. Wigley. 1985. *Climatic Trends for Tropical Africa: A research report for the Overseas Development Administration*. Climatic Research Unit, School of Environmental Sciences. East Anglia: University of East Anglia.

Fleuret, A. 1986. "Indigenous Responses to Drought in Sub-Saharan Africa." *Disasters* Vol.10(3):224-229.

Foltz, J. 1991. "Mali Livestock Sector II Project, New Livestock Project Design and Livestock Marketing Analysis." International Agricultural Programs. Madison: University of Wisconsin.

Food and Agriculture Organization of the United Nations (FAO). 1992. "FAO in Action: Audio-Visual Training in Mali." *Ceres* 136: 14.

Francis, C.A. 1986. *Multiple Cropping Systems*. New York: Macmillan Publishing Co.

Francis, C.A. and J.H. Sanders. 1978. "Economic Analysis of Bean and Maize Systems: Monoculture versus associated cropping." *Field Crops Research* 1:319-335.

Franke, R.W. and B.H. Chasin. 1980. *Seeds of Famine: Ecological destruction and the development of dilemma in the West African Sahel*. Landmark Studies. Montclair: Allanheld, Osmun and Co. Publishers.

Freidson, E. (ed). 1973. *The Professions and Their Prospects*. London and New York: Hogarth. In *Knowledge Application: The knowledge system in society*, Holzner, B. and J.H. Marx 1979. Boston: Allyn and Bacon, Inc.

Freire, P. 1986, *Pedagogy of the Oppressed*. New York: Continuum.

Fujisaka, S., Prain, G., and D.M. Warren. (forthcoming). *Biological and Cultural Diversity: The role of indigenous agricultural experimentation in development.* London: Intermediate Technologies Publications.

Gallais, J. 1967. *Le Delta Intérieur du Niger Vol.1.* Dakar:IFAN.

Gamser, M.S. 1988. "Innovation, Technical Assistance, and Development: The importance of technology users." *World Development* Vol.16(6):711-721.

Glaser, B.G. and A.L. Strauss. 1967. *The Discovery of Grounded Theory: Strategies for qualitative research.* Chicago: Aldine.

Gliessman, S. 1990. *Agroecology: Researching the ecological basis for sustainable agriculture.* New York: Springer-Verlag.

Gliessman, S.R., R. Garcia, M.A. Amador. 1981. "The Ecological Basis for the Application of Traditional Agricultural Technology in the Management of Tropical Agro-Ecosystems." *Agro-Ecosystems* 7:173-185.

Gnägi, A. 1991. "Nous Avons Perdu le Respect, Mais la Pitié n'est pas veu dans Nos Coeurs: Prozesse des sozialen wandels und soziokulturelle heterogenität im arrondissement Ouélessébougou, Mali." Berne: Institut für Ethnologie.

______. 1992. "Elaborationn Participative de Technologies: Développement s'une métode à partir de l'example de la technologie apicole locale dans l'arrondissemet de Ouelessébougou, Mali." Berne: Institut d'Ethnologie.

Grigsby, B. 1989. "Lending, Borrowing, and Women's Social Organizations in Rural Mali." Dept. Forest Resources. University of Idaho. Moscow: Consortium for International Development/Women in Development.

Gritzner, J.A. 1988. *The West African Sahel: Human agency and environmental change.* Geography Research Paper No.226. Chicago: University of Chicago.

Grosz-Ngaté, M. 1986. *Bambara Men and Women and the Reproduction of Social Life in Sana Province, Mali.* Doctoral Dissertation. Department of Anthropology. East Lansing: Michigan State University.

_________. 1989. "Hidden Meanings: Exploration into a Bamanan Construction of Gender." *Ethnology* Vol.28(3):167-182.

Gubbels, P. 1988. "Peasant Farmer Agricultural Self-Development." *ILEIA* 4(3):11-14.

______. 1992. "Farmer-First Research: Populist Pipedream of Practical Paradigm. Prospects for Indigenous Agricultural Development in West Africa." Masters Thesis. East Anglia: University of East Anglia.

Gueye, B. and K. Schoonmaker Freudenberger. 1991. "Introduction à la Méthod Accélérée de Recherche Participative (MARP): Quelques notes pour appuyer une formation practique." London: International Institute for Environment and Development.

Guillet, D., L. Furbee, J. Sandor, and R. Benfer. 1995. "A Methodology for Combining Cognitive and Behavioral research: The Lari Soils Project." In *The Cultural Dimension of Development: Indigenous knowledge systems*, Warren, D.M., L.J. Slikkerveer, and D. Brokensha (eds). London: Intermediate Technology Press.

Guinko, S. and L.J. Pasgo. 1992. "Harvesting and Marketing of Edible Products from Local Woody Species in Zitenga, Burkina Faso." *Unasylva* 168, Vol.43:16-19.

Gupta, A.K. 1990. "Inventory of Peasants Innovations for Sustainable Development: An annotated bibliography."Centre for Management in Agriculture. Ahmedabad: Indian Institute of Management.

Gurvitch, G 1971. *The Social Frameworks of Knowledge.* Oxford: Basil Blackwell.

Haberman, J. 1976. *Communication and the Evolution of Society.* Boston: Beacon Press.

Hammersley, M. and P. Atkinson. 1983. *Ethnology: Principles in Practice.* New York: Travistock Publications.

Haray, F. and R.G. Havelock. 1971. "Anatomy of a Communication Arc." *Human Relations*, 25:413-426. In *Indigenous Knowledge Systems and Development*, Brokensha, D., D.M. Warren, and O. Werner (eds) 1980. Washington, D.C.: University Press of America.

Harlan, J.R., J. Pasquereau. 1969. "Décure Agriculture in Mali." *Economic Botany* Vol.23(1): 70-74.

Harrison, P. 1878. *The Greening of Africa: Breaking through the battle for land and food.* New York: Viking/Penguin, Inc.

Hatch, J. 1976. "The Corn Farmers of Motupe: A study of traditional farming practices in Northern Coastal Peru." Monograph No.1. University of Wisconsin-Madison. Madison: Land Tenure Center. In *Rural Development: Putting the last first*, Chamber, R. 1983. Harlow: Longman Scientific & Technical.

Havelock, R.G. 1973. *Planning for Innovation Through Dissemination and Utilization of Knowledge.* Center for Research on Utilization of Scientific Knowledge, Institute for Social Research. Ann Arbor: University of Michigan.

Haverkort, B., J. van der Kamp, and A. Waters-Bayer (eds). 1991. *Joining Farmers' Experiments*. London: Intermediate Technology Publications.

Hayward, D. and J. Oguntoyinbo. 1987. *The Climatology of West Africa*. London: Hutchinson.

Henning, R.K. 1989. "Programme Spécial Energie Mali: Production d'Huile de Pourghere comme Carburant." Programme Spécial Energie. Bamako: GTz and Direction National de Hydaulique et de l'Energie.

__________. 1992. "Promotion de la Lutte Contre l'Erosion au Sahel Grace á la Production et á l'Utilisation d'Huile Végétale comme Carburant." Eschborn: GTz.

Herrara, A.O. 1981. "The Generation of Technologies in Rural Areas." *World Development* Vol.9:21-35.

Hiemstra, W., C. Reijntes, and E. van der Werf. 1992. *Let Farmers Judge: Experiences in assessing agricultural innovation*. London: Intermediate Technology Publications.

Hills, T.L., and R.E. Randall (eds.). 1968. "The Ecology of the Forest/Savanna Boundary (Proceedings of the I.G.U Humid Tropics Commission Symposium, Venezuela, 1964)." McGill University Savanna Research Project, Savanna Research Series No.13. Department of Geography. Montreal: McGill University.

Holtzman, J.S. 1986. "Rapid Reconnaissance Guidelines for Agricultural Marketing and Food Systems Research in Developing Countries." MSU International Development Papers. Working Paper No. 30. Department of Agricultural Economics. East Lansing: Michigan State University.

Holzner, B. and J.H. Marx. 1979. *Knowledge Application: The knowledge system in society*. Boston: Allyn and Bacon, Inc.

Hopkins, B. 1965. *Forest and Savanna: An introduction to tropical plant ecology with special reference to West Africa*. London: Heinemann.

Hoskins, M. 1994. "Supporting Farmer Extension and Research." *Forest, Trees and People Newsletter* No.23:4-8.

Hunt, D. 1991. "Farming System and Household Economy as Framework for Prioritising and Appraising Technical Research: A critical appraisal of current approaches." In *Rural Households in Emerging Societies*, Haswell, M. and D. Hunt (eds). Oxford: Berg Publication.

Imersheim, A.W. 1977. "The Epistemological Basis of Social Order: Towards ethno-paradigm analysis." In *Sociological Methodology*, Heist, D.R. (ed). San Fransico: Jassey-Bass Inc.

Imperato, P.J. and E.M. Imperato. 1982. *Mali: A handbook of Historical Statistics*. Boston: G.K. Hall & Co.

International Crop Research Institute for the Semi-Arid Tropics (ICRISAT). 1978. "ICRISAT Annual Report 1978." Ouagadougou, Republic of Upper Volta, Ministry of Rural Development. In Jaeger, 1986, *Agricultural Mechanization*. Boulder: Westview Press.

_______. 1979. "Report of the 1979 Season: Cooperative Program." Bamako: ICRISAT.

_______. 1984. *Agrometeorology of Sorghum and Millet in the Semi-Arid Tropics: Proceedings of the International Symposium*, 15-20 November, ICRISAT Center, Patancheru, India. Patancheru: ICRISAT.

_______. 1985. "ICRISAT Annual Report 1984." Patancheru: ICRISAT.

_______. 1989. "ICRISAT Annual Report 1988." Patancheru: ICRISAT.

_______. 1989b. *Soil, Crop, and Water Management Systems for Rainfed Agriculture in the Sudano-Sahelian Zone: Proceedings of an International Workshop, 11-16 January, ICRISAT Center, Niamey, Niger*. India: ICRISAT.

Information Centre for Low-External Input and Sustainable Agriculture (ILEIA). (forthcoming). *Farmers' Research in Practice*. Leusden: ILEIA.

Institut de Recherches Agronomiques Tropicales et des Cultures Vivieres (IRAT). 1974. "Bilan Techniques et Financier des Recherches en Matiere d'Agronomie Generale et de Cultures Vivières Conduites par l'IRAT de 1962 a 1974 au Mali: Proposition de Programme Pluriannuel de Recherches." Bamako: IRAT.

_______. 1975. "Fiches Techniques." Bamako: IRAT.

Indigenous Knowledge and Development Monitor. 1994. Special Issue on Gender and Indigenous Knowledge Vol.2(3). The Hague: CIRAN/Nuffic.

Inglis, J.T. (ed) 1993. *Traditional Ecological Knowledge: Concepts and Cases*. International Program on Traditional Ecological Knowledge and International Development Research Centre. Ottawa: Canadian Museum of Nature.

International Board for Plant Genetic Resources (IBPGR) and Royal Botanic Garden. 1984. *Forage and Browse Plants for Arid and Semi-Arid Africa*. Rome and Kew: IBPGR.

International Bank for Reconstruction and Development (IBRD). 1970. "Economic Development in Mali: Evolution, Problems and Prospects. Volume II Notes on Agriculture, Livestock and Fisheries." Report No. AW-14a. Washington D.C.: International Bank for Reconstruction and Development.

International Fund for Agricultural Development (IFAD). 1993. "The State of the World Rural Poverty: A profile of Africa." Rome: IFAD.

International Service for National Agricultural Research (ISNAR). 1990. "Analyse du Système national de Recherche Agronomigue du Mali." rapport au Minstère de l'Agriculture, République du Mali. ISNAR R46f. The Hague: ISNAR.

International Union for Conservation of Nature (IUCN). 1989. *The IUCN Sahel Studies: 1989*. Nairobi: IUCN.

Jaeger, W.K. 1986. *Agricultural Mechanization: The economics of animal draft power in West Africa*. Westview Special Studies in Agricultural Science and Policy. Bolder: Westview Press.

Jago, N.D. , A.R. Kremer and C. West. 1993. "Pesticides on Millet in Mali." Natural Resources Institute. Bulletin 50. Chatham Maritime: Natural Resources Institute.

Jiggins, J. and H. de Zeeuw. 1992. "Participatory Technology Development in Practices: Process and methods." In *Farming For the Future: An introduction to low-external input and sustainable agriculture*, Reintjes, C., B. Haverkort, and A. Waters-Bayer (eds). London: MacMillan Press.

Johannes, R.E. (ed). 1989. *Traditional Ecological Knowledge: A collection of Essays*. Gland and Cambridge: IUCN.

Johnson, A.W. 1972. "Individuality and Experimentation in Traditional Agriculture." *Human Ecology* Vol.1 (2):149-159.

Jones, B. 1938. "Desiccation and the West African Colonies." *The Geographical Journal* Vol. XCI(5): 401-423.

Jones, M.J. and A. Wild. 1975. *Soils of West African Savanna*. Technical Communication No.55. Harpenden: Commonwealth Bureau of Soils.

Jones, N. and J.H. Miller. (no date). "Jatropha curacas: A Multipurpose Species for Problematic Sites." ASTAG Technical Papers, Land Resources Series No.1, The World Bank, Asia Technical Department Agricultural Division. Washington, D.C.: The World Bank.

Jones, W.I. 1976. *Planning and Economic Policy in Mali*. Thèse No.230 Université de Genève, Institut Universitaire de Hautes Etudes Internationales. Washington, D.C.: Three Continents Press.

Josens, G. 1983. "The Soil Fauna of Tropical Savannas. III The Termites." In *Ecosystems of the World Vol.14: Tropical Savannas*, Bourlière, F. (ed). Amsterdam: Eisevier Scientific Publishing Co.

Jungerius, P.D. 1985. "Perceptions and Use of the Physical Environment in Peasant Societies." The 16th Norma Wilkinson Memorial Lecture. Reading Geographical Papers No.93. Reading: University of Reading.

Kagbo, R.B. 1986. "Some Observations on the OHVN On-Farm Recherche and Extension Programs (Background information for preparing the Project's Phase II)." Bamako: OHV.

_________. 1987. "Recommendations aux Paysans de l'OHV (en rapport avec les résultats des programmes d'essais en mileau paysan)." Bamako: OHV.

_________. 1988. "Bénéfices Attendus de l'Adoption de Certaines Innovations dans la Zone OHV." Bamako: OHV.

_________. 1988. "Rapport de fin de Contrat." Bamako: OHV.

Kagbo, R.B. and A. Diarra, 1988. "Résultats des Essais Realisés en Zone OHV en 1987." Bamako: OHVN.

Kater, L.J.M., S. Kante, and A. Budelman. 1992. "Karité (*Viterllaria paradoxa*) and Néré (*Parkia biblobosa*) Associated with Crops in South Mali." *Agroforestry Systems* 18:89-105.

Kates, Robert W. 1981. "Drought Impact in the Sahelian-Sudanic Zone of West Africa: A comparative analysis of 1910-15 and 1968-74." Background Paper No.2. Center for Technology, Environment, and Development. Worcester: Clark University.

Katz, C. 1991. "Sow What You Know: The struggle for social reproduction in rural Sudan." *Annals of the Association of American Geographers* Vol.81(3):488-515.

Kelly, G.A. 1955. *The Psychology of Personal Constructs. Volume 1. A Theory of Personality*. New York: W.W. Norton & Co., Inc.

Kessler, J.J. 1992. "The Influence of Karité (*Vitellaria paradoxa*) and Néré (*Parkia biglobosa*) Trees on Sorghum Production in Burkina Faso." *Agroforestry Systems* 17:97-118.

King, F.H. 1911. *Farmers of Forty Centuries*. Emmaus: Rodale Press.

King, G.R. 1986. "Economics of Farming Systems Study, Operation Haute Vallée, Mali." Washington, D.C.: Checchi and Company Consulting, Inc.

Kingsbury, D., C. McCorkle, and A. Fessenden. 1994. "Sustainable Cropland Management in Mali: Actions, Contributing Conditions, Practices and Change." Washington, D.C.: USAID.

Klee, G.A. (ed). 1980. *World Systems of Traditional Resource Management*. New York: John Wiley and Sons.

Kleene, P. 1984. "Experimental Approaches in Southern Mali." In *Coming Full Circle: Farmers participation in the development of technology*, Matlon, P, R. Cantrell, D. King, and M. Benoit-Cattin (eds). Ottawa:IDRC.

Knight, C.G. 1974. *Ecology and Change: Rural modernization in an African Community*. New York: Academic Press.

_______. 1980. "Ethnoscience and the Africa Farmer: Rationale and strategy." In *Indigenous Knowledge Systems and Development*, Brokensha, D., D.M. Warren, and O. Werner (eds). Washington, D.C.: University Press of America.

Knorr-Cetina, K.D. 1981. *The Manufacture of Knowledge: An essay on the constructivist and contextual nature of science*. Oxford: Pergamon Press.

Koening, D. 1986a. "Social Stratification and Labor Allocation in Peanut Farming in the Rural Malian Household." *African Studies Review* Vol.(3):107-127.

_______. 1986b. "Research for Rural Development: Experiences of an Anthropologist in Rural Mali." In *Anthropology and Rural Development in West Africa*, Horowitz, M.M. and T.M. Painter (eds). IDA Monographs in Development Anthropology. Boulder: Westview Press.

Kolasa, J., and S.T.A. Pickett (eds). 1991. *Ecological Heterogeneity*. Ecological Studies 86. New York: Springer-Verlag.

Kowal, J.M. and A.H. Kassanm. 1978. *Agricultural Ecology of Savanna: A study of West Africa*. Oxford: Clarendon Press.

Kremer, A. and K. Sidibé, 1991. "Mali Millet Pest Project (Projet Pilot Britannique) Economics Report 1990." Natural Resources Institute.

Krings, T. 1987. "The Advantages and Risks of Ox-Plowing and Monoculture in the Central and Southern Savannas of the Republic of Mali." *Applied Geography and Development* Vol.30:46-63.

______. 1991. "Indigenous Agricultural Development and Strategies for Coping with Famine: The case of Senfou (Pomporo) in Southern Mali (West Africa)." *Bayreuther Geowissenschaftliche Arbeiten* Vol.15:69-81.

Kuhn, T.S. 1970. *The Structure of Scientific Revolutions*. Second Edition. Chicago: University of Chicago Press.

Lachenmann, G. 1986. "Rural Development in Mali: Destabilization and social organization." *Quarterly Journal of International Agriculture* Vol.25(3):217-233.

Lawler, E.E. III. 1985. "Challenging Traditional Research Assumptions." In *Doing Research That Is Useful for Theory and Practice*, E.E. Lawler, A.M. Mohrman, Jr., S.A. Mohrman, G.E. Ledford, Jr., T.G. Cummings and Associates (eds). San Francisco: Jossey-Bass Publishers.

Lawson, George W. (ed.) 1986. *Plant Ecology in West Africa: Systems and processes*. Chichester: John Wiley and Sons.

Lebeau, F. 1986. "Technology Transfer Study Opération Haute Vallée Mali: Second Phase." Washington, D.C.: Checci and Company Consulting Inc.

Leisinger, K.M. and K. Schmitt (eds). 1995. *Survival in the Sahel: An ecological and developmental challenge*. The Hague: ISNAR.

Le Moigne, M., and M. Chavatte. 1972. "Etude de l'Evolution des Facteurs de Production Mise en Place Pendant les Dix Dernieres Annees et de Leurs Effets." C.E.E.M.A.T./S.E.A.E.

Lewis, J.V.D. 1979. *Descendants and Crops: Two poles of production in a Malian peasant village*. A dissertation, Yale University.

Leynaud, E. 1962. *La Modernisation Rurale dans la Haute-Vallée du Niger: Mission Leynaud-Roblot*. 4 Volumes. Paris: BDPA

______. 1966. "Fraternités d'Âge et Sociétés de Culture dans la Haute-Vallée du Niger." *Cahiers d'Etudes Africaines* Vol.VI(21):41-68.

Leynaud, E. and Y. Cisse. 1978. *Paysans Malinke du Haute Niger (Tradition et développement rural en Afrique Soudanaise)*. Paris: Editions Imprimeries.

Lionberger, H.F. 1959. "Community Prestige and the Choice of Sources of Farm Information." *The Public Opinion Quarterly* Vol.23(1):110-118.

Lionberger, H.F. C.J. Yeh, and G.D. Copus. 1975. "Social Change in Communication Structure: Comparative study of farmers in two communities." Rural Sociological Society Monograph Number 3. Morgantown: West Virginia University.

Long, N. 1984. "Creating Space for Change: A perspective on the sociology of development." Inaugural lecture, Wageningen Agricultural University, in Drinkwater, M. (1992) "Visible Actors and Visible Researchers: Critical hermeneutics in an actor-oriented perspective." *Sociologia Ruralis* 32(4): 367-388.

____. 1989. "Conclusion: Theoretical reflections on actor, structure and interface." In *Encounters at the Interface: A perspective on social discontinuities in rural development*, Long, N. (ed). Agricultural University: Wageningen.

Longhurst, R. and M. Lipton. 1989. "The Role of Agricultural Research and Secondary Food Crops in reducing Seasonal Food Insecurity." In *Seasonal Variability in Third World Agriculture*, Sahn, D.E. (ed) . John Hopkins Press: Baltimore and London.

Low, A. 1986. "On-Farm Research and Household Economics." In *Understanding Africa's Rural Households and Farming Systems*, Moock, J.L. (ed). Westview's Special Studies Series on Africa. Bolder: Westview Press.

Luery, A. 1989. "Women's Economic Activities and Credit Opportunities in the Operation Haute Vallée (OHV) Zone, Mali." University of Arizona. Tucson: Consortium for International Development/Women in Development.

Luft, J., and H. Ingham. n.d. "Constructive Openness." Mimeograph.

MacDonald, Lee H. 1986. *Natural Resources Development in the Sahel: The role of the United Nations System*. Tokyo, Japan: The United Nations University.

Maignien, R. 1961. "The Transition from Ferruginous Tropical Soils to Ferrallitic Soils in the South-West of Senegal." *African Soils* Vol.6:173-228.

Marshall, C. and G.B. Rossman. 1989. *Designing Qualitative Research*. Newbury Park: Sage Publications.

Mathias-Mundy, E. and C. McCorkle. 1989. "Ethnoveterinary Medicine: An annotated bibliography." CIKARD Bibliographies in Technology and Social Change No.6. Ames: Iowa State University.

Matlon, P.J. 1977. "The Size Distribution, Structure and Determinants of Personal Income among Farmers in the North of Nigeria." Ph.D. Dissertation. Ithaca: Cornell University.

______. 1980. "Local Varieties, Planting Strategies, and Early Season Farming Activities in Two Villages of Central Upper Volta." West Africa Economics Program Progress Report 2. Ouagadougou: ICRISAT.

______. 1990. "Improving Productivity in Sorghum and Pearl Millet in Semi-Arid Africa. *Food Research and Institute Studies* Vol.XXII(1):1-43.

Matlon, P., R. Cantrell, D. King, and M. Benoit-Cattin. 1984. *Coming Full Circle: Farmers' participation in the development of technology*. Ottawa: IDRC.

Mazur, R.E. 1984. "Rural Out-Migration and Labor Allocation in Mali." In Goldscheider (ed.) *Rural Migration in Developing Countries: Comparative studies of Korea, Sri Lanka, and Mali*. Boulder: Westview Press.

McArthur, D. 1978. "Information Sources for Farmers From Outside Their Farms." *Agricultural Administration* 5:275-280.

McCall, M.K. 1988. "Indigenous Technical Knowledge in Farming Systems and Rural Technology: A bibliography on Eastern Africa." University of Twente, Technology and Development Group. Working Paper No.38. Enschede: University of Twente.

McConnell, W. 1993. "Local Ecological Knowledge and Environmental Management in The Republic of Mali, West Africa." Master of Arts Thesis. Programme for International Development and Change. Worcester: Clark University.

McCorkle, C.M. and C. Kamité, 1986. "Farmers Associations Potential Study Operation Haute Vallée Mali." Washington, D.C.: Checchi and Company Consulting Inc.

McCorkle, C.M., R.H. Brandstetter, and G.D. McClure. 1988. "A Case Study on Farmers Innovations and Communication in Niger." Communication for Technology Transfer in Agriculture. Washington, D.C.: Academy for Educational Development.

McCorkle, C., M. Coulibaly, S. Coulibaly, D. McHugh, G.W. Selleck, and D. Sidibe. 1993. "USAID/Mali Farming Systems Research and Extension Project: Phase II Evaluation Report." Washington, D.C.: Development Alternatives Inc. and Institute for Development Anthropology.

Megahed, H.T. 1970. "Socialism and Nation-Building in Africa: The case of Mali (1960-1968)." Studies on Developing Countries No.36. Budapest: Center for Afro-Asian Research of the Hungarian Academy of Sciences,

Meillassoux, C. 1960. "Essai d'Interprétation du Phenomène Économique dans les sociétés traditionnelles d'Auto-Subsistence." *Cahiers d'Etudes Africaines* I(4):38-67.

Miedema, R. and W. van Vuure. 1977. "The Morphological, Physical and Chemical Properties of Two Mounds of *Macrotermes Bellicosus* (Smeathman) Compared with Surrounding Soils in Sierra Leone." *Journal of Soil Science* Vol.28:112-124.

Milne, B.T. 1991. "Heterogeneity as a Multiscale Characteristic of Landscapes." In *Ecological Heterogeneity*, Kolasa, J., and S.T.A. Pickett (eds). Ecological Studies 86. Springer-Verlag: New York.

Milne, G. 1935. "Some Suggested Unites of Classification and Mapping, Particularly for East African Soils." *Soil Research* Vol.4(3):183-198.

Miracle, M.P. 1966. *Maize in Tropical Africa*. Madison: University of Wisconsin Press.

________. 1967. *Agriculture in the Congo Basin: Tradition and change in African rural economies*. Madison: University of Wisconsin Press.

Montagne, P. 1985. "Contribution of Indigenous Silviculture to Forestry Development in Rural Areas: Examples from Niger and Mali." *Rural Africana* Vol.23/24: 61-64.

Moock, J. L. (ed). 1986. *Understanding Africa's Rural Households and Farming Systems*. Boulder: Westview Press.

Moock, J.L. and R. E. Rhoades (eds). 1992. *Diversity, Farmer Knowledge, and Sustainability*. Ithaca: Cornell University Press.

Moormann, F.R. and B.T. Kang. 1978. "Microvariability of Soils of the Tropics and Its Agronomic Implication with Special Reference to West Africa." In *Diversity of Soils in the Tropics*, American Society of Agronomy. ASA Special Publication Number 34. Madison: ASA.

Moris, J. 1989. "Indigenous versus Introduced Solutions to Food Stress in Africa." In *Seasonal Variability in Third World Agriculture: The consequences for food security*, Sahn, D.E. (ed). Baltimore: John Hopkins Press.

________. 1991. *Extension Alternatives in Tropical Africa*. London: Overseas Development Institute.

Mortimore, M. 1989. *Adapting to Drought: Farmers, famines and desertification in West Africa*. Cambridge: Cambridge University Press.

Moseley, W. 1993. "Indigenous Agroecological Knowledge Among the Bamabara of Djitoumou, Mali: Foundation for a sustainable community." Master of Science Thesis. School of Natural Resources. Ann Arbor: University of Michigan.

Moses, Y.T. (ed). 1986. *Proceedings: African Agricultural Development Conference. Technology, Ecology and Society*. California State Polytechnic University, Pomona Kellogg West Conference, May 28 - June 1, 1985. Pomona: California State Polytechnic University.

Mulla, D.J. 1989. "Soil Spatial variability and Methods of Analysis." In *Soil, Crop, and Water Management Systems for Rainfed Agriculture in the Sudano-Sahelian Zone: Proceeding of an International Workshop, 11-16 Jan. 1987, ICRISAT Sahelian Center, Niamey, Niger*, ICRISAT. Patancheru: ICRISAT.

Müller, C. 1855. *Geographici Graece Minores Vol 1*. Paris: Didot.

Mundy, P. 1991. "Bibliography of Indigenous Communication." Unpublished manuscript.

Mundy, P. and J.L. Compton. 1991. "Indigenous Communication and Indigenous Knowledge." *Development Communication Report* No.74(3):1-4.

________________. 1995. "Indigenous Communication and Indigenous Knowledge." In *The Cultural Dimension of Development: Indigenous knowledge systems*, Brokensha, D., L.J. Slikkerveer and D.M. Warren (eds). London: Intermediate Technology Publications.

Mwanthi, M.A. and V.N. Kimani. 1993. "Agrochemicals: A potential health hazard among Kenya's small-scale farmers." In *Impact of Pesticide Use on Health in Developing Countries*, Forget, G., T.Goodman, and A de Villiers (eds). Ottawa: International Development Research Centre.

Narby, J. and S. Davis. 1983. "Resource Development and Indigenous Peoples: A comparative bibliography." Boston: Anthropology Resource Center.

National Oceanic and Atmospheric Administration (NOAA). 1979. "Weather-Crop Yield Relationships in Drought Prone Countries of Sub-Saharan Africa: Appendix to the Final Report." Atmospheric Science Department, University of Missouri-Columbia. Columbia: NOAA/University of Missouri-Columbia.

National Research Council (NRC). 1984a. *Agroforestry in the West African Sahel*. Washington, D.C.: National Academy Press.

______________________. 1984b. *Environmental Change in the West African Sahel*. National Academy Press: Washington, D.C.

______________________. 1986. *Proceedings of the Conference on Common Property Resource Management*. Washington, D.C.: National Academy Press.

______________________. 1992. *Neem: A tree for solving global problems*. Washington, D.C.: National Academy Press.

______________________. 1993. *Vetiver: A thin green line against erosion*. Washington, D.C.: National Academy Press.

______________________. 1995. *Lost Crops of Africa: Vol.1 - Grains*. Washington, D.C.: National Academy Press.

______________________. (forthcoming). *Lost Crops of Africa: Vol.2 - Cultivated Fruits*. Washington, D.C.: National Academy Press.

______________________. (forthcoming). *Lost Crops of Africa: Vol.3 - Wild Fruits*. Washington, D.C.: National Academy Press.

Nazhet, S.M. and C.M. Coughenour. 1987. "The Communication of Agricultural Information in Sudanese Villages." Report No.5 INTSORMIL CRSP. Dept. of Sociology. Lexington: University of Kentucky.

N'Diayé. 1970a. *Les Castes au Mali*. Collection "Hier." Bamako: Éditions Populaires.

_____. 1970b. *Groupes Ethniques au Mali.* Colletion "Hier." Bamako: Éditions Populaires.

Neimeyer, R.A. 1985. *The Development of Personal Construct Psychology*. Lincoln: University of Nebraska Press.

Niamir, M. 1990. "Herders' Decision-Making in Natural Resources Management in Arid and Semi-Arid Africa." Forests, Trees and People, Community Forestry Note No.4. Rome: FAO.

Nicholson, S.E. 1976. "A Climatic Chronology for Africa: Synthesis of geological, historical, and meteorological information and data." Doctoral Dissertation. Madison: University of Wisconsin.

_________. 1982. "The Sahel: A climatic perspective. Summary." CILSS/Club Du Sahel and Organization for Economic Cooperation and Development. Sahel D(82) 187-Summary.

Niemeiyer, D. (forthcoming). "Coping with Environmental Dynamics: Adaption and experimentation in indigenous Sudanese water harvesting." In *Biological and Cultural Diversity: The role of indigenous agricultural experimentation in development*, Fujisaka, S., G. Prain, and D.M. Warren (eds). London: Intermediate Technology Publications.

Norem, R.H., R. Yoder, and Y. Martin. 1989. "Indigneous Agricultural Knowledge and Gender Issues in Third World Agricultural Development." In *Indigenous Knowledge Systems: Implications for agricultural and international development*, Warren, D.M., L.J. Slikkerveer, and S.O. Titilola (eds). Studies in Technologies and Social Change No.11. Ames: Iowa State University.

Norman, D.W., D.H. Pryor, and C.J.N. Gibbs. 1979. "Technical Change and the Small Farmer in Hausaland, Northern Nigeria." African Rural Economy Paper No. 21. African Rural Economy Program, Department of Agricultural Economics. East Lansing: Michigan State University.

Nye, P.H. and D.J. Greenland. 1960. *The soil Under shifting Cultivation*. Technical Communication No.51. Harpenden: Commonwealth Bureau of Soils.

Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM). 1974. *République du Mali. Précipitations Journalières de L'Origine des Stations a 1965*. Comite Interafricain d'Etudes Hydrauliques. République Française, Ministére de la Coopération. Office de la Recherche Scientifique et Technique Outre-Mer, Sevice Hydrologique.

Ohm, H.W. and J. G. Nagy (eds). 1985. *Appropriate Technologies for Farmers in Semi-Arid West Africa*. West Lafayette: Purdue University.

Okali, C., J. Sumberg, and J. Farrington. 1995. *Farmer Participatory Research: Rhetoric and reality*. London: Intermediate Technology Publications.

Okali, C., J. Sumberg, and K.C. Reddy. 1994. "Unpacking a Technical Package: Flexible messages for dynamic situations." *Experimental Agriculture* 30:299-310.

Pawluk, R.R., A.J. Sandor, J.A. Tabor. 1992. "The Role of Indigenous Soil Knowledge in Agricultural Development." *Journal of Soil and Water Conservation* July-August:298-302.

Peace Corps. 1991. "20 Ans au Service du Peuple Malien." Rapport Annuel. Bamako: Peace Corps.

Piere, C. 1989. *Fertilité des Terres de Savanes: Bilan de trent ans de recherche et de développement agricoles au sud du Sahara*. Ministère de la Coopération et du Développement et le Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD-IRAT). Paris: Nain Graphic.

Pingali, P., Y. Bigot and H.P. Binswanger. 1987. *The Mechanization and the Evolution of Farming Systems in sub-Saharan Africa*. Baltimore: John Hopkins University Press.

PIRT. 1989a. "Inventaire et Evaluation des Ressouces de la Zone O.H.V.: Volume 1 Rapport Technique." Bamako: OHVN.

___. 1989b. "Inventaire et Evaluation des Ressouces de la Zone O.H.V.: Volume 2 Annexes." Bamako: OHVN.

Polanyi, M. 1966. *The Tacit Dimension*. Garden City: Doubleday and Company.

Posner, J.L, E.W. Crawford, and M. Kamuanga. 1990. "Farmer Participation in On-Farm Trials: The case of lowland rice in southern Senegal." In Proceedings of the Association for Farming Systems Research-Extension 10th Annual Symposium, Oct.14-17, 1990, Michigan State University. East Lansing: Michigan State University.

Potts, M.J., G.A. Watson, R. Sinung-Basuki and N. Gunadi. 1992. "Farmer Experimentation as a Basis for Cropping Systems Research: A case study involving true potato seed." *Experimental Agriculture* Vol.29:19-29.

Powell, J.M., and T.O. Williams. 1993. "Livestock, Nutrient Cycling and Sustainable Agriculture in the West African Sahel." International Institute for Environment and Development Gatekeeper Series No.37. London: IIED.

Rao, M.R. and R.W. Wiley. 1980. "Evaluation of Yield Stability in Intercropping Studies on Sorghum/Pigeon Pea." *Experimental Agriculture* 16:105-116.

Ravnborg, H.M. 1992. "The CGIAR in Transition: Implications for the poor, sustainability and the national research systems." Overseas Development Institute, Agricultural Administration (Research and Extension) Network Paper 31. London: ODI.

Reardon, T., A.A. Fall, V. Kelly, C. Delgado, P. Matlon, J. Hopkins, and O. Badiane. (forthcoming). "Agriculture-Led Income Diversification in the West African Semi-Arid Tropics: Nature, distribution, and importance of production-linkage activities." In *African Ecnomic Issues*, Atsain, Wangwe and Drabek (eds.).

Reardon, T. C. Delgado, and P, Matlon. 1992. "Determinants and Effects of Income Diversification Amongst Farm Households in Burkina Faso." *The Journal of Development Studies* Vol.28(2):264-269.

Reij, C. 1988. "The Present State of Soil and Water Conservation in the Sahel." Sahel D(89)329. OCDE/OECD and CILSS.

____. 1991. "Indigenous Soil and Water Conservation in Africa." Gatekeeper Series No.27. London: International Institute for Environment and Development.

Rhoades, R.E. and R. Booth. 1982. "Farmer-Back-to-Farmer: A model for generating acceptable agricultural technology." *Agricultural Administration* Vol.11:127-137.

Rhoades, R.E. and A. Bebbington. 1988. *Farmers Who Experiment: An untapped resource for agricultural development*. Lima: CIP.

Richards, P. 1979. "Community Environmental Knowledge in African Rural Development." *IDS Bulletin* Vol.10(2):28-36.

_______. 1985. *Indigenous Agricultural Revolution*. London: Unwin Hyman Ltd.

_______. 1986. *Coping with Hunger: Hazard and experimentation in an African rice-farming system*. The London Research Series in Geography No.11. London: Allen and Unwin.

_______. 1989a. "Farmers Also Experiment: A neglected intellectual resource in African science." *Discovery and Innovation* Vol.1(1):19-24.

_______. 1989b. "Agriculture as Performance." In *Farmer First: Farmer innovation and agricultural research*, Chambers, R., et al. (eds). London: Intermediate Technology Publications.

_______. 1994. "Local Knowledge Formation and Validation: The case of rice production in Central Sierra Leone." In *Beyond Farmer First: Rural people's knowledge, agricultural research and extension practice*, Scoones and Thompson (eds). London: IT Publications.

Riches, C.R., L.J. Shaxson, J.W.M. Logan and D.C. Munthali. 1993. "Insect and Parasitic Weed Problems in Southern Malawi and the Use of Farmer Knowledge in the Design of Control Measures." Overseas Development Institute, Agricultural (Research and Extension) Administration Network Paper 42a. London: ODI.

Roberts, Nigel, ed. 1989. *Agricultural Extension in Africa*. A World Bank Symposium. Washington, D.C.: The World Bank.

Rodier, J.A. 1982. "Evaluation of Annual Runoff in Tropical African Sahel." Travaux et Documents de l'O.R.S.T.O.M. No.145. Paris: O.R.S.T.O.M.

Roger, A. 1993. "Third Generation Extension: Towards an alternative model." *Rural Extension Bulletin* No.3:14-16.

Rogers, E. 1983. *Diffusion of Innovation* (3rd ed). New York: The Free Press.

Röling, N. 1989. "The Agricultural Research-Technology Transfer Interface: A knowledge systems perspective." Linkages Theme Paper No.6. The Hague: ISNAR.

RONCO. 1985. "Evaluation Operation Haute Vallée Mali," Washington, D.C.: RONCO Consulting Corp.

Roose, E. 1977. "Erosion et Ruissellement en Afrique de l'Ouest: Vingt années de mesures en petites parcelles expérimentles." Travaux et Documents de l'O.R.S.T.O.M. No.78. Paris: O.R.S.T.O.M.

Rosenberg, N.J., B.L. Blad, and S.B. Verma. 1983. *Microclimate: The biological environment*. Second edition. New York: John Wiley and Sons.

Rosenmayr, L. 1988. "More Than Wisdom: A field study of the old in an Africa village." *Journal of Cross-Cultural Gerontology*. Vol.3(1):21-40.

Rosenthal, T.L. and B.J. Zimmerman. 1978. *Social Learning and Cognition: Advances in theory and research*. New York: Academic Press.

Ruddle, K. and W. Manshard. 1981. *Renewable Natural Resources and the Environment*. Dublin: Tycooly International Publishing Ltd.

Ruthenberg, H. 1980. *Farming Systems in the Tropics*. Oxford: Claredon Press.

Ryan, B. and N.C. Gross. 1943. "The Diffusion of Hybrid Seed Corn in Two Iowa Communities." *Rural Sociology* Vol 8(1):15-23.

Sahn, D.E. (ed.). 1989. *Seasonal Variability in Third World Agriculture: The consequences for food security*. Baltimore: Johns Hopkins University Press.

Sall, A. (n.d.). "L'Organisation du Monde Rural du Mali (1910-1988) 1. Evolution et Perspectives 2. Pricipaux Textes Organization." Bamako: Editiond-Imprimerie du Mali.

Schilling, T., F. Bidinger, O. Coulibaly, E. Smith, and B. Teme. 1989. "Final Evaluation: ICRISAT/Mali Project Phase II (688-0226)." Bamako: USAID.

Schultz, B.B. 1984. "Ecological Aspects of Stability in Polycultures Versus Sets of Monocultures of Annuals." Doctoral Dissertation. School of Natural Resource Management. Ann Arbor: University of Michigan.

Scoones, I. and J. Thompson. 1992. "Beyond Farmer First Rural People's Knowledge, Agricultural Research and Extension Practice: Towards a theoretical framework." Before Farmer First Overview Paper No.1. London: IIED.

_____________ (eds). 1994. *Beyond Farmer First: Rural people's knowledge, agricultural research and extension practice*. London: Intermediate Technology Publications.

Scott-Wendt, J., R.G. Chase and L.R. Hossner. 1988. "Soil Chemical Variability in Sandy Ustalfs in Semiarid Niger, West Africa." *Soil Science* Vol.145(6):414-419.

Secretariat d'Etat aux Affires Etrangeres/Société d'Etudes pour le Développement Economique et Social (SEDES). 1972. "Les Perspectives de Développement A long Terme: A partir du Développement Rural. Tome II. Mali 1968-1986." Paris: SEDES.

Seyler, J.R. 1993. "A Systems Analysis of the Status and Potential of *Acacia albida* in the Peanut Basin of Senegal." Senegal Agricultural Research II Project. AID Contract No. 685-0957-C-8004-00. Dakar: U.S.A.I.D.

Shaikh, A., E. Arnold, K. Christopnersen, R. Hagen, J. Tabor, and P. Warshall. 1988a. "Opportunities for Sustained Development: Successful natural resource management in the Sahel, Volume 1/Main Report." Office of Technical Resources and Sahel Office, Africa Bureau. Washington, D.C.: USAID.

_____. 1988b. "Opportunities for Sustained Development: Successful natural resource management in the Sahel, Volume 2/Case Descriptions." Office of Technical Resources and Sahel Office, Africa Bureau. Washington, D.C.: USAID.

Sharland, R.W. 1989. "Indigenous Knowledge and Technical Change in a Subsistence Society: Lessons from the Moru of Sudan." Overseas Development Institute, Agricultural Administration Unit. Agricultural Administration (Research and Extension) Network Paper 9. London: ODI.

________. 1991. "Trees in the Garden: Interaction between the wild and agricultural domains in practice among the Moru of the southern Sudan." *Unasylva* 42(164):55-62.

Sikana, P. 1993. "How Farmers and Scientists See Soils: Mismatched models." *ILEIA Newsletter* Vol. 9(1):15-16.

Singh, R.D. 1988. *Economics of the Family and Farming Systems in Sub-Saharan Africa: Development Perspectives*. Boulder: Westview Special Studies.

Sivakumar, M.V.K. 1989. "Agroclimatic Aspects of Rainfed Agriculture in the Sudano-Sahelian Zone." In *Soil, Crop, and Water Management Systems for Rainfed Agriculture in the Sudano-Sahelian Zone: Proceeding of an International Workshop, 11-16 Jan. 1987, ICRISAT Sahelian Center, Niamey, Niger*, ICRISAT. Patancheru: ICRISAT.

Slaybaugh-Mitchell (in preparation). "Indigenous Production and Animal Husbandry: An annotated bibliography." CIKARD Bibliographies in Technology and Social Change No.6. Ames: Iowa State University.

SODETEG Aide Technique pour la Coopération et le Développement (SATEC). 1985. "Etude des Opérations de Développement Rural (ODR) et des Organismes Similaires. Deuxième phase propositions de redressement. Rapport de Synthèse (edition provisoire)." Paris: SATEC.

South-East Consortium for International Development (SECID). 1987. "Farming Systems Research and Extension in the Zone of the Opération Haute Vallée du Niger in Mali: A rapid reconnaissance survey." Mali Farming Systems Research and Extension Project. Chapel Hill: USAID and Institut d'Economie Rurale.

Sperling, L., M.E. Loevinsohn, and B. Ntabomvura. 1993. "Rethinking the Farmer's Role in Plant Breeding: Local bean experts and on-station selection in Rwanda." *Experimental Agriculture* 29:509-519.

SPORE. 1991. *SPORE* No.32:5.

___. 1993. "Shade Increases Crop Yields." *SPORE* No.44:10.

Steedman, C., T.E. Daves, M.O. Johnson, and J.W. Sutter, with E.J. Berg, R.J. Bingen, and M.J. Morgan. 1976 "Mali: Agricultural Sector Assessment." Final Report. Center for Research on Economic Development, the University of Michigan. Ann Arbor: CRED.

Steentoft, Margaret. 1988. *Flowering Plants in West Africa*. Cambridge: Cambridge University Press.

Steffen, P. 1992. "The Roles and Limits of the Grain Market in Assuring Food Security in Northeastern Mali: Implications for Public Policy." Doctoral Dissertation. Department of Agricultural Economics. East Lansing: Michigan State University.

Steila, D. and T.E. Pond. 1989. *The Geography of Soils: Formation, distribution, and management*. Savage Maryland: Rowman & Littlefield Publishers.

Sternberg, R.J. and R.K. Wagner. (eds.) 1986. *Practical Intelligence: Nature and origins of competence in the everyday world*. Cambridge University Press: Cambridge.

Sterns, J.A. and R.H. Bernsten. 1994. "Assessing the Impact of Cowpea and Sorghum Research and Extension in Northern Cameroon." International Working Paper No.43. Department of Agricultural Economics. East Lansing: Michigan State University.

Stewart, I. 1986. "Response Farming: A scientific approach to ending starvation and alleviating poverty in drought zones of Africa." In *Proceedings: African Agricultural Development Conference: Technology, Ecology and Society*, Moses, Y.T. (ed). California State Polytechnic University, Pomona, Kellog West Conference Center, May 28-June 1, 1985. Pomona: California State Polytechnic University.

______. 1989. "Potential for Response Farming in Sub-Saharan Africa." In *Soil, Crop, and Water Management Systems for Rainfed Agriculture in the Sudano-Sahelian Zone: Proceeding of an International Workshop, 11-16 Jan. 1987, ICRISAT Sahelian Center, Niamey, Niger*, ICRISAT. Patancheru: ICRISAT.

Stolzenback, A. 1992. "Learning by Improvisation: The logic of farmers' experimentation in Mali. An explorative case-study to experimental activities of farmers in Sanado, Mali." Unpublished manuscript.

________. 1993. "Farmers' Experimentation: What are we talking about?" *ILEIA Newsletter* Vol. 9(1):28-29.

Stoop, W.A. 1986. "Agronomic Management of Cereal/Cowpea Cropping Systems for Major Toposequence Land Types in the West African Savanna." *Field Crops Research* 14:301-319.

______. 1987a. "Variations in Soil Properties Along Three Toposequences in Burkina Faso and Implications for the Development of Improved Cropping Systems." *Agriculture Ecosystems and Environment* 19:241-264.

______. 1987b. "Adaptation of Sorghum/Maize and Sorghum/Pearl Millet Intercrop Systems to the Toposequence Land Types in the North Sudanian Zone of the West African Savanna." *Field Crops Research* 16:255-272.

Strauss, A. and J. Corbin. 1990 *Basics of Qualitative Research: Grounded theory procedures and techniques*. Newbury Park: Sage Publications.

_______________. 1994. "Grounded Theory Methodology." In *Handbook of Qualitative Research*, N.K. Denzin and Y.S. Lincoln (eds). Thousand Oaks: Sage Publications.

Sundberg, S. 1989. "OHV Food Consumption and Expenditure Survey: Preliminary results on incomes sources in the OHV." Unpublished report.

Swift, J. 1979. "Notes on Traditional Knowledge, Modern Knowledge and Rural Development." *IDS Bulletin* Vol.10(2):41-43.

Swindell, K. 1988. "Agrarian Change and Peri-Urban Fringes in Tropical Africa." In *Rural Transformation in Tropical Africa*, Rimmer, D. (ed). Athens: Ohio University Press.

Sy, B.S. and M.Y. Bah. 1989. "Village Associations and Agricultural Extension in the Republic of Mali." In *Agricultural Extension in Africa*, Roberts, N. (ed). A World Bank Symposium. Washington, D.C.: The World Bank.

Tamboura, B.B. 1983. "A Comparative Economic Analysis of Agricultural Production in Three Regions in Mali, West Africa." Masters Thesis. Graduate College. University of Vermont.

Tangara, M. 1992. "Family Social Structure, Farm Operation Characteristics and the Adoption of New Technologies for Sustainable Farming Systems in Mali." Doctoral Dissertation. Department of Sociology. Ames: Iowa State University.

Technical Advisory Committee (TAC). 1993. "The Ecoregional Approach to Research in the CGAIR: Report of the TAC/Center Directors Working Group." TAC Secretariat of the CGIAR. Rome: FAO.

Teme, B, D. Keita and O. Coulibaly. 1993. "Analyse des Relations Entre la Recherche et le Developpement ou la Problematique de Transfert des Technologies en Agriculture. Seminaire sur la Liaison recherche-Developpement 15-16 Avril, 1993". Bamako: DRSPR.

Thomas, W.I. 1923. *The Unadjusted Girl*. New York: Harper Tourch Books. In *Knowledge Application: The knowledge system in society*, Holzner, B. and J.H. Marx. Boston: Allyn and Bacon, Inc.

Thomasson, G.C. 1981. "Maximizing Participative Planning: Cultural and psychological aspects of user-centered soil resource inventory data preparation and presentation." In *Soil Resource Inventories and Development Planning: Selected papers form the proceedings of workshops*, Soil Management Support Services, Soil Conservation Services, U.S. Department of Agriculture. Technical Monograph No.1. Washington, D.C.: USDA.

Thomson, J.T. 1987. "Land and Tree Tenure Issues in Three Francophone Sahelian Countries: Niger, Mali, and Burkina Faso." In *Land, Trees and Tenure*, Raintree, J.B. (ed). Nairobi and Madison: ICRAF and the Land Tenure Center, pages 211-216.

Thomson, J.T., D.H. Feeny, and R.J. Oakerson. 1986. "Institutional Dynamics: The evolution and dissolution of common property resource management." In *Proceedings of the Conference on Common Property Resource Management*, National Research Council. Washington D.C.: National Academy Press.

Toulmin, C. 1986. "Access to Food, Dry Season Strategies and Household Size Amongst the Bambara of Central Mali." *IDS Bulletin* Vol.17(3):58-66.

______. 1992. *Cattle, Women, and Wells: Managing household survival in the Sahel*. Oxford: Clarendon Press.

______. 1991. "Staying Together: Household responses to risk and market malfunction in Mali." In *Rural Households in Emerging Societies*, Haswell, M. and D. Hunt (eds). Oxford: Berg Publication.

Towner, G. 1980. *The Architecture of Knowledge*. Washington, D.C.: University Press of America.

United Nations (UN). 1971. "Integrated Approach to rural Development in Africa." Social Development Section of the Economic Commission for Africa. Social Welfare Services in Africa, No.8. New York: U.N.

United States Agency for International Development (USAID). (no date). "DHV Project: An Abstract." Bamako: USAID.

_____. 1978. "Operation Haute Vallee (688-0210) Project Paper." Bamako: USAID.

_____. 1982. "The Opération Haute Vallée Project in Mali is Experiencing Serious Problems." Regional Inspector General for Audit Abidjan. Audit Report No. 7-688-82-1. Bamako: USAID.

_____. 1984. "Farming Systems Research/Extension (688-0232) Project Paper." Bamako: USAID.

_____. 1986. "Operation Haute Vallée (688-0210) Internal Evaluation, February 1986." Bamako: USAID.

_____. 1988. "Mali: Development of the Haute Vallee (688-0233) Project Paper." Bamako: USAID.

_____. 1992. Strengthening Research Planning and Research on Commodities (SPAR) Project Paper (688-0250)." Bamako: USAID.

_____. 1993. "Development of Haute Vallee Project: Amendment Number One." Bamako: USAID.

Uphoff, N. 1986. *Local Institutional Development: An analytical sourcebook with cases*. Kumarian Press: West Hartford.

van der Poel, P. and B. Kaya. 1990. "Synthèse des Activités de Recherche de la DRSPR l'Amenagement Anti-Erosif (1986-1989)." Amsterdam: Institut Royal des Tropiques (KIT) and DRSPR (Sikasso).

van der Pol, F. 1992. "Soil Mining: An unseen contributor to farmer income in southern Mali." KIT Bulletin 325. Amsterdam: Royal Tropical Institute.

van Shaik, P., M. Gaudreau, J. Lichte, R. Cook, and D. Rudisuhle. 1991. "Evaluation: Farming Systems Research/Extension Project (688-0232)." Washington, D.C.: Experience Inc.

van Staveren, J.P. and Stoop, W.A. 1985. "Adaptation to Toposequence Land Types of West Africa of Different Sorghum Genotypes in Comparison with Local Cultivars of Sorghum, Millet, and Maize." *Field Crops Research* 11(1985):13-35.

Van Wambeke, A. 1982. "Calculated Soil and Temperature Regimes of Africa: A compilation of soil climatic regimes calculated by using a mathematical model developed by F. Newhall (Soil Conservation Service, USDA, 1972)." Department of Agronomy and Soil Management Support Services, Soil Conservation Service, U.S. Dept. of Agriculture. Ithaca: Cornell University.

Van Wambeke, A., and R. Dudal. 1978. "Macrovariability of Soils in the Tropics. In *Diversity of Soils in the Tropics*, American Society of Agronomy. ASA Special Publication Number 34. Madison: ASA.

Van Westen, A.C.M. and M.C. Klute. 1986. "From Bamako, with Love: A case study of migrants and their remittances." *Tijdschrift voor Econ. en Soc. Geografie* Vol.77(1):42-49.

Vandermeer, J. 1989. *The Ecology of Intercropping*. Cambridge: Cambridge University Press.

Vierich, H. 1984. "Accommodation or Participation? Communication Problems." In *Coming Full Circle: Farmers participation in the development of technology*, Matlon, P., R. Cantrell, D. King, and M. Benoit-Cattin (eds). Ottawa: IDRC.

Vierich, H.I.D. and W.A. Stoop. 1990. "Changes in West African Savanna Agriculture in Response to Growing Population and Continuing Low Rainfall." *Agriculture, Ecosystems and Environment* 31(1990):115-132.

Viguier, P. 1952. "Centre de Colonisation en Terre Sèche de M'Pésoba (Soudan)." *L'Agronomie Tropicale* Vol.7(2):180-183.

______. 1939. *La Riziculture Indigène au Soudan Français*. Paris: Larose.

von Maydell, H.J. 1990. *Trees and Shrubs of the Sahel: Their characteristics and uses*. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ). Weikersheim: Verlag Josef Magraf.

Walker, D.H., F.L. Sinclair, and R.I. Muetzelfeldt. 1991. "Formal Representation and Use of Indigenous Ecological Knowledge About Agroforestry: A pilot phase report." School of Agriculture and Forest Science. Bangor: University of Wales.

Warner, K. 1991. "Shifting Cultivators: Local technical knowledge and natural resource management in the humid tropics." Forests, Trees and People, Community Forestry Note No.8. Rome: Food and Agricultural Organization of the United Nations.

Warren, D.M. 1991. "Using Indigenous Knowledge in Agricultural Development." World Bank Discussion Paper No.127. Washington, D.C.: The World Bank.

______. 1992. "A preliminary Analysis of Indigenous Soil Classification and Management Systems if Four Ecozones of Nigeria." Discussion Paper RCMD 92/1, April 1992. Resource and Crop Management Division (RCMD), International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, and African Resource Centre for Indigenous Knowledge (ARCIK), Nigerian Institute of Social and Economic Research (NISER). Ibadan: IITA/ARCIK/NISER.

Warren, D.M., L. Jan Slikkerveen and S.O. Titilola (eds). 1989. "Indigenous Knowledge Systems: Implications for agriculture and international development." Studies in Technology and Social Change No.11. Technology and Social Change Program. Ames: Iowa State University.

Warren, D.M., L.J. Slikkerveer, and D. Brokensha (eds). 1995. *The Cultural Dimension of Development: Indigenous Knowledge Systems*. IT Studies in Indigenous Knowledge and Development. London: Intermediate Technology Publications.

Warshall, P. 1989. "Mali: Biological diversity assessment." USAID, Bureau of Africa, Office of Technical Resources, Natural Resources Branch. Natural Resources Management Support Project, Project No. 698-0467. Tuscan: Office of Arid Lands Studies.

Waters-Bayer, A. and J. Farrington. 1993. "Supporting Farmers' Research and Communication: The role of grassroots agricultural advisors." *Quarterly of International Agriculture* Vol.32(2):170-189.

Watts, M. 1983. *Silent Violence: Food, famine & peasantry in Northern Nigeria*. Berkeley: University of California Press.

Weber, M.T., J.M. Staatz, J.S. Holtzman, E.W. Crawford, and R.H. Bernsten. 1988. "Informing Food Security Decisions in Africa: Empirical analysis and policy dialogue." *American Journal of Agricultural Economics* Vol.70(5):1044-1052.

Weijenberg, J., M.H. Collion, D. Belmans, J. Brossier, H. Bruneau, M. Kooijman, J. Lefort, J. Masterson, and H. Muhtar. 1993. "*Project National de Recherche Agricole. Aide-Memoire: Mission d'Evaluation du 29 Mars au 23 Avril, 1993.*" Bamako: World Bank.

Wentling, M.G. 1983. "*Acacia albida*: Arboreal keystone of successful agro-pastoral systems in Soudano-Sahelian Africa." Ithaca: Cornell University. In "A Systems Analysis of the Status and Potential of *Acacia albida* in the Peanut Basin of Senegal," Seyler, J.R. Senegal Agricultural Research II Project. AID Contract No. 685-0957-C-8004-00. Dakar: U.S.A.I.D.

Western, D. 1982. "The Environment and Ecology of Pastoral People in Arid Savannas." *Development and Change* Vol.13:183-211.

Wheeler, D. 1984. "Sources of Stagnation in Sub-Saharan Africa." *World Development* Vol.1291):1-23.

Whyte, W.F. (ed). 1991. *Participatory Action Research*. Newbury Park: Sage Publications.

Wilding, L.P., and L.R. Drees. 1978. "Spatial Variability: A pedologist's viewpoint." In *Diversity of Soils in the Tropics*, American Society of Agronomy. ASA Special Publication Number 34. Madison: ASA.

Wilken, G.C. 1987. *Good Farmers: Traditional agricultural resource management in Mexico and Central America*. Berkeley: University of California Press.

Wilson, H.T. 1984. *Tradition and Innovation: The idea of civilization as culture and its significance*. London, Boston: Routledge & Kegan Paul.

Wilson, P. 1983. *Second-Hand Knowledge: An inquiry into cognitive authority*. Westport, Conn.: Greenwood Press.

World Bank. 1974. "Appraisal of Integrated Rural Development Project, Mali." Agriculture Projects Department. West Africa Regional Office. Report No. 340a-MLI. Washington, D.C.: World Bank.

_______. 1979. "Agricultural Sector Assessment for Nigeria." Washington, D.C.:The World Bank. In *The Silent Violence: Food, Famine & Peasantry in Northern Nigeria*, Watts, M. Berkeley: University of California Press.

______. 1989a. *Sub-Saharan Africa: From crisis to sustainable growth.* Washington, D.C.: World Bank.

______. 1990. *Vetiver Grass: The hedge against erosion*. 3rd Edition. The Asia Technical Department, Agriculture Division. Washington, D.C.: World Bank.

______. 1993. *World Development Report 1993*. Washington, D.C.: World Bank

World Resources Institute (WRI). 1994. "World Resources 1994-95: A guide to the global environment." New York and Oxford: Oxford University Press.

Yeboah, A.K., J.S. Cadwell, M. Fofana and T.B. Maiga. 1991. "Utlisation de Critere de Classification Multiple pour l'Identification des domaines de Recommendation et de Recherche." Bamako: DRSPR.

Yeboah, A.K. 1993. "Farming Systems Research and Extension Project, Mali: Intermediate Impact Indicators." Bamako: DRSRP/USAID/SECID.

Zahan, D. 1960. *Sociétés d'Initiantion Bambara: Le n'Domo, Le Korè*. Paris: Mouton & Co.

_____. 1974. *The Bamabara*. Leiden: E.J. Brill.

_____. 1979. "Principes de Medecine Bambara." In *African Therapeutic Systems*, Ademuwagun, Z.A., J.A.A. Ayoade, I.E. Harrison, and D.M. Warren (eds). Waltham: Crossroads Press.

Zaretzke, K. 1982. "The Idea of Tradition." *The Intercollegiate Review* Spring/Summer: 85-96.

Zolad. 1985. "Projet de Recensement des Technologies Traditionnelles au Mali." Dossiers Techniques. Projet de Recensement des Technologies Traditionnelles. Bamako: Division du Machinisme Agricole.

Government Documents

Anon. 1992. "Etude du Système de Vulgarisation de l'OHVN. DRAFT."

Commission Naitonale de Planification de l'Economie Rurale (CNPER). 1972. "Rapport Final de la Commission Naitonale de Planification de l'Economie Rurale. Pour l'elaboration de Plan Quinquennal 1974-78. Premiere Partie: Synthese des travaux des groupes d'etudes des zones rurales." Bamako: CNPER.

Compagnie Malienne pour le Développement des Textiles (CMDT). 1992. "Projet Lutte Anti-Erosive. Rapport Bilan L.A.E. Campagne: Octobre 1990-Septèmbre 1991." Koutiala: CMDT/KIT.

Direction Générale du Plan et de la Statistique. 1972. "Evolution des Activites du Secteur Economique Organise d'Apres les resultats des Enquetes Aupres des Enterprises 1960-1970." Bamako: Service de la Statistique Generale de la Comptabilite Nationale et de la Mechnograpie.

Direction Nationale de la Métérologię (DNM). 1992. "Rapport Technique de la Campagne Agricole 1991-1992." Division de l'Agrométéorologie, Section Etudes et Développement. Bamako: DNM.

Département de Recherche sur les Systèmes de Production Rurale (DRSPR). 1980. "Rapport Synthetique de la Campagne 1979-80, Programmes 1980-81. Comité National de al Recherche Agronomique, Mai 1980." Bamako: DRSPR.

______. 1987. "Commission Technique sur les Systèmes de Production. Document No.5 Volet OHV: Choix des Villages de Recherche; Enquête Typologie." Bamako: DRSPR (Volet OHV).

______. 1988a. "Comité Technique Régional: sur les Systemes de Production Rurale Centre de Sotuba, Résultats Campagne 1987-88." Bamako: DRSPR (Volet OHV).

______. 1988b. "Commissions Techniques Spécialisées sur les Systèmes de Production Rurale: Résultats Campagne 1987-88." Bamako: DRSPR (Volet OHV).

______. 1989a. "Commissions Techniques Spécialisées sur les Systèmes de Production Rurale: Résultats Campagne 1988-89." Bamako: DRSPR (Volet OHV).

______. 1990a. Commissions Techniques Spécialisées sur les Systèmes de Production Rurale: Résultats Campagne 1989-90." Bamako: DRSPR (Volet OHV).

______. 1990c. "Cadre de Collaboration DRSPR-OHV." Bamako: DRSPR (Volet OHV).

______. 1990b. "Plan a Long Terme du Volet OHV du DRSPR: Programme de recherche (1990-1994)." Bamako: DRSPR (Volet OHV).

______. 1991a. "Comité Technique Régional: sur les Systèmes de Production Rurale Centre de Sotuba, Résultats Campagne 1990-91." Bamako: DRSPR (Volet OHV).

______. 1991b. "Commission Technique Spécialisée sur les Systèmes de Production Rurale: Résultats Campagne 1990-1991." Bamako: DRSPR (Volet OHV).

______. 1991c. "Approche Recherche Système: Note méthodologique No.1." Sikasso: DRSPR (Sikasso).

______. 1992a. "Comité Technique Régional sur les Programme Systèmes de Production Rurale, Centre de Sotuba, Résultats Campagne 1991-92." Bamako: DRSPR (Volet OHV).

______. 1992b. "Synthèse Evaluation Paysanne." Bamako: DRSPR (Volet OHV).

______. 1992c. "Caracterisation Socio-Economique des Unites de Production en Zone de l'Office de la Haute Vallee du Niger." Bamako: DRSPR (Volet OHV).

______. 1992d. "Information Generales sur les Villages de Recherche du DRPSR Sotuba et Taux d'Adoption des Technologies par les Paysan pour L'Ensemble de la Zone OHVN." Bamako: DRSPR (Volet OHVN).

______. 1992e. "Prévulgarisation Concept et Méthodologie: Note méthodologique No.5." Sikasso: DRSPR (Sikasso).

______. 1992f. "Prise en Compte des Preoccupations des Femmes dans les Activites de Recherche du Volet OHVN: Resultats, Difficultes et Perspectives." Bamako: DRPSR (Volet OHV).

______. 1992g. "Commission Technique sur les Systèmes de Production. Document No.5, Volet OHV, A. Choix des Villages de Recherche B. Enquete Typologie." Bamako: DRSPR.

______. 1992h. "Commission Technique sur les Systèmes de Production Rurale: Synthèse des Résultats de la Campagne 1991/92." Sikasso: DRSPR (Sikasso).

______, Centre Regional de Recherche Agronomique de Sotuba. 1993a. "Comite Technique Regional: Sous Programme Systemes de Production Rurale, Resultats Campagne 1992-93." Bamako: Volet O.H.V.N.

______. 1993b. "Fiches Techniques." Bamako: DRPSR (Volet OHVN).

______. 1993c. "Synthese des Resultats 1986-1992." Bamako: DRPSR (Volet OHVN).

______. 1993d. "Synthèse Evaluation Paysanne." Bamako: DRSPR (Volet OHV).

Institut d'Economie Rurale (IER). 1977. "Evaluation de 'Opération Arachide et Cultures Vivières: Analyse de exploitations agricules de l'OACV effectuée à partire de l'enquête descriptive de 1976." Bamako: IER.

______. 1978. "Evaluation de l'Opération Arachide et Cultures Vivrières: Note de Synthèse Principaux résultats des Enquêtes Menées en 1976 et 1977 sur l'OACV." Bamako: IER.

______. 1988. "Comite National de la Recherche Agronomique, 25ème Session, Bamako 26-29 Avril, 1988. Rapport de la Commission Technique Spécialisée sut les Systèmes de Production Rurale." Bamako: IER.

______. 1990. *Memento Techniques Culturales*. Bamako and Amsterdam: IER/DRSPR/CMDT/Institut Royal des Tropiques.

______. 1992. "Plan Strategique de la Recherche Agronomiue du Mali: Options de developpement pour l'IER." Bamako: IER.

Ministère du Plan, Cabinet. 1987. "Esquisse du cadre d'un plan d'action de restructuration cas par cas des Opérations de Développement rural. Document provisoire." Bamako: Min. du Plan.

Ministère du Plan et de l'Economomie Rural. (no date). "Organization de Monde Rural en République du Mali." *Action Rurale édition spéciale*. Imprimerie Maubert et Cie: Paris

Ministere du Plan et de la Statistique. (no date). "Plan Quinquennal de Developpement Economique et Social." Min. du Plan et de la Statistique: Bamako.

Ministere de la Production, Service de l'Agriculture. (no date). "L'Agriculture au Mali: Situation actuelle. Perspectives." Min. de la Production: Bamako.

Ministere de la Production. 1972. "Etude Preparatoire a l'Execution de la Campagne de Vulgarisation de Masse pour la Protection des Semences et des Recoltes au Mali. Tome II: Etude des attitudes et motivations des élites paysannes. Contract d'Etude No.861." Paris and Rome: MARCOMER and So.TE.S.A.

Office de la Haute Vallée du Niger (OHVN). (no date). "Termes de Reference des Spécialistes de la Division Vulgarisation." Bamako: OHVN/Division Vulgarisation.

_____. (no date). "Calendrier de Travail Destiné Aux Secteurs." Bamako: OHVN/Section Vulgarisation et Animation Feminine.

_____. (no date). "Recomendations du 10e Séminaire de l'OHV á Oueléssébougou." Bamako: OHVN.

_____. (no date). "Recommendations Issues du Séminaire de Sélingué." Bamako: OHVN.

_____. 1986. "Categorisation des Exploitations en Zone OHV: Séminaire de Oueléssébougou." Bamako: OHVN/Division Stat. Plan. Evaluation.

_____. 1988. "Projet de Restructuration de l'OHV." Bamako: OHVN.

_____. 1989. "Structure Organisationnelle et Attributions des Agents de la Division Vulgarisation." Bamako: OHVN/Division Vulgarisation.

_____. 1990. "Evaluation Activitiés des Chefs Sous Secteur." Bamako: OHVN/DCDR.

_____. 1991a. "Etat d'Avancement de l'Execution des Objectifs Assignés á la Vulgarisation dans le Cadre du Projet D.H.V.." Onzième Seminaire Annuel de l'OHV Tenu les 23-24-25 Avril, 1991, á Oueléssébougou. Bamako: OHVN/Division Vulgarisation.

_____. 1991b. "Buts et Objectives du Projet." Bamako: OHVN/Cellule de Suivi.

_____. 1991c. "Structure Organisationnelle de l'Opération Haute Vallée." Bamako: OHVN/Cellule de Suivi.

_____. 1992a. "Rapport Annuel d'Activités: Campagne Agricole 1991-1992." Bamako: OHVN.

_____. 1992b. "Plan de Campagne Agricole: 1992-93." Bamako: OHVN.

_____. 1992c. "Communication O.H.V.N. au Seminaire sur la Recherche Systeme a Sikasso du 17-21 Novembre, 1992." Bamako: OHVN.

_____. 1992d. "Evaluation Paysans Pilotes." Bamako: OHVN/DCDR.

_____. 1992e. "Rapport sur les Activités du Projet, Rapport d'Avancement No. 5." Bamako: OHVN/Cellule de Suivi.

_____. 1992f. "Contribution de l'OHVN á la Gestion des Ressources Naturelles dans sa Zone d'Intervention." Seminaire Annuel de l'OHVN les 12-13 et 14 Mai, 1992. Bamako: OHVN.

_____. 1993a. "Rapport Annuel d'Activités: Campagne Agricole 1992-1993." Bamako: OHVN.

_____. 1993b. "Plan de Campagne Agricole: 1993-94." Bamako: OHVN.

_____. 1993c. "Programme d'Activites P.N.V.A.: Campagne 1993/94." Bamako: OHVN.

Section de Reglementation et de Controle des Semences Selectionnees (SRCSS). 1987. "Catalogue Officiel des Espèces et Variétés Tome 1, Espèces Vivriéres." Sotuba-Bamako:IER/DRA.

Section de Recherche sur les Cultures Vivrière et Oléagineuses (SRCVO). 1979. "Projet SAFGRAD au Mali: Rapport de la Campagne 1979." Bamako: SRCVO.

_____. 1989. "Projet Sol-Eau-Plante. Agroclimatologie Operationnelle. Resultats de la Campagne 1988-89 et propositions de programme 1989." Commission Technique Spécialisée des Productions Vivrières et Oléagineuses. Bamako du 11 au 15 Avril 1989. Bamako: SRCVO.

_____. 1992. "Projet Sol Eau Plante: Agroclimatologie Opérationnelle. Résultats de la Campagne 1991-1992, Propositions de Programmes 1992. Comité du Programme Ressources Naturelles." Bamako: SRCVO.

Sélingué. 1992. "Seminaire: Analyse des systemes de fourniture de service aux paysans et aux associatios billageoises. Rapport de Synthese. Novembre 1992." Bamako: OHVN.

Union Soudanaise R.D.A. (no date). "La Politique Economique de l'Union Soudanaise R.D.A."