A Comparative Study to Identify Factors Affecting Adoption of Soil and Water Conservation Practices Among Smallhold Farmers in the Njoro River Watershed of Kenya

Steven P. Huckett
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A COMPARATIVE STUDY TO IDENTIFY FACTORS AFFECTING ADOPTION OF
SOIL AND WATER CONSERVATION PRACTICES AMONG SMALLHOLD
FARMERS IN THE NJORO RIVER WATERSHED OF KENYA

by

Steven P. Huckett

A dissertation submitted in partial fulfillment of the
requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

Human Dimensions of Ecosystem Science and Management

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2010
ABSTRACT

A Comparative Study to Identify Factors Affecting Adoption of Soil and Water Conservation Practices Among Smallhold Farmers in the Njoro River Watershed of Kenya

by

Steven P. Huckett, Doctor of Philosophy

Utah State University, 2010

Natural resource conservation is important for human well-being, especially in fragile environments of developing countries. This study occurred in 2006 among 6,500 smallhold farmers residing along a 25-km segment of a heavily utilized river. Research objectives were to determine use and adoption constraints for 14 soil and water conservation practices (SWCPs). Farms were reportedly contributing to a decline in river water quality via soil erosion. Recent occupation of the upper watershed by immigrants magnified concerns that resource degradation could escalate. A multi-method approach incorporating quantitative surveys, qualitative interviews, and participant observation was used to interpret constraining factors within the biophysical and historical context of the watershed. Adoption rates for SWCPs were expected to be low (less than 20 percent). Increased formal education, income, access to information, and security of land tenure and soil characteristics, were expected to positively influence adoption. Data analysis
included descriptive statistics and use of classification and regression trees. Results indicated that all sampled farms had adopted at least two SWCPs, with an average of six per farm. Favored practices were those that were easier to implement and more effective for resource protection and food production. Years in residence (tenure security) and income emerged as primary explanatory variables for adoption of SWCPs, while soil quality and formal education were secondary. Only 27 percent of surveyed farmers held title deeds, but the others perceived that land occupation conferred “ownership” and hence implemented SWCPs. A follow-up visit in 2009, after the region had endured a year of highly publicized ethnic conflict, immigration and farm expansion continued with SWCPs being adopted. Njoro communities mostly remained intact and appeared resilient. While small farms likely contribute to watershed-scale problems and declines in quality and quantity of water in the River Njoro, farmers have made remarkable strides—largely on their own—to conserve natural resources. Future research should examine how a general lack of infrastructure off-farm and study-site context contributes to reduced watershed-resource quality. Further protection of soil and water is best served by a more aggressive policy and extension education framework that links food security, household well-being, and natural resource management.
DEDICATION

First, I wish to thank all the smallhold farmers, key informants, and community leaders who facilitated my fieldwork in the Njoro River watershed and who generously contributed their time and knowledge to this research. I owe them a particular debt of gratitude. I am grateful to members of the SUMAWA project for their support and assistance during my time in Kenya. My special thanks go to Eunice Ngari and Ben Kimwei, my faithful companions and employees in Kenya for the duration of my time there. Without them, the field data collection and, ultimately, this research would not have been possible. To my companions and fellow graduate students on the SUMAWA project whom I shared this adventure with, I will always have the fondest memories of our time together in the field and at Treetops.

Second, I extend my sincere thanks to those folks at Utah State University (USU). To my dissertation committee: D. Layne Coppock, Scott Miller, Joanna Endter-Wada, Mark Brunson, and Ron Ryle for their patience and guidance throughout this process. In particular, my thanks go to my major advisor, D. Layne Coppock, for his unwavering dedication to seeing me through to this end. I also want to express my deep appreciation to all my colleagues and staff members who provided their time, efforts, and enthusiastic support to help make my degree program a success. First among them is my friend and mentor Susan Durham for her wise and gentle coaching, which got me through my statistical data analysis in spite of my resistance and slow uptake. My sincere thanks to Judy Kurtzman who always provided me a sunny disposition and positive encouragement, despite the turmoil around us; to my professors and advisors in ENVS
for helping to give me some clarity of thought so that I could make wise choices; and for
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inspirational. Finally, I want to extend special thanks to Tracy Jones whose guidance,
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You are my hero.

And finally to my family, to whom I owe a great debt of gratitude, many thanks
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children, Jennifer and Benjamin, who have been steadfast in their support and
unwavering love for their crazy old man who decided to return to school at a late age.
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Without Whit’s support, completion of my doctorate would not have been possible.
I love you all.
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Steven P. Huckett
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CHAPTER 1
MERGING PERSPECTIVES OF SMALLHOLDER FARMER
CONSERVATION BEHAVIOR

Objectives of Research

Sustainable management of watersheds, conservation of soil resources, and enhancement of the quantity and quality of water resources is recognized as increasingly important for communities worldwide (UNEP, 2001). Conservation of soil and water resources is most critical in developing countries where populations utilize marginal lands for their subsistence, and access to modern agricultural subsidies and production resources is limited. Therefore, the overall objective of this research is to discover and gain a better understanding of how decisions are made to adopt soil and water conservation practices (SWCPs) by impoverished smallholder farmers in the River Njoro (Njoro) watershed of Kenya, from a holistic point of view.

I examine a range of biophysical, geologic, economic, political, and anthropocentric (culture, history, ethnicity, gender, etcetera) factors with the intent to understand how they influence farmer’s decision-making. This comparative approach provides a broad framework for examining seemingly disparate factors to gain insights into why farmers choose to adopt conservation practices, especially when they receive little technical or state support, in the face of abject poverty. Clarification of why SWCPs are adopted and implemented on small-scale farms will improve our ability to identify important constraints to conservation of soil and water resources in impoverished, predominantly agricultural watersheds.
Lynam and Stafford Smith (2003) state that “. . . human processes are [at least] as important as the ecological processes” to understanding management of water resources and of agricultural land use practices. In this vein, this study focuses more on how the human aspect of soil and water conservation at a watershed scale is influenced as I attempt to build bridges between social and biophysical perspectives. With awareness of the principles of systems theory, we are better equipped to identify and integrate key components of interlinked systems (i.e., social, institutional, biophysical). This approach allows for development of greater understanding of the larger issue of human behavior and our role in the impairment to watershed resources. By examination of a multitude of factors and how they interact to influence smallholder farmers’ SWCPs adoption decisions, insights into how to improve policy and allocation of scarce resources so that more effective watershed management programs in developing nations may result. Ultimately, my hope is that this research will improve the livelihoods of small-scale farmers and the rural poor worldwide.

Introduction

Soil and water resources are critical resources necessary for life and our survival. Less than 3-percent of all water on earth is nonsaline, fresh water suitable for human consumption; however, over 75 percent of this is locked away as ice in glaciers and polar icecaps with the balance found in underground aquifers, surface waters, and soil moisture (Leopold, 1974). Therefore, protecting these resources against degradation is vital for continued productivity and food production for humankind, provision of regenerative ecosystem services, and maintenance of biodiverse landscapes. Through time, the
expansion of human populations has led to the alteration of natural landscapes into urban settlements, agricultural systems (crops and livestock grazing) for food production, and harvest of natural resources (timber, minerals, etcetera) to satisfy our ever-increasing demand for resources.

History shows us that, as humans have migrated onto wildlands and expanded our agronomic and livestock rearing activities, impairment of water resources has resulted (Duttweiler and Nicholson, 1983; Pierce and Frye, 1998). Sedimentation of surface waters from erosion, nutrient loading by animal wastes, and impairments due to agro-chemicals has damaged aquatic habitats, led to eutrophication of stream waters, and resulted in negative changes to stream channel morphology and hydrologic characteristics (Duttweiler and Nicholson, 1983; Molles and Dahm, 1990; Dunne and Leopold, 1995; Shivoga, 2001). This alteration of the land surface has altered nature’s water cycle (Figure 1.1) and has led to degradation of aquatic habitats, elimination of native fisheries, and to declines in water quality and quantity for human uses.

Additionally, soil erosion is a natural process occurring on every landscape (Dunne and Leopold, 1995; Brady and Weil, 1999). Physical forces (wind, water, and disturbance by animals and cultivation) and biogeochemical forces (chemical weathering) work together to create a highly dynamic system of soil formation, plant growth, nutrient replenishment and depletion, and loss of soil materials due to erosion. Vegetation contributes root biomass and facilitates the formation and maintenance of soil biotic communities, which
Figure 1.1. Generalized water cycle. Source Earthscan.
increases soil organic matter volume, supports soil structure, and increases water infiltration rates (Brooks et al., 1991; Naiman, 1992; Dunne and Leopold, 1995). These factors support the maintenance of cohesive soil structure, overall soil stability, and decomposition of large particulate organic matter into important soil nutrients, which are then available for vegetative growth. Furthermore, natural soil fertility is maintained by a complex interaction of the aforementioned with climate, soil biota, and biogeochemical cycles.

On uncultivated lands, the integrity of soil resources is maintained both spatially and temporally by this dynamic and complex system. The diverse mosaic of vegetation mollifies soil erosion by reducing surface flow velocities by creating a more tortuous pathway across the entire soil surface. However, with the intensification of agricultural activities, regular tillage and removal of plant residues has accelerated the loss of soil nutrients through increased soil erosion. Concurrently, an accumulation of grazing animals on native grassland and riparian zone habitats has, in many areas, led to over-grazing. Thus, as the impacts of human settlement have accumulated, modification of wildlands has led to soil loss that negatively affects plant root establishment and vegetative cover of the soil surface. This is especially true on marginal lands and where severe climatic regimes limit plant growth that can leave soils bare and subject to further degradation. Therefore, the condition of soil and water resources is closely related to human population density and intensification of agricultural activities and is not considered herein as a “gift of nature.”

Innovation has facilitated a continuous increase in food production potential and improved food security throughout our history through development of improved (domesticated) crop and livestock varieties. This, in turn, has facilitated expansion of the
human race into nearly all habitable corners of earth. As populations continued to grow and expand, it stands to reason that farmers of early historical periods may not have been as concerned with soil erosion. They likely collected wild foods concurrently with small-scale crop production and moved to new “virgin,” more-productive lands whenever the soils became “worn out” (Odum, 1989; Diamond, 1999). Intensification of agricultural activities inevitably led to declines in soil fertility as cropping removed plant materials and nutrients from the landscape (Boserup, 1965; Odum, 1975; Brady and Weil, 1999), and continued expansion of societies and alteration of land cover have accelerated the degradation of land and water resources (Odum, 1989; Brooks et al., 1991; Turner et al., 1993). Inadequate knowledge of soil eco-physiology, plant ecology, or a full understanding of the dynamic relationships that people had with the land in all likelihood inhibited full understanding of the consequences of soil erosion (Pierce and Frye, 1998; Diamond, 1999). These conditions are evident in many areas of the world today where lands have become degraded by unsustainable agriculture or grazing pressures. Thus, if care is not taken, degradation of soil and water resources will continue until cultivation of crops is no longer possible.

As earth has become dominated by human settlement, maintenance of healthy ecosystems is increasingly critical for providing adequate supplies of clean water, soils, forage for livestock, food security, and stable socioeconomic foundations. Loss of biodiversity via modification of landscapes and environmental degradation are increasing at a faster rate than ever before in human history. As Yaffee postulated in 1997, most environmental problems are the result of human behavior. This, I believe, goes hand in hand with the value we assign to the world around us (Steven Huckett, personal
observation). Yaffee (1997) suggests that five recurring human behaviors serve to exacerbate natural resource problems, i.e., short-term rationality out competing long-term rationality, competitive v. cooperative behaviors, fragmentation of values and interests, fragmentation of responsibilities and authorities, and fragmentation of information and knowledge. Being what we are, it seems that humans introduce complexity to any situation as we develop structures and institutions for controlling the environment around us (Steven Huckett, personal observation). Therefore, in an effort to avoid recurring environmental problems, proactive meaningful dialogue among individuals and communities is necessary for generative learning to occur (Lee, 1993; Yaffee, 1997). When a common integrated vision and an understanding of possible solutions to natural resource problems is shared, stakeholders are more likely to sustain their involvement in seeing these problems resolved (Lee, 1992; Lee, 1993; Brick, 2001). Lee (1992) and Snow (2001) have also suggested that when environmental managers have an appreciation of all stakeholders’ associations to their ecological resources, a higher degree of compatibility among participants, and degree of success, may be realized.

Traditional “scientific” investigations of impairment of natural resources have focused primarily on biophysical features, an approach that typically underestimates or ignores the human perspective and human influences on the environment. Conversely, social research of the environment has regularly avoided consideration of the biophysical features of landscapes, focusing instead on peoples’ perceptions and behaviors to explain degradative processes and natural resource management behaviors. Consequently, parallel knowledge is developed but remains disconnected. These biased approaches have ramifications for policy development, planning and management activities, and
implementation of resolutions meant to address environmental issues of concern. Striving to merge these separate lines of thought is necessary to form comprehensive and quantifiable models that merge concerns for human well-being and the integrity of natural resources. From this perspective, I believe that a better understanding of the interplay of factors that influence peoples’ decision-making that leads to impairment of soil and water resources is essential for sustaining an increasing human population, for protecting biodiversity, and for facilitating ecosystems services.

Theoretical Framework

Adoption-Diffusion Research

This research focuses on small-scale farmers and the key factors influencing their decision to adopt new soil and water conservation management approaches. Adoption-diffusion decisions are made by a dynamic process whereby innovations become known to a decision-making individual, collective or organization, or governmental/regulatory authority, then adopted and implemented to satisfy a particular concern (Rogers, 2003). Innovations are defined as “an idea, practice, or object that is perceived as new by an individual or other unit of adoption” (Rogers, 2003). Innovation adoption is related to social values, beliefs held by stakeholders, and past behaviors within the social systems in question. Knowledge about innovations is spread through the social system via the process known as diffusion (Rogers, 2003). History is replete with examples of adoption of innovations that have led to the steady improvement of man’s condition. For example, the Romans’ development and adoption of new administrative organizations provided them the means to impose greater control over vast areas of land and resources;
furthermore, adoption of advanced domesticated crop plants facilitated increased food production and the creation of more stable sedentary settlements from which human society and cultures have developed.

Sociologists trace the study of innovation adoption and diffusion back to the early 1900’s and Tarde’s (1903) work on imitation behavior and to works completed in the 1930’s and 1940’s by Bowers (1938) and Pemberton (1936, 1938). Beginning in the 1940’s and 1950’s, social scientists were interested in the diffusion of agricultural innovations to farmers (Ryan and Gross, 1943) and new technologies through schools and the public health network. Since those early days, adoption-diffusion research has become a multidisciplinary endeavor, studied by scientists in the fields of economics, sociology, public health, agriculture extension, anthropology, psychology, and marketing, to name a few. Despite the use of different terminologies, and coming from different perspectives, the basic findings of adoption-diffusion research are broadly consistent across the various fields of scientific inquiry.

The traditional simple diffusion model is based on the potential adopter’s access to information about the innovation. This is the “principle factor affecting the adoption decision” (Hooks et al., 1983) and is based on subjective expectations and perceptions and not necessarily on an objective truth. The assumption is that rational decisions by the potential adopter will be made based on the information received about the innovation and its associated advantages and disadvantages. This simple model can be described as a continuous, dynamic process whereby all options are open to review and reevaluation as conditions change or new information is obtained. This process occurs spatially, as well
as temporally, within a system. Rogers (2003) describes this decision model as being a five-stage sequential process as follows:

- **Knowledge** – When the potential adopter becomes aware of an innovation’s existence and when understanding of the innovation’s purpose or function is gained. The innovation need not be “new technology” in the sense of being recently discovered or invented, but only needs to be “new” to the potential adopter for their system or operation. The rate of knowledge gain is dependent on characteristics of the decision maker.

- **Persuasion** – This stage is where the potential adopter develops awareness and sets about to gather enough additional information to be able to evaluate the innovation so that a favorable or unfavorable perception is held about the innovation. This stage encompasses learning about the various attributes of the innovation so that a decision is made to pursue use of the innovation.

- **Decision** – Once adequate information is obtained, the adopter makes a decision to evaluate the innovation through trial. This stage allows the adopter an opportunity to gain additional information and skills regarding application of the innovation. Adoption may occur if trials are not possible, but only after substantial information from other sources (i.e., discussion, peer influence, analysis, etcetera) is obtained. The decision process is influenced by both endogenous and exogenous factors acting on the potential adopter and has an equal probability of leading to acceptance or rejection of the innovation.

- **Adoption (implementation)** – If the potential adopter decides that an innovation is beneficial to their system, they put the new idea or practice into use. However,
this decision/evaluation process often occurs simultaneously with implementation and can lead to change and modification of the innovation to fit their particular circumstance (context). This process of “tinkering” is crucial for the next stage of the decision model.

- Confirmation (assessment) – At this stage, the decision maker continues to review and evaluate the performance and effects (positive or negative) of the innovation. Decisions may be reinforced or reversed as reasons for adoption shift from evaluation to perceived benefit. Continuance of use will likely result when adoption of the innovation results in an overall benefit to the adopter; discontinuance of the practice may result if the overall benefit of the innovation is minimal or negative, or when the circumstances of the adopter change (i.e., economic circumstance, better technology, peer pressure).

Innovation adoption is not adequately explained by this simple model, however (Hooks et al., 1983; Saltiel et al., 1994), and even when the associated benefits of the innovation are apparent, adoption is often difficult (Rogers, 2003). This general innovation-decision process model is likely to be context specific to individual decision makers whereby decisions are influenced by personal experiences, information gathering and evaluation abilities, and social and cultural backgrounds. In contrast, certain variables have been identified as factors affecting the adoption decision process and include the attributes of innovations, personal characteristics of potential adopters, and the structure of social systems appearing to influence the adoption decision. It is often difficult to generalize evaluation of how variables effect adoption decisions for multiple innovations
because the influence of individual variables is context specific to the innovation, and to
the innovator, being studied (Pampel and van Es, 1977; Fliegel and van Es, 1983;
Dewees and Hawkes, 1988; Dewees, 1995).

Attributes of Innovations

It is generally accepted that five characteristics of innovations have influence over
adoption decisions and include relative advantage, compatibility, complexity, trialability,
and observability, as described below (Rogers, 2003).

- Relative advantage – This is “the degree to which an innovation is perceived as
  being better than the idea (or practice) that it supersedes” (Rogers, 2003). Relative
  advantage of an innovation depends on the context of the adopter and
  circumstance in which it will be used and can be influenced by a wide range of
  variables including biophysical, economic, social, and governmental factors.
  Some factors influencing relative advantage include social status (Tarde, 1903),
  short-term cost-benefit to the adopter (Marsh et al., 2000; Abidi Ghadim et al.,
  2005), impacts of the innovation on other parts of the adopter’s operation or
  lifestyle (Cary, 1986; Kingwell et al., 1993), long-term profits (Wilkinson and
  Cary, 1992; Makeham and Malcolm, 1993), risk of use of the innovation (Marra
  et al., 2003; Abidi Ghadim et al., 2005), and policies affecting the use of the
  innovation (Helms et al., 1987).

- Compatibility – Evaluation of the apparent consistency with the adopter’s current
  operation, values and beliefs, past experiences, peer influence, and perceived
  needs of potential adopters. Ideas that are more compatible fit more closely with
the situation or circumstance and thus have more meaning to the potential adopter (Rogers, 2003). For instance, an innovation is considered more compatible if it can be readily assimilated into the operation and utilized by the machinery and management of practices already in use. The adopter’s own skill level and abilities are also critical determinant factors in determining whether an innovation is compatible or not (Pannell et al., 2006).

- Complexity – Similarly, the degree of complexity or the extent to which an innovation can be understood and relatively easily implemented is determined by the adopter (Wilkinson, 1989; Rogers, 2003). If the effort needed to implement increases the risk of an innovation failing, the relative advantage of adopting that innovation is proportionately reduced. Also, if an innovation is not complex but adds to the overall complexity of managing existing practices or an existing operation, the innovation itself may be viewed as too complex to adopt (Pannell et al., 2006). Complexity can be measured also by other seemingly unrelated consequences of adoption such as increased effort to implement and maintain increased stress on adopter’s or adopters’ family, and negative impressions of the innovation by members of the social system in which the adopter lives.

- Trialability – This refers to the degree to which an innovation can be tested on a small-scale to reduce the uncertainty associated with adoption; the greater the level of trialability, the greater potential for adoption to occur (Gross, 1942; Ryan, 1948; Tonks, 1983; Ohlmer et al., 1998). Trialing the innovation allows the potential adopter to learn about the nuances of the innovation and to provide an opportunity to learn new skills necessary to implement the innovation.
• Observability – Is the degree to which the measurable effects of an innovation are visible to the adopter and to other individuals in the community (Pannell, 2001; Rogers, 2003). A high level of observability provides greater opportunity for evaluation for relative advantage and complexity by potential adopters and others – “over the shoulder” – in the social system.

In theory, if innovations are compatible with the decision maker’s current operation and demonstrate high degrees of relative advantage, less complexity, trialability, and observability, they will tend to be adopted more quickly (Pannell, 2001; Rogers, 2003). However, other factors may play an important role in stakeholder’s decision to adopt or not to adopt innovation such as economic pressure (Boserup, 1965), operational/technological life cycle change (Marchetti, 1980), and individual development.

Adopters Personal Characteristics

Innovativeness is described as the “degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than the other members of a system” (Rogers, 2003). Individuals are not all created equally, nor do they adopt innovations at the same time or rate. Therefore, adoption research has identified five categories of ideal types of adopter to describe the “innovativeness” of individuals. These five ideal types of adopter can be described by a normally distributed bell-shaped curve with no distinct discontinuities between categories. This classification continuum facilitates application of adoption-diffusion theory to human behavior and to improve our understanding. These five adopter categories are described as follows:
• **Innovators** – This group can be described as venturesome and unafraid of trying new ideas, regardless of peer-social perceptions of their behavior. They are typically not risk-adverse, willing to accept occasional disappointment with the innovation. They are leaders whose skill set allows them to understand and apply more complex technologies and will modify and experiment before abandoning the innovation. They are more willing to seek information from outside the local social system but, conversely, they are often distrusted by other stakeholders in the local system. Innovators role in the diffusion process is to introduce new innovation into the local system.

• **Early Adopters** – These adopters are more integral to the social systems in which they belong and typically accept innovations quickly, after the consequences of innovation adoption are made clearer by the experiences of innovators’. They are considered opinion leaders by many in the system. They are seen as role models for the majority of the community and, for this reason, are sought out by change agents for speeding diffusion. They are typically respected by peers for making judicious decisions when choosing innovations; therefore, they reduce uncertainty via subjective evaluation. They are ahead of the majority.

• **Early Majority** – They are situated just ahead of the majority of the system and typically do not hold positions as opinion leaders. They are more conservative in their willingness to adopt and serve as the communication link between the early adopters and the remainder of the social network. This category encompasses the majority of persons in the social system.
• Late Majority – This group adopts innovation after the majority due to caution and skepticism. Their decision to adopt may be due to limited economic resources and/or peer pressure, which may influence their sense of social standing. They require the most reassurance of the value of the innovation before they feel safe.

• Laggards – This group is typically described as being socially isolated and the last to adopt innovations. They are generally suspicious of change, and of change agents, instead relying on their experience to guide their adoption decisions.

Generally, innovators and early adopters have higher levels of education, are younger, more actively seek information, have higher social status, and have greater income than late or nonadopters. Innovators and early adopters have large interpersonal networks and possess a less “pessimistic” attitude than late or nonadopters.

Understanding the adoption process among innovators and early adopters is important because of their influence on the other members of the social system who typically seek out these peers (opinion leaders) in order to gain information rather than relying on technical data about the innovation (Rogers, 2003).

Social System Characteristics

A social system is defined as “a set of interrelated units that are engaged in joint problem solving to accomplish a common goal” where each social system (i.e., stakeholder groups, communities, etcetera) has distinctive norms and structures that can lead either to facilitate or discourage adoption (Rogers, 2003). Westley et al. (2002) describes social systems “as any group of people who interact long enough to create a shared set of understandings, norms, or routines to integrate action, and established
patterns of dominance and resource allocation.” Like most organizations, social systems are dynamic and generative, constantly adjusting to new conditions and, thus, it is difficult to change any one part without affecting change throughout the entire system. Social norms provide structure and have significant influence over the adoption decisions of individuals and/or social groups. This may be especially true in agricultural centered social systems where community demands and economic constraints can preclude innovation adoption despite an individual’s desire to adopt (Hooks et al., 1983; Saltiel et al., 1994) and because potential adopters do not have complete control over the adoption decision (Hooks et al., 1983; Nowak, 1992).

Adoption and Agricultural Conservation Practices

In agricultural systems, producers experience high levels of uncertainty due to economic, institutional, social, and environmental factors. High competition, product price instability, and low returns to investment are normal characteristics of the agricultural market and contribute to these feelings of uncertainty (Workman et al., 1972; Kearl, 1975; Buttel and Swanson, 1986; Workman and Evans, 1993). When producers are faced with the decision to adopt conservation practices, they must commonly decide between improving and protecting environmental quality versus maintaining profitability of their farm. By and large, the decision to survive economically is made (Swanson et al., 1986; Saltiel et al., 1994) whereas adoption of conservation practices is discouraged because “returns to investment in conservation are [typically] low and usually not realized for years” (Swanson et al., 1986).
The traditional diffusion model assumes that potential increased profitability to the individual is an adequate incentive to adopt new technologies. However, adoption of resource conservation practices more often benefits the whole of society, leaving individual interests as secondary to societal goals (Pampel and van Es, 1977; Fliegel and van Es, 1983). Increased societal concern for potential environmental impairments due to agricultural production has led to demands for more conservation-minded and sustainable agricultural practices (Saltiel et al., 1994). Expectation by members of the greater social unit becomes problematic if they believe or insist on farmers assuming a stewardship obligation. However, farmers cannot be expected to voluntarily bear the entire burden of investing in and implementing conservation practices, especially when faced with the real uncertainties discussed above (Buttel and Swanson, 1986) or when the cost of implementation conflicts with societal demands for inexpensive foods coming from a highly productive farm industry (Swanson et al., 1986).

In other research, factors other than economic issues have been found to influence decisions to adopt conservation practices. For instance, Nowak and Korsching (1983) found that when a strong attachment to traditional farming methods exists, farmers are unlikely to implement best management practices, which are considered innovations, even if economic incentives were offered to cost-share the initial costs of implementation. Their findings also indicated that many farmers did not have the managerial skills, additional capital, or the knowledge required to implement and then sustain the new practices (Nowak and Korsching, 1983).

To corroborate this position, a study of Iowa farmers revealed that farmers with larger operations, because they had more money to invest and better managerial skills,
were more likely to adopt and use conservation tillage technologies (Bultena and Hoiberg, 1983). They were also younger, more educated, more familiar with newer practices, and more likely to accept the risk associated with innovation adoption. However, the operator’s perception of what others would think (responses) about the innovation was the factor having the single greatest effect on adoption decisions. In this study, conservation tillage is a highly visible modification to the farm, and the response of neighbors and friends to the innovation appeared to be an important determinant of adoption decisions and exemplifies the powerful influence of the social system and local social norms.

“Systems-Context” Perspective

This study was based on a general systems perspective with particular attention to the context in which decisions are made. Simply stated, a system is a collection or network of variables which have external causal relationships to one another, and perhaps internal influence on itself (Dörner, 1996). Examining an issue from a systems perspective means identifying and recognizing how the many different variables may have exogenous and endogenous effects on each other, the system, and feedback onto themselves. Interrelationships of variables may be categorically grouped as positive feedback, negative feedback, buffering, critical variables, and indicators variables (Dörner, 1996); whereas feedback is considered a form of communication between variables which ultimately results in causation of an effect. Positive feedback indicates that an increase or decrease in a particular variable will result in a corresponding increase or decline in that variable and tends to weaken the stability of the system, e.g., single
species populations. Negative feedback is described as opposite causation or what one would experience when an increase in one variable produces an opposite effect (decrease) in another and vice versa. This, in effect, helps to stabilize the system by returning the system to a state of equilibrium; e.g., a thermostat is a technological example of a variable communicating negative feedback (Dörner, 1996).

Buffering in a system implies that many variables regulate feedback or reaction of a system to an effect; thus, if a system has many variables involved in feedback mechanisms, it is considered “well-buffered.” A poorly buffered system would be one that did not trend toward equilibrium or one in which positive feedback was strong. Critical variables are those that interact or communicate reciprocally with many variables in the system. These are key variables; if they are altered, many variables are affected and the system as a whole is significantly influenced. Indicator variables are, on the other hand, influenced by many variables in the system but have little influence themselves on variables or the system as a whole (Dörner, 1996). However, indicator variables can provide significant clues as to the overall status of the system under consideration, e.g., the Northwestern spotted owl (*Strix occidentalis*) as an indicator of old-growth forest ecosystem health.

Ecosystem studies belong to a broad division of the field of ecology and can be described as differentiating the whole of the environment into discrete units of organization, (i.e., from the molecular level to the community level). These discrete units can be further arranged into a discernable hierarchical organization providing a conceptual structure of discreet levels or domains and variables operating within the system. Ecosystems are composed of both biotic organisms and abiotic environments that
“are inseparably interrelated and interact upon each other” (Odum, 1971; Odum, 1975). Thus, an ecosystem is defined as “any unit that includes all [biotic] organisms in a given area interacting with the physical [abiotic] environment so that a flow of energy leads to clearly defined trophic structures, biotic diversity, and material cycles” to form a stable, functional unit of nature (Odum, 1971; Odum, 1975). People and their behaviors are considered herein as integral to ecosystems or watersheds, not apart from it.

When examining social, economic, and biophysical systems, operating across multiple spatiotemporal scales, the task of uncovering specific interactions within and between (sub)systems may seem overwhelming. However, hierarchy theory provides a framework for segregating systems into discernable levels or domains so that observation across (sub)systems over multiple spatiotemporal scales is facilitated. Organization within hierarchical systems results from differences in rates of processing or communication between the various levels of the system (Simon, 1973; Allen and Starr, 1982; O’Neill et al., 1986). Conceptually, a hierarchical system is composed of multiple levels ranging from higher large and slow (constraining) levels to lower levels, which are small and fast (catalytic); higher levels in the system provide the “environment” in which smaller, faster levels operate (Allen and Starr, 1982). In effect, rates of process are constrained by larger, slower (sub)systems. Common characteristics are identified and used to define levels of organization and to set one level apart from the levels above and below it. This delineation is necessary so that observation may occur at three levels concurrently, whereas each level is dynamically controlled by the activities of the levels directly above and below it. Higher levels impose constraints such as climate or
precipitation rates, whereas lower levels provide further constraints such as cropping effects on soil nutrients and vegetation.

Individual domains within the hierarchy are at once whole entities in and of themselves and also comprise a part of a greater ecosystem (sensu “holon” as coined by Koestler, 1967). In short, a system is the integration of all its parts; a holon functions as self-regulating autonomous entities and is part of the greater system(s). A holon’s position in a hierarchy is determined by “patterns of constraint” imposed by other holons in the system (Allen and Starr, 1982). Transfer of energy or materials between levels is termed communication and implies connectedness between levels and variables within systems (Allen and Starr, 1982). Hierarchies are thus partly ordered sets of (sub)systems having nonlinear and asymmetric interactions, resulting in the sum of variations of the whole being less than the sum of variations of all its parts.

Levels of organization are essentially subsystems of the whole, semi-autonomous levels of structure and processes produced by interactions among variables occurring at the same speed (Simon, 1973; Allen and Starr, 1982; O’Neill et al., 1986; Allen and Hoekstra, 1992; Holling, 2001; Holling et al., 2002). Hierarchies are transitory in nature where nested levels form mutually reinforcing relationships and are maintained by changing processes across multiple scales. Driving forces or variables influence the rates of processes that determine flows of matter and energy among all levels and components of the ecosystem. Energy flow may lead to organization (accumulation, decreased entropy) or to destruction (transfer to another level, increased entropy), resulting in emergence of new properties within systems.
From this conceptualization, nested and nonnested (sub)systems may exist. Nested hierarchies are those where the higher level unit(s) contain and simultaneously are composed of all lower levels (Koestler, 1967; Allen and Starr, 1982). Levels are described as a form of taxonomic grouping where the higher unit is the sum of all lower level units and are well-suited to a reductionist model of scientific analysis. A simple example of a linear hierarchy is the Russian “Matroyshka” nested doll (Figure 1.2). When one opens the largest, first doll, another is contained within. Open the next and another smaller one appears, and so on until the last doll is too small to contain another. It is important to note that the concept of hierarchy within ecosystems is not meant to imply top-down control, but rather the idea is used to describe the exchange of information (i.e., energy, matter, catalysts, and ideas) across multiple levels within the greater (sub)system. Variables operating at similar levels of organization can be grouped into classes or levels by the rate in which specified properties are being processed. Levels are relatively isolated from those above (superior) and below (inferior); higher levels are relatively larger and slower, seemingly constant compared to the lower levels in question, whereas lower levels are seen as being smaller and faster, e.g., background noise.

However, hierarchies are rarely linear. Most may be conceived as being dendritic, tree-like structures with each level divided into smaller and smaller (sub)systems, or branches, down to their basic components (Figure 1.3 – example of a non-linear dendritic hierarchy). Nonnested hierarchies can be described as relaxing the general requirement of constraint; higher levels are not wholly composed of all lower levels, nor are lower levels necessarily constrained by higher levels. Individual units of the hierarchy are considered to be quasi-independent (sub)systems within a hierarchy (Koestler, 1967;
Figure 1.2. Generalized linear hierarchical structure.
Figure 1.3. Example of nonlinear dendritic hierarchy.
Allen and Starr, 1982). Non-nested hierarchies lend themselves to explaining “why” a system operates rather than just “how” it operates (Koestler, 1967; Allen and Starr, 1982). Social systems are an example of non-nested hierarchies. For example, in a military (or corporate) command, the commanding officer is clearly in control of the greater system; however, she or he is not constrained by, nor composed of, all lower level officers within the system. The highest-level officer is not derivable from the sum of activities of lower level subordinates in their command. In other words, emergent properties expressed by the highest-level officer are not determined by properties of lower level officers within the organization. If this were so, the “why” would be lost under the immensity of noise generated by focusing on the “how” (i.e., each individual within the command) of the system (Allen and Starr, 1982). This is not to say, however, that the behavior of the highest-level officer is not influenced by the behavior of subordinates.

Social systems grow from the interactions of people over sufficient time and space to develop shared sets of norms, routines, and understanding. They result from integration and adaptation to the conditions in which people coexist at multiple spatial and temporal scales. Resultant patterns of behavior, dominance and submission, and the allocation of resources thus are established by discreet levels of organization or hierarchy which may be made up of units as small as individuals or as large as groups of individuals such as towns, states, or nations. This ability to define and communicate throughout the hierarchical system provides a framework to adapt and prosper as new conditions are presented.
Through language formation and usage, concepts of “power,” “authority,” and “legitimacy” can be defined and values are communicated so that order (conformity) is endorsed. Moreover, the ability to create symbols and construct meaning combine to form the basis for social values and norms, and the context for an individual’s perception of the world in which they live, i.e., one’s own reality. Four elements of symbol creation are important for understanding the context of how social systems interact with ecological systems. First, people are able to make sense of things to invent and reinvent the world they live in. This implies the ability to impose value on natural systems, which may lead to natural systems behaving differently when outside of man’s influence. A powerful example is that of the garden, where people shape the land to conform to their particular values or norms. Second is the ability of man to reflect and then externalize thoughts to create another reality within the space of the garden from what already existed. This “created” reality is easily traversed and reconfigured when deemed necessary; i.e., self-organization. Amalgamation of different values and traditions into a culture can result in rapid change that may be permanent or reversible, depending on the cultural memory of the time. Third, people within social systems reflect on their world both forwards and backwards, providing the means to generate expectation and then to manipulate their environment to satisfy those expectations. These actions may be logical and productive or they may turn out to have negative influences or impacts. Finally, externalization of human values onto ecological systems can alter the course of natural systems dynamics. Spatiotemporal scales can become highly altered as a result of man’s ability to explore and manipulate a variety of environmental niches. This can lead to the creation of greater complexity of both social and ecological systems and may have
detrimental (or beneficial) effects on long-term sustainability of ecosystems (Holling, 2001; Holling et. al., 2002).

In the study of systems, emphasis is given to the observer so that the level of observation is defined by the question(s) being asked. This limits the observers’ scale of perception and controls the level of analysis that is possible (Simon, 1973; Allen and Starr, 1982; O’Neill et al., 1986; Allen and Hoekstra, 1992; Holling et al., 2002). By limiting the focal unit to specific levels within the hierarchy, the observer is able to “insert” themselves into any level of a system and to set any criteria for observation. This simplifies examination and understanding of complex behaviors by applying appropriate spatiotemporal scales. The observer is then free to determine what they will not study, thereby reducing the degree of external “noise” so that relatively simple systems may be isolated and behavior identified, e.g., single level, single phenomena (Simon, 1973; Allen and Starr, 1982; O’Neill et al., 1986).

Understanding the contextual settings of the individual or social group within a system is crucial for discovery of viable explanations that describes the behavior(s) of the system. In the examination of context, two factors should be considered when developing a “context map” sensu Honadle (1999) or conceptual picture of the system and the variables therein (Kane and Trochim, 2009). First, the “problem context” or relationship between the system and the threat to the resources of concern should be considered. The second factor in developing a context map is the “social context” at work within the system. To gain the fullest understanding of stakeholder behavior, it is imperative to know, to the greatest extent possible, the conditions in which the stakeholder operates and to be cognizant of the key variables acting upon the stakeholder within the system.
When defining the problem context, an understanding of the biophysical conditions, possible constraints, options available to the stakeholder, actions that do and do not work within the system, and the level of skills possessed by the people or stakeholder is necessary. Understanding the particular social conditions that define the problem is also critical. To accomplish this, four dimensions of the problem context setting should be examined (Honadle, 1999). First, the degree of connectivity (discreteness) between variables and the stakeholder needs to be unveiled to the best possible extent. Having a grasp of what the key factors are and how they are interrelated is instrumental to developing understanding of the issues at hand. Second, the rate of progression of the problem, or temporal scale(s) in which the key variables work (i.e., seasonal patterns: are they cyclical, linear, or nonlinear in nature, are there obvious thresholds to consider, etcetera), help to delineate patterns within the system. Third, determination of whether the problem is spatially or temporally static or dynamic is important; i.e., is the problem fixed to a specific location or does it migrate through the system, is it a perennial or ephemeral problem, etcetera. Last, one must establish what boundaries exist and where those boundaries are located in order to fully account for the extent and magnitude of the problem, therefore sociopolitical, natural, cultural, and perceptual boundaries, to name a few, are examined.

Insight into system hierarchies and the dynamics of a system provides an important mechanism for gaining a better perspective of how people perceive their world. With this increased awareness, better understanding and insights into the realities, and therefore the context, in which people interact with variables and adapt to change
(adaptive learning) may be achieved so that more effective watershed management policy and programs may be identified and implemented.

Structure of Dissertation

This study was conducted in the Njoro watershed (Njoro) of Kenya, East Africa to evaluate the level of occurrence of SWCPs on smallhold farms and to identify constraints to adoption experienced by farmers. Key informant interviews, participant observation, household surveys, and review of secondary information were undertaken to describe socioeconomic and biophysical aspects of the watershed. The Njoro was chosen because it is a microcosm of the land and water management problems facing much of Kenya today. Water resources have been impaired by sedimentation, nonpoint source pollution, loss of riparian habitat, and input of animal waste in many reaches of the river; over 55 percent of households utilize water directly from the Njoro for domestic consumption, and many more utilize the river for watering their livestock. Other sources of water are developed groundwater supplies, surface water (springs) diversions, and surface supplies from outside the watershed. Additionally, wastewater discharges to surface waters are increasingly common as the populations of small-scale farms, peri-urban,¹ and urban areas increase. The matrix of water users includes rural, peri-urban and urban communities, private and industrial users, public water suppliers, pastoralists, small- to large-scale agricultural producers, and government agencies including the Kenya Wildlife Service at Lake Nakuru National Park (LNNP).

¹ Peri-urban is a combination of the words peripherally and urban; generally related to the urban areas that lie on the outer edges of the city. The characteristics tend to be part urban and part rural, and often the areas where squatters tend to settle. Definition is adopted from The World Bank Group (1999-2001), glossary of terms which can be found at http://web.mit.edu/urbanupgrading/upgrading/resources/glossary.html.
My aim is to improve our understanding of constraining factors on small-hold farmers that help to explain adoption of SWCPs; then, to link these findings to other research being conducted concurrently on the biophysical characteristics of the watershed (e.g., soil erosion, loss of riparian zone integrity, impacts to water resources). This information may then be used to better manage watershed resources dominated by small-hold farm activities and improve the quality of information provided to decision-makers who are responsible for producing effective policy.

Chapter 2 presents an overview of the biophysical and demographic settings of the Njoro and a concise history of the area. Description of the watershed environment will be provided in Chapter 3 to provide a baseline benchmark perspective of the socioeconomic and biophysical conditions in which smallholders in the River Njoro (Njoro) watershed of Kenya live and operate. Chapter 4 quantitatively examines factors influencing the adoption behavior of small-scale farmers in the Njoro watershed. Fourteen soil and water conservation practices are examined to quantify and evaluate small-scale farmers on-the-ground adoption of conservation practices. Chapter 5 provides a synthesis of the qualitative evaluation of explanatory factors influencing adoption of conservation practices and farmers’ perceptions of biophysical conditions found in the watershed. This discussion will be presented as an interpretation of how these factors relate to impairment of water resources. Finally, Chapter 6 provides the summary of findings and conclusions from this research and implications for future research.
CHAPTER 2

NJORO WATERSHED AND SUSTAINABLE MANAGEMENT OF RURAL WATERSHEDS (SUMAWA) PROJECT

Introduction

This research is focused on discovery of explanatory factors that influence adoption of soil and water conservation practices (SWCPs) by small-scale farmers. Ultimately, this information is intended to assist with the evaluation of conditions effecting surface water quality so that better policy may be developed and more successful watershed management programs may be devised. The Sustainable Management of Rural Watersheds (SUMAWA) Collaborative Research and Support Program, under a U.S. Agency for International Development (USAID) grant PCE-G-00-98-00036-00, supported this research. The primary function of SUMAWA was to implement a crosscutting research program to facilitate discovery of critical factors associated with the impairment of water resources in the River Njoro watershed (Njoro) of Kenya’s Rift Valley. Please see Figure 2.1.

SUMAWA was a multidisciplinary research effort focusing on a wide range of biophysical and human-related factors governing watershed processes. The Njoro is considered a critical watershed that is undergoing considerable population growth and land cover change. This has resulted in negative impacts on water resources, human health, rural livelihoods, and local economies. The primary SUMAWA project goal is to develop knowledge so that local stakeholder engagement and applied research are
Figure 2.1. River Njoro location map.
coordinated to result in improved watershed conditions (ecosystems health).

As an experimental watershed, research efforts were directed toward better understanding variables considered to be driving conditions throughout the basin; i.e., ecological and hydrological dynamics (land cover change, water resources), and the social metrics (economic, institutions, and human health). The majority of these efforts have been directed toward the uplands portion of the watershed where livestock and small-hold agriculture are significant components. This process included both high-quality academic research and stakeholder involvement to yield long-term solutions.

SUMAWA’s research team was composed of scientists from two Kenyan academic institutions (Moi University and Egerton University), two Kenyan governmental organizations (Kenya Fisheries Department and Kenya Wildlife Service), and three U.S. academic institutions (University of Wyoming, University of California-Davis, and Utah State University). The project established a multidisciplinary team that was delineated into four components: watershed hydrology, ecology, stakeholder involvement, and applied economics. Numerous studies were undertaken to provide the basic information for a range of simulation models for this watershed system including:

- Participatory rural appraisal of communities within the watershed
- Analysis of short- and long-term climate and runoff records to identify dynamic interactions related to land cover change
- Generation of land cover maps to quantify land cover change spatiotemporally for the watershed and surrounding region over the past 31 years (eight images)
- Characterization of the soils within the watershed
• Building a geographic information system (GIS) database to inform project teams and provide spatial data for simulation models
• Parameterization of several spatially explicit simulation models to examine the hydrologic response to land cover change
• Assessing water infrastructure and distribution networks
• Isolation of ecological indicators related to land cover change such as habitat fragmentation and biodiversity
• Evaluation of grazing and agricultural farming practices.

The information developed from this project was intended to inform decision-makers for developing appropriate policy for more effective land management.

Site Description

Biophysical Setting

The Njoro is part of the greater Mau Forest Complex (4,000 km²), the largest remaining forest matrix in Kenya. This forest complex is considered one of Kenya’s key “water towers,” which serves as a national benchmark for monitoring the critical processes of rainwater catchment and distribution in this semi-arid country (Kenya Forests Working Group, 2006). The river Njoro originates at over 3,200 meters above sea level (masl) from the Mau Escarpment on the western slopes of the Great Rift Valley near the town of Mau Narok. From the escarpment, it descends through indigenous and plantation forested landscapes, lands recently converted to small-scale agriculture, villages and settlements and peri-urban communities before emptying into Lake Nakuru,
an internationally recognized Ramsar\textsuperscript{2} site on the floor of the Great Rift Valley. Lake Nakuru is an important wildlife sanctuary and tourist destination that provides a source of income for the local and national economies (Figure 2.2).

The upper portions of the Njoro watershed encompass a mosaic of vegetation types including open meadows, mixed forests, and bamboo (\textit{Arundinaria alpina}) thickets. These high-elevation habitats have been described as “afromontane” and “archipelago-like” (Obare and Wangwe, 2004). Remnants of colonial-period plantation forests of cypress (\textit{Taxodium sp.}), sheoak (\textit{Allocasuarina sp.}), and eucalyptus (\textit{Eucalyptus sp.}) are also evident in the middle portions of the watershed. The extent and rate of vegetation cover change in the upper portions of the Njoro can be seen in unsupervised classification maps of land cover from 1986 to 2003 (Figure 2.3, Baldyga \textit{et al.}, 2004).

This small watershed encompasses approximately 280 km\textsuperscript{2}; the study area was defined by the area from the mouth of the river upslope to where small-scale farms interface with the Mau forest. The lower portion of the study area consists of small- to large-scale farms from the village of Nessuit downstream to the boundary of LNNP, whereas the upper half of the study area extends from the community of Nessuit and consists of newly established small-scale subsistence farms. The Njoro is a vital source of fresh water for nearly 250,000 people, either through direct extraction from the river or indirectly via extraction of near surface groundwater resources.

\textsuperscript{2} The Ramsar List was established in response to Article 2.1 of the Convention on Wetlands (Ramsar, Iran, 1971). Lake Nakuru was designated as a protected site in May 1990.
Figure 2.2. Njoro Watershed locations map.\textsuperscript{3}

\textsuperscript{3} Map compiled by Huckett from data provided by Sustainable Management of Rural Watersheds (SUMAWA) project. Miller, S.N. and W.A. Shivoga, Principle Investigators. A USAID GL-CRSP funded project (grant PCE-G-00-98-00036-00).
Figure 2.3. Land cover in the River Njoro watershed.¹

¹ Source: Data is derived from Baldyga, T.J., S.N. Miller, W. Shivoga, M. Gichaba. 2004, and annual reports of the Sustainable Management of Rural Watersheds (SUMAWA 2005); a USAID GL-CRSP funded project.
The Njoro is in a geologically active region of the Great Rift Valley, underlain by bedrock materials comprised mainly of volcanic derived materials. The watershed is predominantly confined by shallow bedrock throughout the study area; however, this bedrock exhibits highly fractured conditions, both laterally and perpendicular to the valley floor. As a result, inflow/outflow of water resources of the river is generally restricted to shallow local aquifers and hyporheic recharge zones. Coupled to a shallow soil overburden, water retention throughout the study area appears to be low, which may explain [partially] why the river tends to be dried out during the dry season in several reaches throughout its length (Chemelil, 1995; SAPS-JBIC, 2002).

Historically, the river becomes influent as it approaches its terminus near the LNNP boundary and is generally thought to lose much of its flow to the fractured bedrock and porous substrate materials of the Rift Valley floor, thus contributing to water tables around the lake (Jenkins et al., 2004). Concurrently, upper reaches of the river have run dry, and boreholes have failed in recent years, causing alarm and periodic water rationing (Jenkins et al., 2004). The volcanically derived nature of the geologic formations in the Rift Valley, coupled with the paucity of available geologic information (Chemelil, 1995; Jenkins et al., 2004), makes it difficult to establish definitive groundwater flow patterns, stream-aquifer interactions, and groundwater discharge/recharge zones.

Derived from Tertiary age lavas, the soils in the Njoro watershed (Figure 2.4) are classified as Mollic Andisols and are generally considered fertile (Kenya National Agricultural Laboratories, 1980), especially when compared to soils found elsewhere in Kenya. Long-term mean annual rainfall varies from less than 800 mm at LNNP to greater
Figure 2.4. Generalized soils map of the Njoro watershed.\textsuperscript{5}

\textsuperscript{5} Data Source: Sustainable Management of Rural Watersheds (SUMAWA) project. Miller, S.N. and W.A. Shivoga, Principal Investigators. A USAID GL-CRSP funded project.
than or equal to 1,600 mm in the uppermost portions of the catchment. Precipitation patterns are trimodal with peaks occurring in April (highest), August (second), and November (third); the dry season is generally from January to March (Chemelil, 1995; SAPS-JBIC, 2002). Mean monthly air temperature varies between 13.5° C in August to 18.5° C in March. Estimates indicate that the Njoro supplies approximately 39 percent of surface inflow to Lake Nakuru (Chemelil, 1995; SAPS-JBIC, 2002). Potential maximum evapotranspiration (ETmax) over the entire Njoro watershed is estimated at 1,150 mm/year (evaporation pan readings, Egerton University, 1965-1993) and peaks in March (Jenkins et al., 2004). With annual valley ETmax exceeding valley rainfall in the semi-arid Rift Valley, upper catchments of watersheds such as the Njoro provide a critical net rainfall capture zone for water resources.

Site History

During colonial times, the British Forest Department developed pioneering agroforestry methods to facilitate the establishment of forest plantations on clear-cut areas to offset the effects of conversion of indigenous forests and to develop managed softwood plantations of exotic commercially valuable trees for income generation (Loogie and Dyson, 1962). Colonial rules allowed Africans, who entered into contract with the colonial Forest Department, to temporarily settle and cultivate up to two hectares of land yearly, within forest plantations, in exchange for nine months of their labor with the forest department (Loogie and Dyson, 1962). Termed the “Tyunga” or “Shamba” systems, laborers cultivated the interstitial spaces between tree seedlings, growing mainly maize and beans for sustenance during the laborers’ “off” months.
As part of their rule, the British enforced policies prohibiting the felling of trees in riparian areas by establishing large “no-cut” zones extending perpendicularly some distance from the stream in an effort to protect water resources. Determination of the exact distance was problematic, however, as official records varied between the various regulatory agencies (from 10 m to 100 m). This policy was apparently an outgrowth of their awareness that riparian vegetation provided ecological services including regulation of sedimentation, stream flow, and general watershed hydrology (Carroll, 1947).

Historically, land users in the Nakuru District of the Njoro watershed were the pastoral Maasai, Samburu, Kalenjin, Ogiek, and Turkana peoples. Land ownership was not manifested in the western concept of holding title deed to land, but rather was established by traditions or customary “rights of use” according to various customs of the predominant ethnic groups. However, colonial rule had a significant influence on the demographics of the area by facilitating an influx of farmers from the Kikuyu, Kisii, Luhya, and Luo ethnic communities (Bates, 1989; Ahluwalia, 1996). At the district level, estimates of the historic matrix of inhabitants indicated that the population was about 60 percent Kikuyu, 15 percent Kalenjin, with the balance being made up of all other tribes (Daniels and Bassett, 2002). During the colonial period, the provincial government instituted policies that prohibited priority ownership or use of land by Africans (Bates, 1989; Ahluwalia, 1996; Daniels and Bassett, 2002). In essence, provincial law dictated that lands would be reserved for the priority use of white settlers. This, of course, included all prime farmlands, grasslands, and timberlands where commodities could be profitably produced for export (Bates, 1989; Ahluwalia, 1996). This forced displacement of the more sedentary African farmers onto traditionally pastoral lands and onto marginal
lands in the neighboring districts of Nyanza, Central, and Western Provinces during the colonial and postcolonial periods. As a result, large-scale overpopulation and environmental stress on already marginal lands ensued (Daniels and Bassett, 2002).

In the 1960s, colonial rule in Kenya ended following more than a decade of civil unrest during the Mau-Mau Rebellion. Jomo Kenyatta, a Kikuyu and then-head of the Kenya African National Union (KANU) party, was elected Prime Minister in May 1963. After the Republic of Kenya gained independence in December 1963, Kenyatta was declared its first president (Berman, 1990). New policies allowing priority ownership permitted Africans to purchase land through state-run land collectives and land disbursement and settlement schemes. Due to intense population pressures in neighboring districts, and backed by strong allegiances of the new president and his Kikuyu-dominated government, the Kikuyu were keen to settle these newly available prime farmlands in Nakuru District. As a result, the most favorable lands were preferentially sold and distributed to Kikuyu throughout the district (Daniels and Bassett, 2002).

After independence, relative calm prevailed until the early 1990s. Kenyatta died in office in 1978, and power passed to his Vice-President, Daniel arap Moi. Moi, who was Kalenjin and from the central Rift Valley, effectively took control of KANU despite his status as an ethnic minority. Then, beginning in 1991, the government began a program of land resettlement that has been characterized as politically motivated (Kahl, 1998; Daniels and Bassett, 2002; Sang, 2002). These actions ushered in a wave of rural ethnic violence in large portions of the Rift Valley, Nyanza, and Western Provinces in late 1991. By the end of 1993, at least 1,500 people had been killed and more than 300,000 were internally displaced (Daniels and Bassett, 2002). Kahl (1998) reported that
available evidence indicated that high-ranking government officials, including the vice president, minister of local government, Members of Parliament (MPs), other close advisers to the president, as well as local elites, were all involved. These factions wanted President Moi and his fragile coalition of minority groups to remain in power by boosting voting roles where political opposition dominated. To accomplish this, state elites capitalized on and manipulated a set of demographically, environmentally, and historically rooted land grievances. These provided both incentives and opportunities for state exploitation through instigation of ethnic conflict involving pastoral groups (the Kalenjin, Maasai, Samburu, and Turkana) and farmer groups (the Kikuyu, Kisii, Luhya, and Luo) throughout the region (Kahl, 1998).

Due to these many difficulties, active management of timber plantations in the Mau Forest Complex and Njoro watershed experienced a virtual hiatus from 1963 until the 1980s (Sang, 2002). Tribal clashes associated with the 1991-92 and 1997 presidential elections further facilitated encroachment of landless people onto public forestlands of the Rift Valley, Nyanza, and Western Provinces in general, and in Nakuru and Molo Districts in particular. During both of these periods, Nakuru District and the Njoro watershed became a center of ethnic violence, with the Kikuyu ethnic group often being the focus of expulsions. An estimated 40,000 persons were displaced from their farmland during the 1997-98 clashes alone (Sang, 2002). These actions resulted in an additional wave of Kalenjin people being settled on newly de-gazetted\textsuperscript{6} five-acre tracts in the Njoro watershed (Sang, 2002). Resident Ogiek peoples were also given the opportunity to

\textsuperscript{6} Lands removed from government roles or taken from public ownership and made available for private sale and/or settlement.
obtain five-acre parcels in the area, albeit in different locations and at lower elevations than their original forested “homelands” (Sang, 2002).

This situation pitted the newly settled Kalenjin and other aligned ethnic groups against the primarily farming communities of Kikuyu, Luo, and Luhyia in violent clashes. Extensive property damage and loss of life occurred throughout the region with as many as 300,000 people being displaced (Human Rights Watch, 1993; Human Rights Watch, 1998). Illegal acquisition of lands was commonplace as Kalenjin attackers seized land away from those landowners who had fled the violence (Daniels and Bassett, 2002). Reports of politicians’ illegal acquisition and allocation of government lands into private ownership were commonplace (Republic of Kenya, 1992; Republic of Kenya, 2004).

Unfortunately, ethnic tensions continue, and the potential for clashes remains part of daily life for people in the Njoro. As a recent example, in early 2006 skirmishes erupted over a land-ownership dispute between the Kikuyu and Kalenjin communities living in a settlement scheme located at Likia community, just south of Egerton University. Family and sympathetic supporters of the communities came from as far away as Molo town (30 km), Nakuru Town (35 km), and Mau-Narok (45 km) to join in the clash. Officials reported that over 20 people were killed, 150 houses torched, and over 200 injured (Kenya Red Cross Society, 2006; Human Rights Watch, 1998). Then, in September and October of 2006, clashes again erupted in the Sigotek – Teret settlement just outside of Njoro town, as members of the Kipsigis (a sub-tribe of Kalenjin) and the Ogiek communities clashed over the alleged rustling of a few sheep. Reports indicated that more than 450 homes were burned, dozens of people injured, and up to six people killed during the incident (Kenya Red Cross Society, 2006; IRIN News, 2007). Again, in
2007 and 2008, after the deeply flawed presidential elections, history repeated itself when thousands of young men swept the countryside, burning homes and attacking members of rival ethnic groups. Kenya was drug into chaos once again when politicians from all sides gave speeches that stoked long-standing hatred among ethnic groups and leaflets calling for ethnic killings mysteriously appeared before the vote. Making matters worse were local tribal chiefs who held meetings to plot attacks on rivals. In the worst events, up to 50 women and children seeking sanctuary in a church were burned alive (the East African Standard, 2008). Also, the East African Standard (2008) reported that “at least 16 people - most of them women and children - were burnt to death in a house torched by attackers in Naivasha” and that bodies were strewn in open fields, people had been hacked to death while another was stoned to death (The East African Standard, 2008). In other instances people were pulled from their cars and off public busses, then hacked to death because of their ethnicity or political affiliation (The East African Standard, 2008). These problems start and end with land.

Current Resource Management, Users, and Infrastructure

As early as 1972, watershed conservation efforts were underway in the Central Rift Valley in watersheds around the City of Nakuru. The World Wildlife Fund (WWF) had been involved with expanding the resource base of LNNP through land purchase and wildlife conservation efforts (Daniels and Basset, 2002). In 1988, the Overseas Development Agency of the United Kingdom, in collaboration with WWF, created and implemented the Lake Nakuru Conservation and Development Project. This project was intended to create public awareness of the importance of the LNNP and associated
natural resources and to build capacity in the local population through public outreach and education about the benefits of environmental stewardship. This also provided opportunities for conservation and development activities by local groups (Daniels and Basset, 2002).

One broad theme of this project was to develop awareness in the local population that land uses in the watershed have an effect on the ecological condition of the lake. These activities aimed to alleviate negative impacts to the lake by focusing on soil and water conservation and reforestation efforts in surrounding sub-watersheds. In 1988, four specific environmental programs (education, assessment, planning, and conservation) were established to address these goals via capacity building and awareness programs. The conservation program in particular provided educational opportunities to local farmers in sustainable agricultural practices, soil terrace building, agroforestry, and tree nursery management (Byers, 1996; Daniels and Basset, 2002).

More recently, a rapidly expanding peri-urban and urban population, centered on Egerton University campus, Njoro Township, Ngata Township, and Nakuru Municipality, make up the bulk of the population in the Njoro. As the fourth largest city in Kenya, Nakuru Municipality is the most urbanized town in the watershed with expanding peri-urban communities, slum settlements, and extensive industrial and commercial activity (Sang, 2002). Contemporary users include nomadic pastoralists (Maasai), dispersed small- to large-scale farms (some with irrigation systems), urban and peri-urban communities, small- to medium-scale private industrial facilities, large institutions, and public agencies such as the Kenya Ministry of Water and the Kenya Wildlife Service at LNNP. The majority of rural and peri-urban households obtain their
water directly from the river for domestic and livestock needs. Other sources of water include local groundwater and surface waters (springs), imported ground and surface water supplies from outside the watershed, and household rainwater collection for domestic use. Developed groundwater supplies, surface water diversions, and wastewater discharges are becoming increasingly common in peri-urban areas as small-scale commercial, industrial, and agro-processing activities intensify and water vendors becomes more common.

Basic infrastructure for transportation, water, sewage, and public services is minimal at best; for instance, one paved road links Nakuru Town to Egerton University. Other roads linking one community to another consist of gravel in the lower, better developed portions of the study area and dirt roads/footpaths in the upper portions. Personal transportation is primarily by foot, bicycle, or donkey cart. Other transport includes matatu’s (mini-vans), taxis, or private cars that provide de facto public transportation in the area.

Small-scale agriculture predominates in the study area with more modern large-scale farms scattered throughout the mid- and lower elevations of the study area. In areas upstream of the town of Nessuit, agronomic conditions are generally considered sub-optimal for the current maize/bean dominated agricultural crop production systems due mainly to climatic conditions (Mr. Kiuru, Kenya Ministry of Agriculture, Njoro Extension Service Officer, personal communication).
CHAPTER 3

DESCRIPTION OF THE RIVER NJORO SMALLHOLDER FARMING SYSTEM

Introduction

Water resource problems are problems of people (Satterlund, 1972). They are the focus of most, if not all, watershed management programs. Of equal importance is the conservation of soil resources for maintaining healthy ecosystems for services critical to human well-being. Management of these two resources is vital to human well-being, especially in developing countries where population pressures have forced the poor onto increasingly marginal lands for their sustenance. As populations grow and move onto more and more marginal lands, the need for adequate food supplies has, in many cases, pitted the quest for sustenance against conservation of natural resources. Therefore, contemporary watershed management programs in developing nations need to be more inclusive and should consider features of the biome (flora, fauna, hydrology, and soil resources) and human activities including agriculture (crops and livestock), forestry, road-building, mining, and expansion of community boundaries. Integration of these issues should be the central focus of regional planning activities when considering measures to protect land and water resources and to maintain the capacity of ecosystems to produce goods and services (Brooks et al., 1991).

World food production has increased significantly in the last 40 years, and yet hundreds of millions of people continue to suffer from hunger worldwide (FAO, 2004).
Increased food production is due mainly to development of high-yield varieties of cereal grains and leguminous crops, increased use of commercial fertilizers, and improved irrigation technologies (FAO, 2004). However, these improvements have not been fully employed in sub-Saharan Africa where nearly 95 percent of arable lands rely on rain-fed dry land farming systems to satisfy crop water needs. Even in areas with adequate rainfall, endemic soil fertility levels are often the limiting factor to increasing food crop production (Rockström, 2000), thereby making conservation of existing resources doubly important.

Soil erosion is a natural function on every landscape and is influenced by biophysical features, i.e., soil morphology, slope, wind, water runoff velocity and density, and type of vegetative cover (Brooks et al., 1991; Naiman, 1992; Dunne and Leopold, 1995). “Healthy” ecosystems are important for maintaining soil resources, water quality, watershed storage capacity, and temporal availability of water (Mulholland, 1992). However, anthropogenic activities such as recreation, infrastructure development, and intensified agriculture tend to alter native vegetation cover, which inadvertently disrupts natural hydrological processes, which may accelerate soil erosion by reducing the natural “buffering” or “filtering” capacity of vegetation cover (Brooks et al., 1991; Naiman, 1992). The potential for soil degradation is especially high when marginal lands and riparian zones are converted to agricultural and grazing uses without appropriate soil and water conservation practices (SWCPs) where excessive soil erosion can lead to greatly reduced food production potential (Reij et al., 1986; Reij, 1991).

Moreover, soil erosion can cause significant impairment of surface water resources by loading the hydrologic system with soil sediments via surface runoff. Soil
sediment laden with nutrients, particulate organic matter, and chemical constituents used on land surfaces (i.e., farm chemicals, animal wastes) can have significant harmful effects on streams, rivers, and receiving waters (e.g., lakes and reservoirs) when exports exceed the hydrologic system’s capacity to absorb or utilize these inputs (Mulholland, 1992) (see Appendix A). These conditions are a serious contributing factor to reduced human well-being (Reij et al., 1986; Reij, 1991). Thus, improving our appreciation of the systemic connectivity of upland ecosystems to riverine/riparian ecosystems is vital for developing a more complete understanding of how biophysical conditions influence individual decisions for managing individual farms and the watershed landscapes in which they are located.

River Njoro

Encroachment into forest and rangelands by people in their quest for food and fiber has significantly altered vegetation cover and disrupted watershed hydrologic characteristics throughout Kenya. For example, over 30 percent of Kenyans do not have access to clean water, and nearly 50 percent of the population lives below established poverty levels. This is due, in part, to degradation of soil and water resources (SUMAWA, 2004-05; SUMAWA, 2005-06). The River Njoro (Njoro) watershed, specifically the lands upstream of Njoro Town, has experienced dramatic land use change over the past 15 years. Large areas of this landscape, previously managed by pastoralists, have been converted from forested land and rangelands by more sedentary, small-scale farmers for subsistence agricultural uses.
Concurrently, it has been reported that water resources have been severely impacted in terms of quality and temporal availability. This issue is particularly important because greater than 55 percent of River Njoro watershed households utilize water directly from surface water sources for domestic purposes, agriculture, and livestock watering. Other sources of potable water include rainwater collection, transfers of surface water from outside the watershed, and wastewater discharges from domestic and commercial users (SUMAWA unpublished Annual Report, 2004-05).

Due to the relative instability in socioeconomic, political, and conversion of native lands for commercial and agricultural uses over the past two decades as described in Chapter 2, we anticipated a relatively chaotic socioeconomic situation on these more recently settled lands (since the early 1990s) generally located above the village of Nessuit. This observation was derived from persons familiar with the watershed, information provided by regional experts, and from personal observation.

Objectives

The central objective of this chapter is to establish a baseline benchmark perspective of the socioeconomic and biophysical conditions that smallhold farmers in the River Njoro (Njoro) watershed of Kenya live and operate. Better understanding of these conditions and constraints will provide a foundation or framework for evaluating impoverished smallhold farmers’ SWCP adoption decisions. To this end, an improved perspective will be gained by taking a more holistic approach to understanding the range of factors that influence smallhold farmers’ adoption decisions. This is critical for understanding one’s propensity to adopt SWCPs and for development of more
comprehensive resource management policies. This, in turn, will foster the creation of more effective and sustainable watershed management programs which has many positive ramifications for improving the human condition in impoverished areas.

Methods

Sample Selection

This study focused exclusively on small- (less than 2.0 ha) to medium-scale (2.0 to 20 ha) farms located along a 25 km reach of the River Njoro. The geography of the study area included two large tributary drainages located above Nessuit, the Sigaon and the Luguma, and the main stem of the river downstream to the village of Ngata (Figure 3.1). The target population of approximately 2,500 farms lies within 500 m of either side of the river thalweg⁷, henceforth called riparian farms. Riparian farms were chosen as the focus of the study due to their proximity to the river and the potential for significant impacts to water resources in the Njoro.

A pilot study conducted in the communities of Kaptembwa and Baruti, densely populated agricultural peri-urban communities on the outskirts of Nakuru Municipality, surveyed 10 smallhold farm heads of households (HoHs). These were selected from a group of households nominated by the community chief as representative of the community, to test the efficacy of a household survey instrument as well as to provide an opportunity for enumerator training.

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⁷ The word thalweg is an English word compounded from the German elements Thal, meaning valley, and Weg, meaning way. It was adopted into English usage for use in geography and geomorphology and signifies the deepest continuous line along a valley or watercourse. In hydrology, the thalweg (occasionally called the "valley line") is a line drawn to join the lowest points along the entire length of a streambed or valley in its downward slope, defining its deepest channel. It thus marks the natural direction (the profile) of a watercourse and fastest flow in a stream or river.
Figure 3.1. Geography of the River Njoro study area.  

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8 Data Source: Sustainable Management of Rural Watersheds (SUMAWA) project. Miller, S.N. and W.A. Shivoga, Principle Investigators. A USAID GL-CRSP funded project (grant PCE-G-00-98-00036-00).
Riparian farms occupied lands through the full extent of the study area, from the agricultural lands/forest interface in the middle portion of the watershed downstream to the communities of Ngata, near Nakuru Municipality. The study area was subdivided into a grid of sample cells measuring 100 m x 100 m in size and centered on the river thalweg so that five grid units lay perpendicular to each side of the river and were mapped using ArcGIS version 9.x. for a total of 2,500 grid units. Universal Trans Mercator Units (UTM) values were determined for the center of each grid unit and used to generate 2,500 unique sample cell locations. From these potential sample locations, 250 sampling points were randomly selected, and their location was identified on a map of the study area to guide enumerators in locating individual households for inclusion in the study (Figure 3.2).

Data Collection

Prior to commencing with the household surveys, village elders and chiefs were consulted out of respect so that alienation of the communities could be avoided. The purpose of the research project was explained to them, and I personally requested permission to proceed with this study. After some deliberation, permission was granted, and the elders agreed to spread the word throughout the community so that my research team would be welcomed. By reaching out to the village elders and chiefs, we instilled a sense of trust in my team and this research.

I also requested that the village elders consult and nominate two members of their communities as potential enumerators for this project. Each nominee was provided an orientation to the research program, then interviewed. Four enumerators were hired to conduct the household interviews: two residents from local communities (one each from
Figure 3.2. River Njoro study household sample locations.\footnote{Data Source: Sustainable Management of Rural Watersheds (SUMAWA) project. Miller, S.N. and W.A. Shivoga, Principle Investigators. A USAID GL-CRSP funded project.}
Njoro and Nessuit) and two master’s level students from Egerton University. The second community person was retained as a backup in case the first could not complete the task. The university students were hired specifically to oversee and supervise household interviews as well as assist with data entry and data quality control. Training included instruction on the purpose of the research, the types of questions they could and could not ask, and explanation of the Institutional Review Board (IRB) policies pertaining to research with human subjects. A semi-structured questionnaire, coupled with informal interview techniques (Dillman, 2000; Charmaz, 2002; Johnson, 2002), was utilized to collect household level data (Appendix B). Interviews were conducted primarily in Kiswahili; however, when necessary, a local language or dialect was utilized to facilitate communication. In sum, the enumerator team was able to converse in eight or more different languages or dialects represented in the watershed.

Household surveys were initiated at the uppermost extent (about 2,600 masl) of the study area where agricultural lands interfaced with forested lands. As enumerators proceeded downstream, they used a hand-held GPS unit to locate each randomly selected grid location. Once the selected grid unit was located, enumerators then located the nearest farm dwelling to the designated UTM. This method allowed for random selection of farmers based on spatial orientation and distance from the river since property boundaries and farm sizes are ill defined within the study area. When selection of specific farmers by UTM location was not possible, such as when multiple houses were located within a sample grid unit, a 10-sided die was used to select randomly a household for inclusion in the study.
Once selected, HoHs were apprised of our purpose for being on their lands, provided an explanation of this research, and then asked to participate in the project. Their informed consent was always obtained prior to beginning the survey. Survey questions focused on explanatory factors that might influence farmer’s decisions to adopt or not adopt a specific conservation practice. Answers to questions regarding knowledge of and implementation of the specific practice were recorded using dichotomous (Yes/No), stakeholder narratives, and Likert-scale responses (Likert, 1932).

Data collected included:

1) Age, gender, ethnicity, level of HoH education, illness, perceptions and attitudes toward the environment, ethnicity, background on religious/cultural influences;

2) Agroecological and biophysical factors including soil types, topography and elevation, hill slope, soil morphology, tillage practices, distance to river, sources of water, perceived water quality, and perceived changes to the riparian zone.

3) Farm size, types of crops and livestock, income (farm, off-farm, and total), distance to markets, whether or not all household food needs were met, access to credit, tenure security, access to extension services, and access to labor.

After an approximately 1.5 hour interview, a farm “walk-about” was conducted in the company of the HoH to visually verify biophysical features of the farm and to verify that SWCPs discussed during the interview had been implemented. These “walk-abouts” took on average about 0.5 hours.
Data Analyses

Data were analyzed using S-PLUS v. 6.2 (Insightful Corp., 2003) and R v. 2.5.0 (The R Foundation for Statistical Computing, 2007) statistical software packages. First, descriptive statistics were generated in S-PLUS for all categorical and numeric variables. The data were then delineated by elevation zone and ethnic group; first, because of settlement patterns within the study area which is considered important due to the more recent history of settlement of land in the Njoro since Kenyan independence (Chapter 2); second, due to the variation in biophysical characteristics observed across the study area. The data for all variables were then screened using contingency table analysis and the Chi-squared tests to determine strength of association and statistical independence. Forty-five independent variables (chosen from the household survey, Appendix B) were analyzed and evaluated against each of the 14 benchmark SWCPs and the total number of SWCPs adopted, as a measure of conservation behaviors (Zar, 1999). The Chi-square ($\chi^2$) analytical test was used to assess statistical significance between two or more variables and to select specific explanatory variables for further analysis (Zar, 1999; Ritchie, 2000). The $\chi^2$ analytical test evaluates the relationship of two variables and the frequency of joint occurrences of an attribute of the variables. The relationship between two nominal variables is analyzed by using a cross-tabulation table; this provides the frequencies of joint occurrence of attributes for a single individual (Zar, 1999; Ritchie, 2000). A p-value of 0.25 was used as the benchmark for selection of explanatory variables. They were then screened to make certain that each was a reasonable indicator of SWCP adoption (i.e., did the variable make sense?).
Characteristics of the Household

From the pool of selected grid locations, 225 farm households were located and asked to participate in the survey. Two hundred twenty-two participated — three households refused — giving a nearly 99 percent participation rate. Households in the study area were located across an elevation range of 700 m.

Figures 3.3 and 3.4 illustrate the composition of sampled HoH by ethnicity and the distribution of ethnic groups by elevation, respectively. Overall, the Kalenjin, Ogiek, and Kikuyu dominated the watershed. The Kikuyu were the dominant ethnic group in elevation zones 1 to 4, while the Kalenjin lived predominantly in elevation zones 4 through 7. This concurs with the historical information concerning Kikuyu presence since the time of colonialism and the historic distribution of lands under the Kikuyu dominated administration since the time of independence. The Ogiek were found living primarily in elevation zones 4 to 7. This make sense in that this area is where a historic trading center (Nessuit) existed prior to independence and is where the Ogiek sought refuge when their homelands were degazetted during the period of time that saw land redistributed in the 1990’s and early 2000’s under the previous administration (Chapter 2). As can be seen, elevation zone 4 represented a convergence zone where members of each of the three dominant ethnic groups were found in nearly equal numbers (Figure 3.4 and Table 3.2). An exception is suggested for elevation zone 1, where the large peri-urban community Kaptembwa and the village of Ngata are located on the outskirts of the City of Nakuru. These communities are comprised of all ethnic groups, partly as a function of the relative
Figure 3.3. Proportion of ethnic groups in Njoro watershed.
Figure 3.4. Ratio of ethnic groups by elevation zone.
location adjacent to Nakuru and partly as a function of living adjacent to the large farms
where seasonal employment as farm labor can be found.

There were five other ethnic groups besides the Kikuyu, Kalenjin, and Ogiek, but these comprised only 3% of the sampled HoHs. They tended to be found in elevation zones 1, 2, and 3 or below 2,300 meters in elevation. They were comprised of HoH from the Luo tribe (1 HoH), Luhya tribe (2 HoH), Kisii tribe (2 HoH), and Marigoli tribe (1 HoH), a sub-group of the Luhya. Mixed households also were present (i.e., Maasai, Samburu/Borana, Swahili, Kamba, Turkana, and others); however, they were not specifically delineated as such nor studied as unique units.

Overall, the average age of HoHs was in the mid- to late-forties, regardless of gender. Statistically, an occasional and slight variation in the average age of HoH by ethnic group (Kikuyu were older) and by elevation (above and below 2,300 meters) was observed (Table 3.1). Njoro households had an overall average household size of 6.4; the number of males per household was slightly greater on average than the number of females per household, whereas children made up nearly 40 percent of household numbers. Children were defined as those persons 14 years of age or younger. Average length of occupancy on their farms (“years on farm”) was reported to be greater than 12 years (minimum = 0.4 yr, maximum = 44.0 yr) with longer residency times being on farms in the mid- to lower-portion of the study area (Table 3.2). This coincides with the relatively recent settlement of lands above 2,300 meters in elevation as reported in Chapter 2. The Kikuyu reported considerably longer residence times (approximately 23 years) than the other respondents; this was significantly greater than that reported by the Kalenjin and Ogiek who occupy lands more recently settled above 2,300 meters.
Table 3.1. Socioeconomic characteristics of Njoro households by ethnic group

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Sample Size (n)</th>
<th>Average Age (yr.)</th>
<th>Head of Household (HoH)</th>
<th>Household Size (no.)</th>
<th>Distance to Market (km)</th>
<th>Years on Farm</th>
<th>Tenure Status (%)</th>
<th>Subsistence Farms (%)</th>
<th>Provided all Food Needs (%)</th>
<th>Income (10^5 KSh)</th>
<th>Access to Credit (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gender (M/F) and Age (yr.)</td>
<td>Child</td>
<td>Adult F</td>
<td>Adult M</td>
<td></td>
<td></td>
<td></td>
<td>Farm</td>
<td>Off-Farm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kalenjin</td>
<td>85</td>
<td>46±1.48^a</td>
<td>77M (45±1.44)</td>
<td>8F (57±6.43)</td>
<td>2.7±0.36</td>
<td>1.8±0.20</td>
<td>2.2±0.30</td>
<td>2.9±0.28^a</td>
<td>8±1.4^a</td>
<td>13 = w/TD</td>
<td>73 = w/o TD</td>
</tr>
<tr>
<td>Kikuyu</td>
<td>61</td>
<td>58±1.70^b</td>
<td>56M (53±1.57)</td>
<td>11F (65±5.42)</td>
<td>1.7±0.44</td>
<td>2.2±0.30</td>
<td>2.2±0.32</td>
<td>1.3±0.24^d</td>
<td>21±3.0^d</td>
<td>72 = w/TD</td>
<td>20 = w/o TD</td>
</tr>
<tr>
<td>Ogiek</td>
<td>70</td>
<td>43±1.82^a</td>
<td>56M (42±1.98)</td>
<td>14F (46±4.57)</td>
<td>3.1±0.54</td>
<td>1.6±0.22</td>
<td>2.0±0.30</td>
<td>2.5±0.24^e</td>
<td>9±1.0^e</td>
<td>1 = w/TD</td>
<td>97 = w/o TD</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>45±5.14^a</td>
<td>6M (50±7.36)</td>
<td>3±0.62</td>
<td>1.8±1.30</td>
<td>2.5±1.24</td>
<td>0.4±0.30</td>
<td>13±7.46^m</td>
<td>3±0.30</td>
<td>50 = w/TD</td>
<td>50 = w/o TD</td>
</tr>
<tr>
<td>All</td>
<td>222</td>
<td>48±2.0^b</td>
<td>186M (46±2.0)</td>
<td>36F (54±6.3)</td>
<td>2.5±0.26</td>
<td>1.8±0.14</td>
<td>2.1±0.18</td>
<td>2.3±0.2^e</td>
<td>13±1.4^e</td>
<td>27 = w/TD</td>
<td>65 = w/o TD</td>
</tr>
</tbody>
</table>

1 For detailed description of the study area, please refer to the text in Chapter 2. Confidence intervals (C.I.) at the 95% level are provided for all values reported unless otherwise indicated. Entries followed by the same letter (a, b, c, . . .) are not significantly different (p ≤ 0.05).
2 Ethnicity reported is inclusive of the major ethnic groups living within the study area. Please refer to Chapter 2 for the text details.
3 Head of household was comprised of both males and females. The values reported here illustrate patterns of HoH characteristics based on gender.
4 Household demographics are represented here whereas a child is defined as those persons ≤ 14 years of age, adult females are those females > 14 years, and adult males are those males > 14 years of age.
5 Distance to market represents the distance to the nearest market where produce may be sold commercially, to buyers for other markets, or bartered for goods and services. Four markets were identified in the study area.
6 Whereas tenure is defined here as: w/TD = owns the farm and has title deed, w/o TD = owns the land but does not have title deed, "other" = tenure arrangement (i.e., renter, squattee, share cropping, etc.) and reported a percentage of RFs in the elevation zone.
7 Subsistence refers to reliance of the household on their residence farm for all their food needs. The value reported reflects the percentage of those HoH who indicated that they relied on their farms for all their food needs.
8 Values are reported as the percentage of the total number of households that had their food needs met in the prior three years; never: provided enough food; 1 = don’t know; responses included here also, enough food in 1 out of 3 years, enough food in 2 out of 3 years, and enough food in all three previous years.
9 Whereas RFs reported income from each source indicated. Values are given as thousands of Kenyan Shillings where 70 KSh = $1.00 US Dollar (USD).
10 The values given for Total income does not always equal the sum of off-farm income and farm income due to missing data, rounding errors, and variance in perceptions of what constituted income as reported by Respondents.
11 Access to credit is reported as the percent of RFs indicating that they actively engaged in obtaining credit for their farming operation.
Table 3.2. Socioeconomic characteristics of Njoro households by elevation zone

<table>
<thead>
<tr>
<th>Elevation Zone (m)</th>
<th>Sample Size (n)</th>
<th>Ethnicity (no.)</th>
<th>Head of Household (HoH)</th>
<th>Household Size (no.)</th>
<th>Household Size (no.)</th>
<th>Distance to Market (km)</th>
<th>Years on Farm</th>
<th>Tenure Status (%)</th>
<th>Subsistence Needs (%)</th>
<th>Provided all Food Needs (%)</th>
<th>Income (10^3 KSh)</th>
<th>Access to Credit (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(2000 to 2099)</td>
<td>18</td>
<td>Kalenjin – 6</td>
<td>51±7.4*</td>
<td>14M (47±5.3)</td>
<td>4F (6±24.0)</td>
<td>2.3±0.84</td>
<td>1.0±0.36</td>
<td>2.2±0.52</td>
<td>0.0±0.40</td>
<td>28 = w/TD</td>
<td>67 = w/o TD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27</td>
<td>Kalenjin – 3</td>
<td>57±5.6*</td>
<td>20M (34±5.6)</td>
<td>7F (5±14.4)</td>
<td>1.8±0.76</td>
<td>1.9±0.44</td>
<td>2.0±0.36</td>
<td>2.0±0.24*</td>
<td>85 = w/TD</td>
<td>11 = w/o TD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18</td>
<td>Kalenjin – 1</td>
<td>52±5.6*</td>
<td>9M (32±5.8)</td>
<td>3F (30±17.2)</td>
<td>2.3±0.80</td>
<td>2.3±0.58</td>
<td>2.1±0.54</td>
<td>0.4±0.14</td>
<td>75 = w/TD</td>
<td>17 = w/o TD</td>
</tr>
<tr>
<td>2</td>
<td>(2100 to 2199)</td>
<td>24</td>
<td>Kalenjin – 17</td>
<td>46±4.4*</td>
<td>27M (46±4.2)</td>
<td>4F (38±21.8)</td>
<td>2.2±0.58</td>
<td>2.2±0.38</td>
<td>2.2±0.50</td>
<td>2.1±0.18*</td>
<td>39 = w/TD</td>
<td>61 = w/o TD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>31</td>
<td>Kalenjin – 11</td>
<td>45±4.0*</td>
<td>47M (43±4.4)</td>
<td>14F (89±8)</td>
<td>2.8±0.56</td>
<td>1.8±0.28</td>
<td>1.9±0.38</td>
<td>1.9±0.24*</td>
<td>2 = w/TD</td>
<td>92 = w/o TD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>61</td>
<td>Kalenjin – 18</td>
<td>44±3.6*</td>
<td>56M (45±3.8)</td>
<td>2F (39±19.0)</td>
<td>2.8±0.48</td>
<td>1.5±0.20</td>
<td>2.3±0.34</td>
<td>3.9±0.22*</td>
<td>0 = w/TD</td>
<td>86 = w/o TD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>58</td>
<td>Kalenjin – 43</td>
<td>49±13.2*</td>
<td>3M (49±13.2)</td>
<td>5.3±1.34</td>
<td>2.3±0.66</td>
<td>2.7±0.66</td>
<td>5.8±0.24*</td>
<td>9.3±1.3*</td>
<td>0 = w/TD</td>
<td>33 = w/o TD</td>
</tr>
<tr>
<td>3</td>
<td>(2200 to 2299)</td>
<td>3</td>
<td>Kalenjin – 3</td>
<td>48±2.0*</td>
<td>186M (46±2.0)</td>
<td>56F (34±6.3)</td>
<td>2.5±0.26</td>
<td>1.8±0.14</td>
<td>2.1±0.18</td>
<td>2.3±0.20*</td>
<td>27 = w/TD</td>
<td>65 = w/o TD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>222</td>
<td>Kalenjin – 85</td>
<td>83±4.6*</td>
<td>81M (46±4.2)</td>
<td>61F (34±6.3)</td>
<td>5.6±0.26</td>
<td>3.5±0.14</td>
<td>5.3±0.28</td>
<td>13±1.4*</td>
<td>13±1.4*</td>
<td>13±1.4*</td>
</tr>
</tbody>
</table>

1 For detailed description of the study area, please refer to the text in Chapter 2. Confidence intervals (C.I.) at the 95% level are provided for all values reported unless otherwise indicated. Entries followed by the same letter (a, b, e, . . .) are not significantly different (p ≤ 0.05).
2 The study area was delineated into elevation zones at 100 m intervals beginning at the lower elevation near the village of Ngata and continuing upstream to the uppermost settled areas around the villages of Sigaon and Logomon.
3 Ethnicity reported is inclusive of the major ethnic groups living within the study area. Please refer to Chapter 2 of the text for details.
4 Head of Household was comprised of both males and females. The values reported here illustrate patterns of HoH characteristics based on gender.
5 Household demographics are represented here whereas a child is defined as those persons ≤ 14 years of age, adult females are those females > 14 years, and adult males are those males > 14 years of age.
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8 Subsistence refers to reliance of the household on their residence farm for all their food needs. The value reported reflects the percentage of those HoH who indicated that they relied on their farms for all their food needs.
9 Values are reported as the percentage of the total number of households that had their food needs met in the prior three years; never provided enough food (DK = don’t know; responses included here also), enough food in 1 out of 3 years, enough food in 2 out of 3 years, and enough food in all three previous years.
10 Whereas Respondents reported income from each of the sources indicated. Values are given as thousands of Kenyan Shillings where 70 KSh = $1.00 US Dollar (USD).
11 The values given for Total income does not always equal the sum of off-farm income and farm income due to missing data, rounding errors, and variance in perceptions of what constituted income as reported by Respondents.
12 Access to credit is reported as the percent of Respondents indicating that they actively engaged in obtaining credit for their farming operation.
household interviews, 92 percent of all respondents (n = 204) reported that they believed they owned their farmland. However, only 59 individuals (27 percent) reported that they actually held a title deed to their farm. When delineated by ethnicity, a greater number of Kikuyu HoH reported holding title deed (n = 44 or 75 percent) of all those reporting holding title deed to their lands. This corresponds with where they lived (lands below elevation zone 4) and speaks to the unbalanced nature of access to land ownership and the long-standing struggle for land in the Rift valley as discussed in Chapter 2.

Most respondents indicated that they depended on their farm for all of their food requirements; however, less than half reported that all of their food needs were met in all of the preceding three years. Moreover, about one-fourth of all respondents indicated that their farms never provided enough to satisfy their household food needs (Tables 3.1 and 3.2). Farmers in the Njoro have several options for marketing their produce, including direct sales at home kiosks, sales to buyers who then move the produce to retail markets, self-transport and sale to the university and other vendors (restaurants or retail markets), and participation in food cooperatives. Distance to market averaged just less than 2.5 km with the distance from market for all ethnic groups; however, the Kikuyu and other ethnic groups were located significantly less far than the Kalenjin and Ogiek. This possibly has implications on income and access to credit.

Food security is strongly and positively associated with the years living on the farm ($\chi^2 = 145.09$, p less than 0.05), whereas the relationship between years on the farm and other socioeconomic features were not as easy to define (Tables 3.1 and 3.2). Further examination of the data reveals that the interaction of these ancillary factors may provide some useful explanation. The factors ‘income’ and ‘having enough food’ may be weakly
related ($\chi^2 = 38.4$, $p = 0.14$), whereas the relationship of farm size to enough food has a strong association ($\chi^2 = 123.5$, $p = 0.01$), and farm size to total income is very strongly associated ($\chi^2 = 458.1$, $p$ less than 0.0001).

Using an exchange rate estimated as one U.S. dollar (USD) equal to 70 Kenyan Shillings (KSh) at the time of the study, the approximate average annual total income (exclusive of credit) for all households surveyed was 87,800 KSh or about 1,254 USD per household. This equates to about 196 USD per person per year calculated for an average household size of 6.4 persons. Average on-farm income was approximately 45,400 KSh (648 USD) whereas 137 farmers (62 percent) reported off-farm income of about 35,600 KSh (509 USD) per annum. Seventeen farmers reported no farm income. Only 23 farmers (10 percent) indicated that they had obtained some form of credit for use in their farming operations (Tables 3.1 and 3.2).

An important factor was revealed from this data. While incomes were not significantly different across ethnic groups (Table 3.1) or across all elevation zones (Table 3.2), total income reported by Kikuyu was substantially higher than that of the other ethnic groups.

Perception of Water Resources

Table 3.3 illustrates delineation of household perception of water resource issues by ethnic group, and Table 3.4 illustrates water-related issues by elevation. Overall, about three-fourths of all respondents reported that their primary source of water for household use was directly from the river, regardless of elevation. Other important sources of
Table 3.3. Water resources of Njoro households by ethnicity

<table>
<thead>
<tr>
<th>Ethnic Group</th>
<th>Sample Size (n)</th>
<th>Primary Water Source (%)</th>
<th>Water Quality (%)</th>
<th>Illness (%)</th>
<th>Toilet type (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Human</td>
<td>Overall</td>
<td>Drinking</td>
<td>Wash/Bath</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kalenjin</td>
<td>85</td>
<td>83 – river</td>
<td>32 – good</td>
<td>36 – good</td>
<td>78 – good</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 – roof</td>
<td>22 – poor</td>
<td>22 – poor</td>
<td>8 – poor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 – spring</td>
<td>1 – NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>21 – roof</td>
<td>56 – poor</td>
<td>70 – poor</td>
<td>13 – poor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>89 – river</td>
<td>29 – good</td>
<td>27 – good</td>
<td>64 – good</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 – borehole</td>
<td>46 – mod</td>
<td>44 – mod</td>
<td>27 – mod</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 – spring</td>
<td>1 – NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ogiek</td>
<td>70</td>
<td>50 – river</td>
<td>0 – good</td>
<td>0 – good</td>
<td>50 – good</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33 – borehole</td>
<td>33 – mod</td>
<td>17 – mod</td>
<td>33 – mod</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17 – roof</td>
<td>67 – poor</td>
<td>83 – poor</td>
<td>17 – poor</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>72 – river</td>
<td>24 – good</td>
<td>25 – good</td>
<td>68 – good</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 – borehole</td>
<td>42 – mod</td>
<td>36 – mod</td>
<td>22 – mod</td>
</tr>
<tr>
<td>All</td>
<td>222</td>
<td>50 – river</td>
<td>24 – good</td>
<td>25 – good</td>
<td>68 – good</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33 – borehole</td>
<td>42 – mod</td>
<td>36 – mod</td>
<td>22 – mod</td>
</tr>
</tbody>
</table>

1 Information presented in this table was derived from interview, observation, and discussion with the HoH to discover their perceptions about their resources.
2 Ethnicity reported is inclusive of the major ethnic groups living within the study area. Please refer to Chapter 2 of the text for details.
3 This information reflects the overall percentage of farmers’ who identified their primary source of water for household and livestock use as indicated. NA represents those farmers who either did not report, or were unsure of, what their primary water was. Values reported for river water included tap water; it was observed that all “tap” water resulted from diversions of water from the river and did not include any kind of treatment systems before delivery to the household.
4 This information reflects the farmers’ perception of water quality available to them for various uses. Laboratory analysis has not been performed to establish actual water quality. Data in cells add to 100% and reflects the respondents’ subjective choice of three possible answers: “good,” moderate (mod),” and “poor” for the purposes indicated.
5 Illness is defined here as that of the stomach or diarrhea, or any other common ailments that affect their ability to work on their farms. The values reported reflect the percentage of farmers who reported being ill for some part of the year.
6 Toilet types are defined as: “flush” = modern toilet with piped water that is gravity flushed, “pit latrine” = a shallow dug hole in the earth, usually with some form of structure, “none/bush” toilet = no facilities (household members use the bush, forest, or farm field as their toilet).
Table 3.4. Water resources of Njoro households by elevation zone

<table>
<thead>
<tr>
<th>Elevation Zone (masl)</th>
<th>Sample Size (n)</th>
<th>Primary Water Source (%) 1</th>
<th>Water Quality (%) 4</th>
<th>Illness (%) 5</th>
<th>Toilet type (%) 6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Human</td>
<td>Overall</td>
<td>Drinking</td>
<td>Wash/Bath</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22 – borehole</td>
<td>17 – mod</td>
<td>17 – mod</td>
<td>11 – mod</td>
</tr>
<tr>
<td>2 (2100 to 2199)</td>
<td>27</td>
<td>15 – river</td>
<td>7 – good</td>
<td>0 – good</td>
<td>44 – good</td>
</tr>
<tr>
<td></td>
<td></td>
<td>59 – borehole</td>
<td>30 – mod</td>
<td>7 – mod</td>
<td>33 – mod</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26 – roof</td>
<td>63 – poor</td>
<td>93 – poor</td>
<td>22 – poor</td>
</tr>
<tr>
<td>3 (2200 to 2299)</td>
<td>24</td>
<td>50 – river</td>
<td>0 – good</td>
<td>4 – good</td>
<td>58 – good</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21 – borehole</td>
<td>50 – mod</td>
<td>29 – mod</td>
<td>33 – mod</td>
</tr>
<tr>
<td></td>
<td></td>
<td>29 – roof</td>
<td>50 – poor</td>
<td>67 – poor</td>
<td>8 – poor</td>
</tr>
<tr>
<td>4 (2300 to 2399)</td>
<td>31</td>
<td>91 – river</td>
<td>19 – good</td>
<td>23 – good</td>
<td>58 – good</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 – roof</td>
<td>58 – mod</td>
<td>52 – mod</td>
<td>39 – mod</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 – spring</td>
<td>23 – poor</td>
<td>26 – poor</td>
<td>3 – poor</td>
</tr>
<tr>
<td>5 (2400 to 2499)</td>
<td>61</td>
<td>92 – river</td>
<td>23 – good</td>
<td>18 – good</td>
<td>77 – good</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 – borehole</td>
<td>44 – mod</td>
<td>52 – mod</td>
<td>13 – mod</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 – spring</td>
<td>31 – poor</td>
<td>29 – poor</td>
<td>10 – poor</td>
</tr>
<tr>
<td>6 (2500 to 2599)</td>
<td>58</td>
<td>84 – river</td>
<td>43 – good</td>
<td>53 – good</td>
<td>78 – good</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 – borehole</td>
<td>45 – mod</td>
<td>31 – mod</td>
<td>15 – mod</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 – roof</td>
<td>12 – poor</td>
<td>14 – poor</td>
<td>7 – poor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 – spring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 (2600 to 2699)</td>
<td>3</td>
<td>100 – river</td>
<td>67 – good</td>
<td>67 – good</td>
<td>100 – good</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0 – mod</td>
<td>0 – mod</td>
<td>0 – mod</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>33 – poor</td>
<td>33 – poor</td>
<td>0 – poor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 – borehole</td>
<td>42 – mod</td>
<td>36 – mod</td>
<td>22 – mod</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11 – roof</td>
<td>33 – poor</td>
<td>39 – poor</td>
<td>10 – poor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 – spring</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Information presented in this table is derived from interview, observation, and discussion with the HoH to discover their perceptions about their resources. Cell totals do not always add to 100% due to rounding errors or incomplete data.

2 The study area was delineated into elevation zones at 100 m intervals beginning at the lower elevation near the village of Ngata and continuing upstream to the uppermost settled areas around the villages of Sigaon and Logomon.

3 This information reflects the overall percentage of farmers who identified their primary source of water for household and livestock use as indicated. NA represents those farmers who either did not report, or were unsure of, what their primary water was. Cell totals do not always add to 100% due to rounding errors or incomplete data.

4 This information reflects the farmers’ perception of water quality available to them for various uses. Laboratory analysis has not been performed to establish actual water quality. Data in cells add to 100% and reflects the respondents’ subjective choice of three possible answers: “good,” moderate (mod.),” and “poor” for the purposes indicated.

5 Illness is defined here as that of the stomach or diarrhea, or any other common ailments that affect their ability to work on their farms. The values reported reflect the percentage of farmers who reported being ill for some part of the year.

6 Toilet types are defined as: “flush” = modern toilet with piped water that is gravity flushed, “pit latrine” = a shallow dug hole in the earth, usually with some form of structure, “none/bush” toilet = no facilities (household members use the bush, forest, or farm field as their toilet).
domestic water were rainwater collection from roof-catchment systems, groundwater, and springs. However, when delineated by ethnic group, the Kikuyu (greater than 62 percent) and other group (greater than 66 percent) reported that borehole water was an important source of water for (their) human use. In contrast, the Kalenjin and Ogiek reported obtaining their water primarily from the river.

Perception of overall water quality appeared to shift depending on ethnic group and elevation whereas, as elevation increased, the perception of “good” water quality also increased (Table 3.4). There is also a notable difference in Kikuyu and “other” group who reported that their perception of overall water quality were not as positive as that reported by the Kalenjin and Ogiek. Kikuyu respondents reported slightly less incidence of illness (i.e., the percent of farmers reporting being ill at least once per year with a stomach illness or diarrhea severe enough to negatively affect their ability to work during the year) than all other ethnic groups. This may be due to length of tenure, having access to borehole water more often, living nearer urban and peri-urban centers, and having better access to medical treatment (Steven Huckett, personal observation).

Three households reported having a flush toilet with the balance relying on either pit latrines (n = 184; 83 percent) or bush toilets (n = 35; 16 percent). No discernable differences were evident when delineating by ethnic group; however, bush toilets prevalence increases with elevation (Table 3.4).

Farm Characteristics

General farm characteristics are illustrated by ethnic group in Table 3.5 and by elevation zone in Table 3.6. Overall, farm size averaged 2.4 ha overall with farm size being greater (p less than 0.05) for the Kalenjin and Ogiek than for the Kikuyu and the
Table 3.5. Agroecological profile of Njoro watershed farms by ethnic group

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>Sample Size (n)</th>
<th>Farm Size (ha)</th>
<th>Average Slope (°)</th>
<th>Source of Water for Crops (%)</th>
<th>Soil Characteristics (%)</th>
<th>Tillage Methods (%)</th>
<th>Most Prevalent Crop</th>
<th>Fallow Lands (%)</th>
<th>Fertilizer / Pesticide Use (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Water Holding Capacity</td>
<td>Erosion Potential</td>
<td>Productivity</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>Observed Erosion</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Soil Productivity</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kalenjin</td>
<td>85</td>
<td>2.5±0.40a</td>
<td>8±1.0d</td>
<td>96 = Rainfall 3 = Both</td>
<td>54 = High</td>
<td>14 = High</td>
<td>20 = High</td>
<td>Mrs. Maize</td>
<td>74 – fert. 39 – pest.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>31 = Avg</td>
<td>25 = Avg</td>
<td>35 = Avg</td>
<td>Potatoes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15 = Low</td>
<td>61 = Low</td>
<td>42 = Low</td>
<td>Beans</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3 = DK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kikuyu</td>
<td>61</td>
<td>1.8±0.78b</td>
<td>4±0.8b</td>
<td>92 = Rainfall 8 = Both</td>
<td>26 = High</td>
<td>8 = High</td>
<td>5 = High</td>
<td>Mrs. Maize</td>
<td>85 – fert. 51 – pest.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>33 = Avg</td>
<td>28 = Avg</td>
<td>31 = Avg</td>
<td>Potatoes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>41 = Low</td>
<td>64 = Low</td>
<td>61 = Low</td>
<td>Beans</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3 = DK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ogiek</td>
<td>70</td>
<td>3.0±0.40b</td>
<td>6±0.7</td>
<td>99 = Rainfall 1 = Both</td>
<td>63 = High</td>
<td>14 = High</td>
<td>10 = High</td>
<td>Mrs. Maize</td>
<td>84 – fert. 27 – pest.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>30 = Avg</td>
<td>30 = Avg</td>
<td>34 = Avg</td>
<td>Potatoes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7 = Low</td>
<td>56 = Low</td>
<td>54 = Low</td>
<td>Beans</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 = DK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>0.8±0.76c</td>
<td>2±1.0</td>
<td>83 = Rainfall 17 = Irrigated</td>
<td>33 = High</td>
<td>17 = High</td>
<td>50 = High</td>
<td>Mrs. Maize</td>
<td>67 – fert. 33 – pest.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>34 = Avg</td>
<td>0 = Avg</td>
<td>17 = Avg</td>
<td>Potatoes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>33 = Low</td>
<td>83 = Low</td>
<td>33 = Low</td>
<td>Beans</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>222</td>
<td>2.4±0.30b</td>
<td>6±0.5</td>
<td>95 = Rainfall 4 = Both</td>
<td>49 = High</td>
<td>13 = High</td>
<td>14 = High</td>
<td>Mrs. Maize</td>
<td>80 – Fert. 38 – Pest</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>49 = Avg</td>
<td>27 = Avg</td>
<td>33 = Avg</td>
<td>Potatoes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20 = Low</td>
<td>60 = Low</td>
<td>51 = Low</td>
<td>Beans</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 = DK</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 For detailed description of the study area, and of the general characteristics of farms in the study area, please refer to the text in Chapter 2. Values for farm size and slope are reported using 95% confidence intervals (+ C.I.). Entries followed by the same letter (a, b, c, . . .) are not significantly different (p ≤ 0.05).
2 Ethnicity reported is inclusive of the major ethnic groups living within the study area. Please refer to Chapter 2 of the text for details.
3 Using a clinometer, enumerators measured the degree angle of the farm both up- and down-slope, and then averaged the two measures.
4 This value is the percent of respondents within the specified elevation zone reporting their source of water for growing crops to be either rainfall, irrigation or a combination of both.
5 Soil characteristics (i.e., water holding capacity, erosion observed, erosion potential and productivity) are those perceived by respondents. Observed erosion was the percent of HoH reporting erosion on their farms and observed by enumerators during the farm “walk-about.” Quantification of erosion amounts was not performed.
6 Tillage refers to turning the soil in preparation for planting crops, cultivation related to weeding, and end-of-season incorporation of plant residues. Machine tillage involved use of a tractor and implements, typically rented. Animal refers to the use of draft animals such as oxen or donkeys. Manual tillage refers to work done by household members or hired labor.
7 Most prevalent crops are those ranked as most prominent in terms of acres planted. Minor crops included spinach/kale, peas, onions, millet/sorghum, vegetables, fruits/nuts, fodder grass, carrots, pyrethrum, sugar cane, medicinal plants, banana, sweet potato, and capsicum.
8 Fallow lands is the percentage of all farms in the study area which actively practiced fallowing for conservation, pasture, or other purposes.
9 Reported as the percent of farms surveyed that use either fertilizer or pesticides during the course of the production year. Quantities applied are unknown.
Table 3.6. Agroecological profile of Njoro watershed farms by elevation zone

<table>
<thead>
<tr>
<th>Elevation Zone (mab)</th>
<th>Sample Size (n)</th>
<th>Farm Size (ha)</th>
<th>Average Slope (°)</th>
<th>Source of Water for Crops (%)</th>
<th>Tillage Methods (%)</th>
<th>Most Prevalent Crops (%)</th>
<th>Fallow Lands (%)</th>
<th>Fertilizer / Pesticide Use (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (2000 to 2099)</td>
<td>18</td>
<td>2.5±0.7bc</td>
<td>6±1.3a</td>
<td>100 = Rainfall</td>
<td>56 = Machine</td>
<td>56 = Machine</td>
<td>16</td>
<td>94 – Fert. Wheat/barley</td>
</tr>
<tr>
<td></td>
<td></td>
<td>55 = Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>78 – Pest.</td>
</tr>
<tr>
<td>2 (2100 to 2199)</td>
<td>27</td>
<td>2.8±0.8b</td>
<td>3±0.6a</td>
<td>100 = Rainfall</td>
<td>44 = Machine</td>
<td>44 = Machine</td>
<td>22</td>
<td>89 – Fert. Wheat/barley</td>
</tr>
<tr>
<td></td>
<td></td>
<td>37 = Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>55 – Pest.</td>
</tr>
<tr>
<td>3 (2200 to 2299)</td>
<td>24</td>
<td>0.8±0.2a</td>
<td>3±1.2a</td>
<td>83 = Rainfall, 4 = Irrigated</td>
<td>21 = Machine</td>
<td>21 = Machine</td>
<td>7</td>
<td>75 – Fert. Carrot Grass/pasture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>38 = Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>42 – Pest.</td>
</tr>
<tr>
<td>4 (2300 to 2399)</td>
<td>31</td>
<td>2.7±0.4b</td>
<td>6±1.2a</td>
<td>94 = Rainfall, 6 = Both</td>
<td>42 = Machine</td>
<td>42 = Machine</td>
<td>16</td>
<td>94 – Fert. Wheat/barley</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 = Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>42 – Pest.</td>
</tr>
<tr>
<td>5 (2400 to 2499)</td>
<td>61</td>
<td>2.7±0.2b</td>
<td>6±1.0a</td>
<td>93 = Rainfall, 7 = Both</td>
<td>10 = Animal</td>
<td>10 = Animal</td>
<td>31</td>
<td>82 – Fert. Cabbage/Kale/Spinach</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 = Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25 – Pest.</td>
</tr>
<tr>
<td>6 (2500 to 2599)</td>
<td>58</td>
<td>2.4±0.2c</td>
<td>7±1.2a</td>
<td>100 = Rainfall</td>
<td>33 = Animal</td>
<td>33 = Animal</td>
<td>33</td>
<td>69 – Fert. Wheat/barley</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 = Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>31 – Pest.</td>
</tr>
<tr>
<td>7 (2600 to 2699)</td>
<td>3</td>
<td>2.4±0.6b</td>
<td>11±4.0bc</td>
<td>100 = Rainfall</td>
<td>100 = Animal</td>
<td>100 = Animal</td>
<td>33</td>
<td>0 – Fert.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 = Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0 – Pest.</td>
</tr>
<tr>
<td>All (2000 to 2699)</td>
<td>222</td>
<td>2.4±3.0bc</td>
<td>6±0.3a</td>
<td>95 = Rainfall, 5 = Irrigated</td>
<td>14 = High</td>
<td>13 = Animal</td>
<td>25</td>
<td>80 – Fert. Wheat/barley</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 = Both</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>38 – Pest.</td>
</tr>
</tbody>
</table>

1 For detailed description of the study area, and of the general characteristics of farms in the study area, please refer to the text in Chapter 2. Values for farm size and slope are reported using 95% confidence intervals (± C.I.). Entries followed by the same letter (a, b, c, . . .) are not significantly different (p ≤ 0.05).

2 The study area is delineated into elevation zones, i.e., 100 m intervals beginning at the lower end of the study area at the village of Ngata, extending upstream to the uppermost-developed areas near the villages of Sigaon and Logomon.

3 Using a clinometer, enumerators measured the degree angle of the farm both up- and down-slope and then averaged the two measures.

4 This value is the percent of respondents within the specified elevation zone reporting their source of water for growing crops to be either rainfall, irrigation or a combination of both.

5 Soil characteristics (i.e., water holding capacity, erosion observed, erosion potential and productivity) are those perceived by respondents. Observed erosion was the percent of HoH reporting erosion on their farms and observed by enumerators during the farm “walk-about.” Quantification of erosion amounts was not performed.

6 Tillage refers to turning the soil in preparation for planting crops, cultivation related to weeding, and end-of-season incorporation of plant residues. Machine tillage involved use of a tractor and implements, typically rented. Animal refers to the use of draft animals such as oxen or donkeys. Manual tillage refers to work done by household members or hired labor.

7 Most prevalent crops are those ranked as most prominent in terms of acres planted. Minor crops included spinach/kale, peas, onions, millet/sorghum, vegetables, fruits/nuts, fodder grass, carrots, pyrethrum, sugar cane, medicinal plants, banana, sweet potato, and capsicum.

8 Fallow lands is the percentage of all farms in the study area which actively practiced fallowing for conservation, pasture, or other purposes.

9 Reported as the percent of farms surveyed that use either fertilizer of pesticides during the course of the production year. Quantities applied are unknown.
“other” group. The difference in farm size was not significant except for the “other” group, which had notably smaller farms. Average slope of riparian farmlands were significantly different ($p < 0.05$) for all ethnic groups. Slope averaged $6^\circ$ overall with a range of $0$ to $23^\circ$. The Ogiek and Kalenjin tended to live on steeper lands ($6^\circ$ and $8^\circ$ on average, respectively) whereas the Kikuyu and “other” group occupied lands of lesser slope ($4^\circ$ and $2^\circ$, respectively) which may reflect their relative location in the watershed (Figure 3.4) and access to more favorable farmlands.

The Kikuyu, Kalenjin, and Ogiek ethnic groups reported that about 95 percent of their farms were devoted to crop production, and that their farms were primarily rain fed. On the other hand, the “other” ethnic group had five of six households reporting use of some form of irrigation. Soil water-holding capability is reported as somewhat bimodal with an apparent differentiation at an elevation of 2,350 masl (approximately located along the Nessuit/Mauche road). Above 2,350 masl, 85 percent of respondents indicated that their soils had average or high water-holding capacity, whereas 59 percent of respondents living below this elevation indicated that their soils had average to high water-holding capacity. Farmers reported higher levels of soil erosion more often at lower elevations, whereas reports of perceived soil productivity increased at higher elevations. Soil tillage was done primarily by manual labor; mechanical means comprised about one-third of tillage operations, while draft animals were used sparingly (13 percent). The frequency of falling land and of fertilizer and pesticide use was consistent across all ethnic groups.
A wide variety of agricultural crops were grown (Tables 3.5 and 3.6), whereas maize was the dominant crop with 181 households across all ethnic groups reporting it as the most important crop. Beans and potatoes were reported as important secondary crops. Almost all farmers intercrop maize/beans, maize/potatoes, or maize/beans/potatoes on their lands; however, almost no one reported actually planting potatoes. Apparently, potato production is a favorable by-product of volunteer plants remaining in the field from past farming practices. Other crops included spinach/kale, peas, onions, millet/sorghum, vegetables, fruits/nuts, fodder grass, carrots, pyrethrum, sugar cane, medicinal plants, bananas, sweet potatoes, and capsicum.

Regarding soil characteristics, opinions of the Kikuyu were consistently less positive than those of the remaining three groups. The Kikuyu generally rated their soils as having lower water-holding capacity and lower productivity; however, they did report less observed and lower potential for soil erosion on their farms than the other three ethnic groups. This is likely due to the location (and slope) of their farms. The methods of soil tillage were similar for all ethnic groups except that 25 of the total number of respondents using animal traction (n = 28) were Kalenjin; the remaining three respondents were Ogiek. Tillage was most commonly performed using manual labor, and secondarily by mechanical means. Fallowing of land was reported by only about one-third of respondents, mostly those with larger farms.

Farmer perceptions of soil productivity was reported to be “average” to “high” by about half of all respondents overall with a distinct uptick in positive perceptions of productivity in elevation zones 3, 6 and 7. In zone 3, this may be due to the relative lower
slope of the area and overall smaller farms size which suggests a reduced potential for soil erosion and more intensive farm management. This perspective is supported by farmer’s reported perceptions of lower soil erosion from their farms in zones 2 and 3 (Table 3.6). This may also be due to an elevated incidence of chickens as the predominant livestock, inferring an availability of chicken manure for fertilizer. In elevation zones 6 and 7, this relatively higher productivity may simply be due to these lands having been more recently converted to farmland and, thus, these soils have not lost as much of their native fertility compared to lands at lower elevations.

A variety of fertilizers and pesticides was used with 178 respondents reporting using some form of fertilizer and 85 respondents using pesticides to control insects. Herbicide use was also reported, but this factor was not enumerated. Diammonium phosphate (DAP) was the predominant fertilizer utilized while calcium ammonium phosphate (CAP), ammonium sulfate, and triple super phosphate were also reported; each of these was applied pre-planting during field preparation. During the growing season, crops were side-dressed with ammonium sulfate nitrate and calcium nitrate during periods of flowering and seed-set. On farms managed primarily with manual labor or draft animals, fertilizers generally were broadcast by hand. Respondents’ reports of application rates were inconsistent and varied widely, making quantification of actual rates of application impossible to determine. In this regard, the reported application rates were well below rates recommended by the Kenya Agricultural Research Institute. This was at least partly due to overall costs of fertilizer materials and lack of individual financial resources. Types of pesticides used and rates of application were more difficult
to ascertain. Several commercial products were reported (i.e., Furadan, Dipterex, Brigade, Karate, Dimecron), as well as pyrethrum and tobacco-extract based pesticides. Application rates reported were based on the respondents’ site-specific conditions and costs, and again provided in terms that were considered to be variable and unreliable.

Perception of Livestock Resources

Data regarding livestock is illustrated according by ethnic group (Table 3.7) and by elevation (Table 3.8). Most respondents kept livestock that included ungulates (i.e., cattle, sheep, goats, donkeys), small mammals and fowl (i.e., rabbits, chickens, ducks/geese, pigeons, and doves), and honey bees. In terms of importance to their farming operation, 147 respondents reported cattle, 33 indicated sheep, and 24 indicated that chickens were the most important livestock to their households, respectively. In terms of second most important livestock, respondents reported sheep, chickens, goats, and then cattle, respectively. The third most important livestock indicated was chickens, goats, and donkeys, respectively. The remaining livestock species were incidental and insignificant in terms of numbers kept, according to respondents. Average farm size also indicates a moderate trend in percent of livestock that were confined, the source of water for livestock, and the number of respondents reporting active manure management.

Twenty respondents indicated that they confine their livestock to corrals at all times, and 17 reported using a zero-grazing management system. The remaining respondents (161) free-grazed their livestock during the day on pasture, roadways and footpaths, and in local riparian zones, then collected and corralled them at night. Regarding livestock water resources, most respondents reported the river as their primary
Table 3.7. Profile of livestock held on farms by ethnic group

<table>
<thead>
<tr>
<th>Ethnicity 2</th>
<th>Sample Size (n)</th>
<th>Livestock Water Source (%)</th>
<th>Livestock Water Quality (%)</th>
<th>Most Prevalent Livestock 4</th>
<th>Estimated No./HH 5</th>
<th>Confined (%) 6</th>
<th>Manure Management (%) 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kalenjin</td>
<td>85</td>
<td>80 – river 93 – good 12 – NA</td>
<td>Cattle 93, Sheep 3, Goats 2, Chickens 1</td>
<td>3.6 72 – night 5 23 – NA</td>
<td>72 – night 5 23 – always 72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kikuyu</td>
<td>61</td>
<td>66 – river 69 – good 10 – poor 3 – NA</td>
<td>Cattle 69, Sheep 18, Goats 10, Chickens 3</td>
<td>1.7 62 – night 23 – always 72</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ogiek</td>
<td>70</td>
<td>90 – river 89 – good 3 – poor 1 – NA</td>
<td>Cattle 89, Sheep 7, Goats 3, Chickens 1</td>
<td>3.9 84 – night 1 15 – NA 36</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>33 – river 83 – good 17 – poor 17 – NA</td>
<td>Cattle 83, Sheep 9, Goats 17, Chickens 17</td>
<td>0.7 50 – night 16 – always 67</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>222</td>
<td>77 – river 85 – good 14 – NA</td>
<td>Cattle 85, Sheep 9, Goats 5, Chickens 8</td>
<td>3.1 73 – night 9 18 – NA 46</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 For detailed description of the study area, and of the general characteristics of farms in the study area, please refer to the text in Chapter 2.
2 Ethnicity reported is inclusive of the major ethnic groups living within the study area. Please refer to Chapter 2 of the text for details.
3 This information reflects the farmers’ perception of water quality available to them for livestock watering. Laboratory analysis has not been performed to establish actual water quality. Data in cells add to 100% and reflects the respondents’ subjective choice of three possible answers: “good,” moderate (mod),” and “poor” for the purposes indicated.
4 Whereas all livestock were considered with most important livestock listed as reported by the respondent. Other livestock present on farms included donkeys, rabbits, pigeons, doves, turkeys, ducks, geese, swine, and bees.
5 This value represents a best estimate of number of prominent livestock per household by ethnic group. Values not adding to 100% is due to non-reporting by respondents.
6 Whereas livestock are either free grazing during the day and confined to a corral or homestead compound at nighttime, or they were zero-grazed and confined at all times. NA = non-response.
7 This value represents the percentage of respondents who report actively collecting manure for use as fertilizer on their croplands or pasture.
Table 3.8. Profile of livestock held on farms by elevation zone ¹

<table>
<thead>
<tr>
<th>Elevation Zone ²</th>
<th>Sample Size (n)</th>
<th>Livestock Water Source (%)</th>
<th>Livestock Water Quality (%) ³</th>
<th>Most Prevalent Livestock</th>
<th>Estimated No./HH ³</th>
<th>Confined (%) ⁴</th>
<th>Manure Management (%) ⁵</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (2000 to 2099)</td>
<td>18</td>
<td>78 – river</td>
<td>61 – good</td>
<td>Cattle</td>
<td>3.6</td>
<td>83 – night</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11 – borehole</td>
<td>22 – mod.</td>
<td>Sheep</td>
<td>2.5</td>
<td>6 – always</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>11 – NA</td>
<td>11 – poor</td>
<td>Goats</td>
<td>1.6</td>
<td>11 – NA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Chickens</td>
<td>2.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 (2100 to 2199)</td>
<td>27</td>
<td>48 – river</td>
<td>63 – good</td>
<td>Cattle</td>
<td>2.7</td>
<td>70 – night</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19 – borehole</td>
<td>18 – mod.</td>
<td>Sheep</td>
<td>4.1</td>
<td>7 – always</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>11 – roof</td>
<td>15 – poor</td>
<td>Goats</td>
<td>1.2</td>
<td>23 – NA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>22 – NA</td>
<td></td>
<td>Chickens</td>
<td>9.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 (2200 to 2299)</td>
<td>24</td>
<td>71 – river</td>
<td>79 – good</td>
<td>Cattle</td>
<td>1.2</td>
<td>58 – night</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 – borehole</td>
<td>8 – mod.</td>
<td>Sheep</td>
<td>4.3</td>
<td>33 – always</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 – roof</td>
<td>12 – poor</td>
<td>Goats</td>
<td>0.2</td>
<td>9 – NA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>13 – NA</td>
<td></td>
<td>Chickens</td>
<td>15.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 (2300 to 2399)</td>
<td>31</td>
<td>81 – river</td>
<td>90 – good</td>
<td>Cattle</td>
<td>1.9</td>
<td>71 – night</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 – spring</td>
<td>10 – mod.</td>
<td>Sheep</td>
<td>5.7</td>
<td>16 – always</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 – NA</td>
<td>0 – poor</td>
<td>Goats</td>
<td>14.8</td>
<td>13 – NA</td>
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</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td>Chickens</td>
<td>6.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 (2400 to 2499)</td>
<td>61</td>
<td>90 – river</td>
<td>93 – good</td>
<td>Cattle</td>
<td>3.3</td>
<td>75 – night</td>
<td>34</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 – borehole</td>
<td>3 – mod.</td>
<td>Sheep</td>
<td>8.9</td>
<td>3 – always</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 – NA</td>
<td>2 – poor</td>
<td>Goats</td>
<td>0.6</td>
<td>22 – NA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Chickens</td>
<td>6.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 (2500 to 2599)</td>
<td>58</td>
<td>79 – river</td>
<td>91 – good</td>
<td>Cattle</td>
<td>3.9</td>
<td>76 – night</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 – borehole</td>
<td>5 – mod.</td>
<td>Sheep</td>
<td>4.4</td>
<td>3 – always</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 – spring</td>
<td>2 – poor</td>
<td>Goats</td>
<td>1.8</td>
<td>21 – NA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 – NA</td>
<td></td>
<td>Chickens</td>
<td>5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 (2600 to 2699)</td>
<td>3</td>
<td>100 – river</td>
<td>100 – good</td>
<td>Cattle</td>
<td>9.7</td>
<td>33 – night</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0 – mod.</td>
<td>Sheep</td>
<td>1.3</td>
<td>0 – always</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0 – poor</td>
<td>Goats</td>
<td>7.0</td>
<td>67 – NA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All (2000 to 2699)</td>
<td>222</td>
<td>77 – river</td>
<td>85 – good</td>
<td>Cattle</td>
<td>3.1</td>
<td>73 – night</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 – borehole</td>
<td>9 – mod.</td>
<td>Sheep</td>
<td>5.6</td>
<td>9 – always</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 – roof</td>
<td>5 – poor</td>
<td>Goats</td>
<td>1.0</td>
<td>18 – NA</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 – spring</td>
<td></td>
<td>Chickens</td>
<td>8.2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ For detailed description of the study area, and of the general characteristics of farms in the study area, please refer to the text in Chapter 2.

² Whereas the study area is delineated into elevation zones, i.e., 100 m intervals beginning at the lower end of the study area around the village of Ngata extending upstream to the uppermost developed areas near the villages of Sigaon and Logomon.

³ This information reflects the farmers’ perception of water quality available to them for livestock watering. Laboratory analysis has not been performed to establish actual water quality. Data in cells add to 100% and reflects the respondents’ subjective choice of three possible answers: “good,” moderate (mod),” and “poor” for the purposes indicated.

⁴ Whereas all livestock were considered with most important livestock listed as reported by the respondent. Other livestock present on farms included donkeys, rabbits, pigeons, doves, turkeys, ducks, geese, swine, and bees.

⁵ This value represents a best estimate of number of prominent livestock per household by ethnic group. Values not adding to 100% is due to non-reporting by respondents.

⁶ Whereas livestock are either free grazing during the day and confined to a corral or homestead compound at nighttime, or they were zero-grazed and confined at all times. NA = non-response. This value represents the percentage of respondents who report actively collecting manure for use as fertilizer on their croplands or pasture.
source of livestock water, 14 households used borehole water, six used roof-catchments, and three used springs for watering their livestock. This is the same general trend as seen for water resources for people. Twenty-six household respondents did not say or were unclear as to where their livestock watered (see Tables 3.7 and 3.8). Manure was collected for use as a crop fertilizer by about half of all respondents; a pattern of behavior was evident whereby the number of farmers collecting manure decreased as one moved from lower to higher elevations. This corresponds well with how farmers perceived the productivity of their soils relative to elevation (zone).

In terms of differences between ethnic groups and livestock, we see a moderate variation in numbers of specific species kept. For instance, the Kikuyu and “other” ethnic groups tend to keep more chickens on their farms than their counterparts. This is partly due to the smaller average farm size for Kikuyu and the “other” group in the Njoro than for the Kalenjin and Ogiek. However, this variety is also grounded in cultural preference for particular meats for consumption. The Kikuyu prefer chicken whereas the Kalenjin are historically pastoral people who raised grazing animals (cattle, goats, and sheep) for their livelihoods.

Information regarding extension services consultations is detailed by ethnic group (Table 3.9) and by elevation (Table 3.10). Farm visits by an extension specialist representing the Extension Service of the Kenyan Ministry of Agriculture were reported by 34 respondents. Of this group, 18 reported that an extension agent had visited their farm only once during their entire tenure. In contrast, 122 respondents reported having attended an official demonstration site sponsored by the Ministry of Agriculture or an
Table 3.9. Profile of extension services by ethnic group 1

<table>
<thead>
<tr>
<th>Ethnicity 2</th>
<th>Sample Size (n)</th>
<th>Access to Extension Services 3</th>
<th>Land Tenure Status (%) 4</th>
<th>Extension Visits by Tenure Status (%) 6</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Agent Visits (%)</td>
<td>Visits to Official Sites (%)</td>
<td>Formal Training (%)</td>
</tr>
<tr>
<td>Kalenjin</td>
<td>85</td>
<td>9</td>
<td>54</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kikuyu</td>
<td>61</td>
<td>29</td>
<td>69</td>
<td>87</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ogiek</td>
<td>70</td>
<td>7</td>
<td>41</td>
<td>50</td>
</tr>
<tr>
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<td>Other</td>
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<td>All</td>
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<td>55</td>
<td>67</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 For detailed description of the study area, and of the general characteristics of farms in the study area, please refer to the text in Chapter 2.
2 Ethnicity reported is inclusive of the major ethnic groups living within the study area. Please refer to Chapter 2 of the text for details.
3 Extension services are provided by extension specialists representing the Agriculture Extension Service, Kenyan Ministry of Agriculture. These values represent the percentage of on-site visits, visits to official demonstration sites, or formal training of respondents at other off-site locations.
4 Formal training in agronomic practices and/or livestock husbandry obtained by respondents to improve their farming practices; may include primary or secondary school training or experiences.
5 Whereas w/TD refers to land ownership with title deed, w/o TD means land ownership without holding title deed, and “Other” refers to some other form of residency arrangement.
6 These values represent the percent of extension visits relative to the respondents tenure status: i.e., of those respondents holding title deed to their land (w/ TD), what percent of them received a visit from their extension agent; of those respondents not holding title deed to their land (w/o TD), what percent of them received a visit from their extension agent; of those respondents living on their farm under some other ownership arrangement (Other), what percent of them received a visit from their extension agent.
Table 3.10. Profile of extension services by elevation

<table>
<thead>
<tr>
<th>Elevation Zone (masl)</th>
<th>Sample Size (n)</th>
<th>Access to Extension Services</th>
<th>Land Tenure Status (%)</th>
<th>Extension Visits by Tenure Status (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Agent Visits (%)</td>
<td>Visits to Official Sites (%)</td>
<td>Formal Training (%)</td>
</tr>
<tr>
<td>1 (2000 to 2099)</td>
<td>18</td>
<td>22</td>
<td>55</td>
<td>72</td>
</tr>
<tr>
<td>2 (2100 to 2199)</td>
<td>27</td>
<td>33</td>
<td>88</td>
<td>92</td>
</tr>
<tr>
<td>3 (2200 to 2299)</td>
<td>24</td>
<td>29</td>
<td>54</td>
<td>87</td>
</tr>
<tr>
<td>4 (2300 to 2399)</td>
<td>31</td>
<td>16</td>
<td>61</td>
<td>74</td>
</tr>
<tr>
<td>5 (2400 to 2499)</td>
<td>61</td>
<td>10</td>
<td>41</td>
<td>59</td>
</tr>
<tr>
<td>6 (2500 to 2599)</td>
<td>58</td>
<td>5</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>7 (2600 to 2699)</td>
<td>3</td>
<td>0</td>
<td>66</td>
<td>33</td>
</tr>
<tr>
<td>All (2000 to 2699)</td>
<td>222</td>
<td>15</td>
<td>55</td>
<td>67</td>
</tr>
</tbody>
</table>

1 For detailed description of the study area, and of the general characteristics of farms in the study area, please refer to the text in Chapter 2.
2 Whereas the study area is delineated into elevation zones, i.e., 100 m intervals beginning at the lower end of the study area near the village of Ngata extending upstream to the uppermost developed areas near the villages of Sigaon and Logomon.
3 Extension services are provided by extension specialists representing the Agriculture Extension Service, Kenyan Ministry of Agriculture. These values represent the percentage of on-site visits, visits to official demonstration sites, or formal training of respondents at other off-site locations.
4 Formal training in agronomic practices and/or livestock husbandry obtained by respondents to improve their farming practices; may include primary or secondary school training or experiences.
5 Whereas w/TD refers to land ownership with title deed, w/o TD means land ownership without holding title deed, and “Other” refers to some other form of residency arrangement.
6 These values represent the percent of extension visits relative to the respondents tenure status: i.e., of those respondents holding title deed to their land (w/TD), what percent of them received a visit from their extension agent; of those respondents not holding title deed to their land (w/o TD), what percent of them received a visit from their extension agent; of those respondents living on their farm under some other ownership arrangement (Other), what percent of them received a visit from their extension agent.
agricultural institute (i.e., university, college, technical institute) to learn new technologies, methods, or marketing opportunities. Of this group, 51 reported attending an official demonstration site at least once per year while another 43 respondents reported that they attend agricultural demonstration sites more than once per year. Formal training in agronomic methodologies and/or livestock husbandry was reported by 148 respondents; primarily these were family members in primary or secondary school.

Specifically, influence of ethnicity on access to extension services where 18 Kikuyu, about seven Kalenjin, five Ogiek, and three of the “other” group reported having been visited by their local extension agent. When delineated solely by ethnic group, the Kikuyu and “other” groups received considerably more attention from extension services than their Kalenjin and Ogiek counterparts in all categories. For respondents owning and holding title deed to their farms, most reported receiving extension visits whereas for those owning but not holding title deed, only a small number (n = 14.4) reported having an extension agent visit their farm. Only one to two respondents who did not own their farm reported visits to their farms by an extension agent (see Tables 3.9 and 3.10).

Summary

Examination of the data presented herein revealed patterns to be considered for improving our understanding of conditions and factors constraining smallhold farmers and their adoption of SWCPs. First, from a socioeconomic perspective, those farmers living in elevation zones 2, 3, and 4 generally report, having lived on their farms for longer periods of time, a higher number of households holding title deed to their lands, the distance to markets is less than at higher elevations, and they report greater income
from the three categories listed. They also report fewer children per household. When
delineated by ethnicity, the Kikuyu and “other” ethnic group predominate in these
elevation zones and concur with the settlement patterns described in Chapter 2.
Additionally, while family size did not differ significantly across elevation, the number of
children per household did increase as elevation increased. This factor may influence
several others such as access to labor and the amount of income available for
implementing SWCPs.

Second, access to water resources varies across elevation zones with those living
in zones reporting access to borehole water being greater than for those living at higher
elevations. This may have ramifications on the perceptions people held regarding water
quality for the different sources available to them. Moreover, the incidence of having no
toilet in the household was reported among those HoH living in elevation zone 4 and
above and increased with elevation.

Last, patterns in how people perceived soil characteristics emerged across the
study area. Slope was significantly less in elevation zones 2 and 3 and coincided with
perceptions of low soil erosion potential. Water holding capacity and soil productivity
tended to be reported as being incrementally higher as one moved upward in elevation
and where cropping of lands is a more recent activity. Generally, perceptions of soil
characteristics related to agronomic conditions generally improved as elevation increased.
The composition of livestock held on farms appears to be weakly related to farm size and
ethnic group preference.
INTRODUCTION

As previously described, soil and water resources are critical resources necessary for life and our survival. The loss of biodiversity via modification of landscapes and environmental degradation are increasing at a faster rate than ever before in human history. Throughout history, earth has become dominated by human settlement, thus making maintenance of healthy ecosystems increasingly critical for providing adequate supplies of clean water, soils, forage for livestock, and food security, which provide for a stable socioeconomic foundation. The condition of soil and water resources is closely related to human population density, resource extraction, and activities such as intensification of agriculture. Expansion of human populations has led to the alteration of these natural landscapes into urban settlements, agricultural systems (crops and livestock grazing) for food production, and harvest of natural resources (timber, minerals, etcetera) at an alarming rate. Therefore, protecting these resources against degradation is vital for maintaining healthy soils for food production, provision of regenerative ecosystem services for clean water and air resources, and maintenance of biodiverse landscapes.

Of particular concern herein is the intensification of agricultural activities on marginal lands where severe climatic regimes limit plant growth, and the endemic soil and water resource base are naturally susceptible to disturbance and degradation. Now that a foundation to describe the biophysical characteristics of the River Njoro has been
established (Chapter 3), I turn my attention to the examination of anthropocentric features of smallholder farm households. This comparative approach will provide the framework for examining why farmers choose to adopt conservation practices, especially when little technical or state support is available, and in the face of living in conditions of abject poverty. Through evaluation of Njoro farmers’ perceptions, values, and social system characteristics, we will further improve our ability to identify important anthropogenic conditions and constraints acting on smallhold farmers’ as they make SWCP adoption decisions. When coupled to the findings of Chapter 3, a general “Systems-Context” perspective of why SWCP adoption decisions are made may be possible.

Objectives and Hypotheses

The central objective of this chapter is to identify the underlying factors influencing small-scale farmers’ decision to adopt and implement Soil and Water Conservation Practices (SWCPs). By identifying why small-scale farmers adopt and implement SWCPs, and which explanatory factors are most important in influencing their decision to adopt, we will be better able to inform extension services and policy development and create improved watershed management programs. The results may facilitate protecting ecosystem services while simultaneously improving the livelihoods of the rural poor in developing areas of the world. Immediate applications include targeting limited funding towards the most critical natural resource conservation issues; assisting farmers in selecting and maintaining those SWCPs that are most practical and effective for their particular circumstances; and improving public policy to facilitate improved technical support for small-scale farmers.
Features of the Njoro farming system have been previously described in Chapter 3 where it was revealed that a highly altered landscape, impairment to water resources, and the heterogeneous social fabric of the Njoro watershed exists. From this knowledge, the following questions were asked concerning the behavior of the small-scale farmers: (1) Do they adopt SWCPs?; (2) why do they choose to adopt, or not adopt, certain SWCPs?; and (3) can adoption patterns be explained using adoption-diffusion theory?

A comprehensive literature review follows that concerns the adoption and diffusion of SWCPs in a developing world context. A review of adoption-diffusion theory was previously presented in Chapter 1. Based on both reviews, I hypothesized that level of education, level of income, land tenure status, access to extension information, and agroecological factors would be the predominant variables to explain adoption of SWCPs among farmers in the Njoro watershed. Land tenure status was expected to be an especially important factor. As previously reviewed in Chapter 2, the Njoro watershed appeared to be a chaotic environment due to the recent occupation of much of the watershed by a variety of displaced people representing several ethnic groups, especially at the higher elevations. I expected that uncertainty of land tenure could encourage less investment in the land by these recent occupants, and hence less implementation of SWCPs would be observed.
Soil and Water Conservation Practices (SWCPs)

To evaluate the degree of adoption and implementation of SWCPs by farmers in the Njoro, practices common to rural Kenya were considered (Thomas, 1988; Gichuki, 1992; Critchley et al., 1994; Tiffen et al., 1994, Cramb et al., 1999; Trumbo and O’Keefe, 2001). Fourteen SWCPs were considered during this study including intercropping, fallowing of farm- and pasture-lands, terracing (fanya juu), micro-catchments, accumulation of crop residues on the soil surface, bunding, agroforestry techniques, grass strips, contour tillage, ditches/trenches, manure application, cut-and-carry fodder, off-stream watering of livestock, and “other” indigenous methods. A few common SWCPs are illustrated in Figure 4.1.

Critchley et al. (1994) provided an in-depth review of SWCPs from all over the developing world. The authors’ draw upon examples from over 135 works examining various introduced and indigenous SWCPs. From their work one can presume that implementation of SWCPs is synonymous with soil erosion abatement. A variety of SWCPs were described including bunding\(^{10}\) with stone, grass-strips, and residue/stover lines placed perpendicular to the hill slope, conservation tillage practices, assorted terracing techniques, intercropping, and soil nutrient management (manure application). Various water-harvesting methods were also discussed such as trenches and ditches to divert water to/from farm fields, terracing, and micro-catchments (small basins dug into

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\(^{10}\) Bunds are defined as any material such as stone, stover, limbs, or a combination of these, bundled into rows or furrows and placed perpendicular to the hill slope to slow the movement of water on the land surface and to trap sediment.
Figure 4.1. Example of common SWCPs.
the soil) to capture and store run-off (Critchley et al., 1994; Tiffen et al., 1994; Cramb et al., 1999; Ellis-Jones and Tengberg, 2000; Trumbo and O’Keefe, 2001).

In Kenya, *fanya juu* is a commonly used method to slow the flow of overland water runoff and stop soil erosion in more arid regions and are part of an expansive collection of earthen terraces. *Fanya juu* consist of trenches cut perpendicular to the hill-slope with the soil thrown upslope side of the ditch, thus forming a small terrace across hill slopes (Thomas and Biamah, 1991; Tiffen et al., 1994). With repeated improvement, the terraces grow in height, consequently resulting in leveling off the field up-slope of the ditch and terrace (*sensu* paddy terraces found in rice-growing regions). These are very similar in function to the *bordos* used in México that are constructed by forming earth, and sometimes stone, into shallow terraces. Another example, found in Tanzania, is the practice of building “ladder terraces” where plant material (stover) is bunded, then covered with earth drawn from upslope (Temple, 1972; Thomas, 1988). These function to obstruct runoff while adding fertility from the decomposing plant materials in the bund. Trenches or ditches are also employed to divert water onto or away from farmlands, depending on climatic conditions, soil types, and infiltration rates.

Stone and stover bunding and terracing are frequently reported SWCPs in Ethiopia (Hallpike, 1972), Cameroon, China, Zimbabwe (Hallsworth, 1987), Rwanda (Lewis and Nyamulinda, 1996), and in Niger and Sudan (Reij et al., 1986; Reij, 1991). Stone bunds are comprised of everything from simple lines of stone placed perpendicular to the slope, to elaborate terrace structures that serve to capture surface runoff, reduce sediment transport away from fields, and to increase water infiltration into the soil. One
effective technique reported from Niger involves laying simple lines of stone in parallel or grid patterns to increase infiltration of precipitation as well as to capture wind-blown sand and soil (Reij, 1991). This effectively accumulates loess and sediment, thus bringing unproductive lands back into production by improving soil structure and increasing soil fertility and water holding capacity. “Trash lines” are another method of bunding in which plant materials and stover from cereal grain such as wheat, barley, oats, and/or legumes are banded and laid across the hill slope to slow or stop the flow of water and to trap sediment. The uses of these are reported in Uganda (Critchley, 1993) and Kenya (Gichuki, 1992).

The SWCPs based on living vegetation, however, are most common and include live fences or grass strips planted perpendicular to the hill slope or associated with terraces and tree rows. These have a long tradition in many areas of the world mainly for stabilizing soils and trapping sediment eroded from farm fields (Critchley et al., 1994). Various agroforestry practices include planting trees and bushes for fodder and wood products, as well as to enrich the soil by fixing atmospheric nitrogen; these have been widely adopted (Critchley et al., 1994). In some areas trees are planted along the edge of cultivated fields to reduce wind erosion and trap sediment due to water erosion. Live fences are another type of agroforestry technique using shrubs and cacti to slow the movement of water and soil from farmlands, while simultaneously acting as a barrier to livestock movement. Examples of live fences are found in Thomas (1988) for Kenya, Nyamulinda and Ngiruwonsanga (1992) for Rwanda, and Carson (1989) for Cameroon.
Common water-conservation measures include micro-catchment structures that trap runoff in small pits, thus enhancing infiltration into the soil. This method is called *matengo* in Tanzania (Hallsworth, 1987) and *tassa* in Niger (Reij *et al.*, 1986; Reij, 1991). In some areas stover is bunded and then formed into square or circle pit micro-catchments, then covered with soil dug from the center. Crop seed is typically planted on the perimeter of the micro-catchment to take advantage of the decomposing organic matter and enhanced soil moisture. Sometimes manure or other organic matter is amended to the bottom of the pit to further increase soil fertility.

Factors Affecting Adoption of Soil and Water Conservation Practices

Understanding why small-scale farmers’ adopt SWCPs is complex. Biophysical and socioeconomic factors are important in this process. The literature indicates that such factors include age, education level, gender, ethnicity, cultural influence and practices, household income, farm size, farm slope, land tenure, access to extension information, distance to markets, access to labor, attitudes and perceptions, and population density.

Berger (2001) examined innovation adoption dynamics and concluded that cost-benefit analyses or household-decision models alone could not explain the patterns here observed. Diffusion of innovations depends on the interactions among individual farm households which, in turn, determine the rate of information exchange. Interactions facilitate the probability of experiential learning by individuals because they then see innovations first hand (Berger, 2001) and are therefore better able to develop a belief in the potential benefit of adopting SWCPs (Bodnár *et al.*, 2006). Direct experience is likely
to be more important than, for example, farmer-to-farmer distribution of plant (seed) materials due to the long period necessary to see tangible results from implementation of most SWCPs (Berger, 2001).

In a study of programmatic approaches to successful adoption of SWCPs in southern Mali, Bodnár et al. (2006) found that farmers take several steps to learn about and accept innovations before they adopt them. First, they must have an awareness of particular problems affecting their land (i.e., recognizing soil erosion symptoms or water quality impairments), and they must be willing to undertake measures to correct the root problem(s) that cause such problems. Farmers then need to recognize what the possible solutions are and be able to acquire the skills to install these corrective measures. Most importantly, they need to believe in the potential benefits of SWCP implementation before any are undertaken (Bodnár et al., 2006).

However, farmers may also be hindered by the complexity or social acceptability of an innovation (Napier, 1991; de Graaff, 1996). Restricted access to necessary inputs, short-term expense, low financial returns, or high risks may discourage adoption of innovations (Napier, 1991; de Graaff, 1996). In support of these views, Cramb et al. (1999) found that household-level cash flow, rather than access to labor, was considered to be a more important explanatory factor for adoption when on- and off-farm income streams were accounted for.

Anley et al. (2007) analyzed 101 smallholder farmers in western Ethiopia and found that farmers’ conservation decisions, and the utilization rate of both improved and traditional soil conservation measures, were influenced by a host of social, economic,
institutional, and agroecological factors. These included age, level of formal education in the household, farm size, tenure security, labor availability, number of extension visits, and natural resource management policy. In this study, age of the head of household (HoH) showed a significant, but negative, effect on use of soil bunding methods; older farmers were less likely to adopt innovations, probably due to shorter planning horizons and inability to invest the required labor in implementation (Anley et al., 2007). The ratio of land size to (available) labor, education level of the HoH, distance of the farm plot from the household, and slope angle of farm fields all had significant, positive influences on the use of improved soil conservation measures (i.e., soil bund, ditch/trench cut-off drain, and terracing (*fanya juu*)). Farmers who had better access to extension services and improved soil conservation measures invested significantly more in building ditches, trenches, and *fanya juu* (Anley et al., 2007).

Several studies cite a positive correlation between level of education and number of SWCPs adopted, therefore indicating that formal education is an important variable explaining adoption behavior (Asrat et al., 2004; Tenge et al., 2004; Anley et al., 2007). It is inferred in these studies that higher levels of education facilitate the individual’s capacity to learn and to make informed decisions (Anley et al., 2007). Bodnár et al. (2006) also found that several steps were essential to learning about and accepting innovations, i.e., awareness of the particular problems, ability to recognize possible solutions, and ability to acquire the skills necessary to implement corrective measures. Bodnár et al. (2006) determined that belief in the potential benefits of SWCP implementation is also a necessary condition. Hence, the capacity to learn and
experiential learning (i.e., years on farm or other observational experiences) become important functional proxies for education level or measures of experience, per se.

Agricultural extension services play an important role in the diffusion of innovations and should not only diffuse new messages and technologies but should remain actively involved in assisting the adoption process (Holt and Schoorl, 1985). They argue that extension services serve as the technical backstop for the initial trial-and-error period when adopting an innovation, in assuring the quality of implementing the SWCP (maintenance), and reassuring farmers during the retirement of old techniques (obsolescence) with newer innovations or techniques. Holt and Schoorl (1985) also indicated that extension services are important for training new participants (innovation – adoption), for maintaining high quality soil erosion control measures (sustained involvement), and for implementing a broad range of natural resource management services in addition to soil and water conservation practices. The findings of Asrat et al. (2004) also support these observations.

This give emphasis to the importance of developing human capital, via education and extension services, for increasing adoption and use of soil conservation technologies, and for developing policies that improve extension services for diffusing information (Anley et al., 2007). Distinguishing between initial adoption and implementation of SWCPs from sustained use of the practice is also an important factor in the analysis of innovation adoption. Initial adoption, or the adoption decision, is mainly determined by the capacity of the farmer to install SWCPs (Gebremedhin and Swinton, 2003), whereas
initial maintenance of the SWCP may be directly related to the level of proactive involvement by extension personnel (Anley et al., 2007).

Asrat et al. (2004) investigated farmers’ willingness to pay for soil conservation practices in the highlands of southeast Ethiopia where soil degradation is a serious problem. Using 17 variables, they investigated a farmer’s willingness to adopt SWCPs using a dichotomous choice and open-ended question format developed by Albertini and Cooper (2000). Data from 100 randomly selected households were analyzed using logistic regression and descriptive statistics. Their findings indicate that four variables had a positive influence on farmers’ willingness to invest; these were level of soil erosion awareness, education level of the head of household, attitude toward soil conservation technology, and awareness of technical assistance. Variables determined to be not statistically significant included age, ratio of dependants to household size, amount of off-farm income, tenure security, access to technical assistance, gender of the HoH, and total number of livestock units held. It was concluded that investments in extension services and increasing farmer education were most likely to improve farmers’ willingness to invest in SWCPs (Asrat et al., 2004).

On agricultural lands of the Usambara Highlands of Tanzania, several investigators examined factors affecting adoption of SWCPs where soil erosion and loss of fertility were reported (Pfeiffer, 1990; Kaswamila and Tenge, 1998; Tenge et al., 2004). Farming systems were characterized as mixed livestock and rain-fed agriculture in the uplands, traditional irrigation systems in valley bottoms, and other off-farm activities. Focus group discussions, household surveys, and farm-level transect walks were
undertaken on 104 farms. Farmers who practiced some form of SWCP were grouped as “adopters,” and those farmers who did not engage in any form of SWCP were classified as “non-adopters” (Tenge et al., 2004). Comprehensive sets of factors were examined including: (1) Those attributable to the household (i.e., age, gender, education level, ethnic affiliation, marital status, perception of soil erosion as a problem, wealth, location in the watershed, type of agriculture (rain-fed or irrigated), livestock keeping, availability of labor, and land tenure); and (2) those external to the household (i.e., access to technical information, contact with extension agents, membership in labor-sharing groups, access to markets, and receipt of remittances). Tenge et al. (2004) concluded that higher levels of formal education and land tenure security were significant factors positively influencing farmers’ decisions to adopt SWCPs. Conversely, involvement in off-farm income generation, fragmentation of land (fields in multiple locations), and lack of perceived short-term benefits (e.g., profit, increased yield, soil improvement) to the farmer negatively influenced adoption of SWCPs (Tenge et al., 2004).

Using case studies of upland conservation farming programs in the Philippines, most notably Sloping Agricultural Land Technology (SALT), Cramb et al. (1999) examined technical and socioeconomic factors that limited adoption of soil conservation technologies. They evaluated farm-level attributes and personal perceptions of farmers, and the consequences of adopting a soil conservation technology at the farm level. Generally, personal attributes such as age and gender were not important explanatory factors for explaining willingness to adopt. One caveat noted, however, was that older and/or female members of the community were less able to, or less interested in, adopting
SWCPs when strenuous labor was involved (Cramb et al., 1999). Awareness of soil erosion had an influence on individual adoption rates due to perceived benefits and experiential differences. Farm-specific factors such as slope, soil type (erosion potential), location of fields, and size of farm holdings were important in explaining adoption of soil conservation practices due to farmer’s experience with their soil resources. On steep slopes (i.e., 5 to 50 percent), the farmers’ level of experience alone overpowered all other potential explanatory variables (Cramb et al., 1999). Moreover, investment in physical soil-conserving technologies becomes more attractive as the size of cultivable land increases; that is, farmers make greater investment in soil conservation investment on large land holdings. This suggests that return on investment, or relative cost-benefit, is important (Anley et al., 2007). These findings imply that, by promoting a strategy of targeting specific soil-conserving technologies toward specific biophysical and socioeconomic conditions (context), overall soil erosion abatement may result (Bodnár et al., 2006; Anley et al., 2007).

Land tenure is a complex and often ill-defined issue in developing countries, especially where varied cultural perceptions of ownership are involved. Rights of tenure (i.e., title deed) and perceived tenure security are thought to be strong indicators of a farmer’s attitude and willingness to implement SWCPs. In several studies, tenure was found to be a significant explanatory variable influencing farmers’ decisions to adopt SWCPs (Gebremedhin and Swinton, 2003; Tenge et al., 2004; Kabubo-Mariara, 2007). However, other authors offer a competing view in reporting that land tenure is not a strong indicator of adoption behavior (Place and Swallow, 2000; Asrat et al., 2004;
Neoclassical theorists have suggested that traditional tenure systems in Africa are inefficient because of communal land-use histories and lack of individual rights to land ownership (Barrows and Roth, 1990). This suggests that an individual’s accountability for maintenance of land resources (e.g., soil, vegetation, or water resources) is assigned a low value by the community and/or culture. These competing reports illustrate the complexity of tenure as an explanatory variable and suggest that other endogenous and exogenous factors interact with tenure to influence a farmer’s adoption decisions.

In Ethiopia, Asrat et al. (2004) found that formal land ownership (holding the title deed) was not a significant factor in farmers’ willingness to pay for SWCPs. This was due to the farmers’ confidence in having long-term access to lands despite the lack of title deed. Research by Hagos and Holden (2006) on the influence of tenure security on farm-level investments supports Asrat et al.’s (2004) findings that tenure security has a weaker influence on willingness to invest than perceptions of return on investment and improved crop yields. This argument is supported by the findings of Place and Swallow (2000) that the relationships between property rights and technology adoption are complicated in several respects. They hypothesize that the nature of the technology or investment will affect the relationships between adoption and property rights (tenure security).

Adoption of innovations may occur even in insecure tenure situations if overall short-term costs are low and benefits accrue quickly (Place and Swallow, 2000). The degree of tenure insecurity is expected to have greater influence on incentives to invest in and adopt difficult-to-implement SWCPs such as terracing, fencing, water harvesting,
agroforestry, and fallowing. Conversely, the effect of insecure tenure is not necessarily pervasive; high-expected profits can overcome the negative incentives that result from insecure property rights (Place and Swallow, 2000). Cramb et al. (1999) found that the issue of land tenure was important but highly inconsistent and heavily influenced by individual farmers’ belief in their secure tenancy rather than actual ownership.

In contrast, other research reports high correlation between levels of land (tenure) security and the decision to adopt SWCPs (Gebremedhin and Swinton, 2003; Tenge et al., 2004). Kabubo-Mariara (2006; 2007) found that farmers in Kenya were more likely to adopt land-conservation practices as their level of tenure security increased. This was particularly true of conservation practices that required more labor intensive inputs or required larger capital investments, where long-term benefits take time to accrue.

Increasing level of uncertainty results when an innovation presents a different suite of problems to be solved by the farmer (Rogers, 2003). Overcoming this uncertainty is a critical step in the adoption process as individuals must gather information, whether by direct experience or instruction, or indirectly by learning from peers, before the innovation is fully accepted (Rogers, 2003). Thus, diffusion is essentially a social process of communicating subjectively perceived information from individual to individual (Rogers, 2003). Cramb et al. (1999) also found that farmer-specific (agroecological) circumstances, rather than personal perceptions or attitudes, served as primary constraining factors to adoption of conservation programs and practices. Their experience with an innovation likely substantiates their sustained use of the innovation; therefore, they become the conduit of information exchange about the innovation for their peers.
Income generation from on-farm and off-farm sources (total income), access to markets, and access to credit are generally reported as important ancillary variables in the process of innovation adoption. Cramb et al. (1999) found that household-level cash flow, rather than access to labor, was considered an important explanatory variable for adoption when on- and off-farm income was accounted for. Income was also reported as an important variable in previous work (Blase, 1960; Ervin and Ervin, 1982; Cramb et al., 1999). Others indicate, however, that limited access to necessary inputs, overall expense of inputs, or low financial returns may hinder innovation adoption (Napier, 1991; de Graaff, 1996).

Farmers’ awareness of soil characteristics affecting their decisions to adopt innovations is widely reported as an important factor influencing the adoption decision (Barrows and Roth, 1990; Pfeiffer, 1990; Cary and Wilkinson, 1997; Kaswamila and Tenge, 1998; Cramb et al., 1999; Beedell and Rehman, 2000; Makokha et al., 2001; Asrat et al., 2004; Tenge et al., 2004). In particular, awareness of the ramifications of slope angle and potential soil erosion, and the individuals’ perceptions and attitudes toward soil erosion based on personal experiences and perceived ability to control erosion, were important (Cramb et al., 1999). An individual’s experiential knowledge of his/her land (soil type, soil fertility, and climate) may play as important a role in adoption of SWCPs as any other measure such as income, access to market and extension services, available labor, or land title deed (Barrows and Roth, 1990; Cary and Wilkinson, 1997; Beedell and Rehman, 2000). These authors generally conclude that individual farmer perceptions and attitudes toward soil erosion, based on their personal experiences and
perceived ability to control these problems (context), are important factors to consider when promoting SWCPs. In this vein, a fuller understanding of the context in which farmers operate is instructive for gaining perspective into their decision processes. Identifying explanatory factors within the context of the farmers’ environment is the key to understanding an individuals’ adoption behavior, i.e., “behavior is a function of consequences” (\textit{sensu} Chance, 1999; Pierce and Cheney, 2004).

Methods

Sample Selection

This study focused exclusively on small- (less than 2.0 ha) to medium-scale (2.0 to 20 ha) farms located along a 25 kilometer (km) reach of the River Njoro. The geography of the study area included two large tributary drainages located above Nessuit, the Sigaon and the Luguma, as well as the main stem of the river downstream to the village of Ngata. The target population lived on approximately 2,500 farms lying within 500 m of either side of the river thalweg, henceforth called riparian farms. Riparian farms were chosen as the focus of the study due to their proximity to the river and the potential for significant impacts to water resources in the Njoro. See Chapter 3 for a description of the farming system and Appendix B for a copy of the survey instrument.

Data Collection

Data were collected on the use of 14 SWCPs. A list of these was presented on page 87. Survey questions focused on explanatory factors that might influence farmer’s decisions to adopt or not adopt a specific practice. Answers to questions regarding both
knowledge of and implementation of the specific practice were recorded using dichotomous (Yes/No) options, stakeholder narratives, and responses using a Likert-scale (Likert, 1932; Babbie, 1999). As reported in Chapter 3, after the approximately 1.5 hour interview, a farm “walk-about” was conducted in the company of the HoH to visually verify biophysical features of the farm and to verify that SWCPs discussed during the interview had been implemented. These “walk-abouts” took on average about 0.5 hours.

Data Analyses

Data were analyzed using S-PLUS v. 6.2 (Insightful Corp., 2003) and R v. 2.5.0 (The R Foundation for Statistical Computing, 2007) statistical software packages. First, descriptive statistics were generated in S-PLUS for all categorical and numeric variables, and then contingency tables were used to screen data for statistical significance and strength of association. Forty-five independent variables were analyzed in terms of their effects on the adoption rates for each of the 14 benchmark SWCPs as well as the adoption rate for all SWCPs (Zar, 1999). The data were then evaluated using the Chi-square ($\chi^2$) analytical test to screen for statistical significance among two or more variables prior to their use in further analyses (Zar, 1999; Ritchie, 2000). The $\chi^2$ analytical test evaluates the relationship of two variables and the frequency of joint occurrences as an attribute of the variables. The relationship between two nominal variables is analyzed by using a cross-tabulation table; this provides the frequencies of joint occurrence of attributes for a single individual (Zar, 1999; Ritchie, 2000). Due to the nature of the data, a p-value of 0.25 was chosen as the benchmark for selection of explanatory variables. These were then screened to make certain that each was a reasonable indicator of SWCP adoption—
in other words, did the variable make sense? In all, 33 explanatory variables were selected for further analysis. See Table 4.1.

Classification and regression tree (TREE) analytical methods developed by De’ath and Fabricius (2000), and modified by Susan Durham (personal communication), were used to examine the data for relationships and identify which explanatory variables were most likely to explain farmers’ adoption decisions. The methods used in TREE analysis are a form of multivariate analysis well suited for examining complex, nonparametric data sets. This statistical technique is ideal for exploring, describing, and modeling complex data (Zhang and Singer, 1999; De’ath and Fabricius, 2000). These methods provide a flexible, robust method of examining nonlinear data, data having high-order interactions, and data sets with missing values. This type of analysis can assist researchers by quantifying interrelated factors that may explain relationships between two or more variables or multiple sets of variables. The response variable is usually categorical or numeric in nature, while the explanatory variables may be categorical, numeric, or a combination of both. Analytical results are represented in an easy to understand graphic (dendrogram) and provide an alternative method to many traditional statistical techniques such as multiple regression, ANOVA, logistic regression, Bayes decision process, and log-linear models (De’ath and Fabricius, 2000; S. Durham, pers. comm.). Additional information (i.e., summary statistics, distribution plots) may be illustrated on the tree graphic to aid interpretation (De’ath and Fabricius, 2000).
Table 4.1. Factors or variables used for TREE analysis

<table>
<thead>
<tr>
<th>Household Features</th>
<th>Farm Characteristics</th>
<th>Income / Socioeconomic</th>
<th>Water / Watershed Characteristics</th>
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<tr>
<td>HoH Gender</td>
<td>Farm Size</td>
<td>Access to Credit</td>
<td>Water Quality</td>
</tr>
<tr>
<td>HoH Level of Education</td>
<td>Primary Crop</td>
<td>Total Income</td>
<td>Water Quality for Washing</td>
</tr>
<tr>
<td>Average Level of Education of the Household</td>
<td>Primary Livestock</td>
<td>Off-Farm Income</td>
<td>Water Quality for Drinking</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>Soil Erosion Observed</td>
<td>Does Farm Provide all Food Needs</td>
<td>Acts that Impaired Water Quality</td>
</tr>
<tr>
<td>Years Lived on Farm</td>
<td>Soil Erosion Potential</td>
<td>Distance to Market</td>
<td>Elevation Zone</td>
</tr>
<tr>
<td>Cultural Effects</td>
<td>Type of Tillage</td>
<td>Perceived Tenure</td>
<td>Slope of Farm</td>
</tr>
<tr>
<td>Religious Effect</td>
<td>Perception of Soil Water Holding Capacity</td>
<td>Tenure Corrected</td>
<td>Unusual Soil Features</td>
</tr>
<tr>
<td>Illness</td>
<td>Access to Extension</td>
<td>Labor Features</td>
<td>Type of Toilet</td>
</tr>
</tbody>
</table>

Attend Off-farm Extension Demonstration
This form of TREE methodology utilizes recursive partitioning, a statistical technique, to divide the data set into more and more homogenous subsets with the ideal result being the formation of some number of subsets of the data with the least amount of impurity or greatest homogeneity (Urban, 2004). Hence, the quality of the tree is directly related to the quality of the information within the terminal nodes (Zhang and Singer, 1999). A classification or regression tree is grown from the top-down to form what looks like the root structure of a tree (Breiman et al., 1984). The trunk, at ground level, forms the root node, with each major root, or branch, leading to a daughter node. Partitioning of the data continues either until no further splitting occurs, because the node contains only one subject, or because the minimum size (set a priori) of the node is attained. The partitioning process is the same for all nodes in the tree. The terminal nodes (leaves) form the basis for developing statistical inference to explain or predict an outcome or event that is in question, i.e., a method for discovering explanatory variables within the dataset (Zhang and Singer, 1999).

Three basic tenets form the basis for efficiently selecting the “best” or optimal tree size: pruning, resubstitution estimate of error, and cross validation (Breiman et al., 1984; De’ath and Fabricius, 2000). Pruning is a process of growing a saturated tree then pruning from the bottom-up until an optimally sized tree results. Resubstitution error refers to examination of a sequence of nested sub-trees, from an initial over-large tree down to the root tree (no splits), then selecting the tree that minimizes the resubstitution estimate of error. Finally, cross-validation is a method of finding an optimally pruned tree by obtaining more precise estimates of prediction error (Breiman et al., 1984). This is
done by fitting the model to a full (saturated) tree and computing a complexity cost (cp). Then the full data set \(S\) is divided into \(n\) subsets \(S_1, S_2, S_3 \ldots S_n\) (typically \(n = 10\)), and the model is then fitted to all subsets. Afterwards, the full model is fitted to all subsets minus one (all except \(S_i\)) until all subsets have been tested. During this 10-fold cross-validation, a cp is computed for each subset and used to determine a mean cp for all cross-validations. This value is used to choose the best, or optimal, tree size. Applied sequentially, these three processes produce the smallest tree size that reliably explains variation of single independent variables within the data set. Obviously, this is a complicated process.

In actual practice, the researcher may select an optimal tree size based on either the minimum cross-validation error or the 1-standard error (1-SE) rule (Breiman et al., 1984). The 1-SE rule represents the smallest estimated error that is within one-standard error of the minimum error for each tree size. By using the 1-SE rule, much smaller trees can result than is suggested by the cross-validation error with minimal increases in estimated error rate (Breiman et al., 1984; De’ath and Fabricius, 2000). Empirical evidence indicates that trees selected using the 1-SE rule more often than not are more robust than those selected using the minimum error rule (Zhang and Singer, 1999). At least five individuals had to be present at each node to split, and at least five individuals had to be present at each terminal node; the 1-SE rule was used for this analysis.
Results

Adoption of SWCPs

When delineated by ethnicity, Table 4.2 illustrates that the average total number of SWCPs implemented differed among ethnic groups. Ethnic groups can be consolidated into two; the Kikuyu and “other” ethnic groups tended to have similar adoption rates, versus the Kalenjin and Ogiek. This was particularly true of labor intensive SWCPs (i.e., *fanya juu*, micro-catchments, ditches, cut-and-carry fodder) and those requiring a longer term to implement and realize a benefit (i.e., agroforestry, grass strips, manure application, off-stream watering of livestock). Overall, for total SWCPs, the Kikuyu and “other” group showed rates for implementation of 7.5 and 7.0, respectively, whereas the Kalenjin and Ogiek had rates of 6.0 and 6.2.

General trends of SWCPs adoption as delineated by elevation zone are presented in Table 4.3. All respondents had implemented some form of SWCPs on their farms; the overall average number of practices implemented was 6.5 practices (Figure 4.2 (minimum of two, maximum of 12). Respondents’ awareness of the 14 individual SWCPs was generally good; all but three practices (*fanya juu*, micro-catchments, and bunding) were known to greater than 80 percent of respondents. Six SWCPs were reportedly implemented (and confirmed by observation) on at least 65 percent of farms surveyed; these SWCPs were intercropping (94 percent), contour tillage (85 percent), collection and spreading manure (77 percent), agroforestry practices (73 percent), leaving plant residue on the soil surface (72 percent), and cut and carrying fodder for livestock (65 percent). Conversely, the remaining eight SWCPs were implemented at much
Table 4.2. Profile of Soil and Water Conservation Practice (SWCPs) adoption by ethnic group

<table>
<thead>
<tr>
<th>Explanatory Variable</th>
<th>Sample Size (n)</th>
<th>Farm Size (ha)</th>
<th>Total SWCPs ± 95% C.I.</th>
<th>Intercrop (%)</th>
<th>Contour Tillage (%)</th>
<th>Manure Application (%)</th>
<th>Agro-forestry (%)</th>
<th>Cut &amp; Carry Fodder (%)</th>
<th>Off-Stream Watering (%)</th>
<th>Grass Strip (%)</th>
<th>Fallow (%)</th>
<th>Ditch / Trench (%)</th>
<th>Bundling (%)</th>
<th>Other (%)</th>
<th>Fanya Juu (%)</th>
<th>Micro-catchments (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kalenjin</td>
<td>85</td>
<td>2.5±0.40b</td>
<td>6.0±0.40a</td>
<td>95</td>
<td>88</td>
<td>65</td>
<td>62</td>
<td>81</td>
<td>62</td>
<td>31</td>
<td>33</td>
<td>21</td>
<td>20</td>
<td>14</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>Kikuyu</td>
<td>61</td>
<td>1.8±0.78ab</td>
<td>7.5±0.46c</td>
<td>92</td>
<td>80</td>
<td>92</td>
<td>56</td>
<td>82</td>
<td>56</td>
<td>57</td>
<td>28</td>
<td>41</td>
<td>21</td>
<td>15</td>
<td>26</td>
<td>13</td>
</tr>
<tr>
<td>Ogiek</td>
<td>70</td>
<td>3.0±0.40b</td>
<td>6.2±0.50ab</td>
<td>97</td>
<td>86</td>
<td>79</td>
<td>71</td>
<td>77</td>
<td>54</td>
<td>41</td>
<td>23</td>
<td>41</td>
<td>19</td>
<td>16</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>6</td>
<td>0.8±0.76a</td>
<td>7.0±2.48a</td>
<td>67</td>
<td>83</td>
<td>83</td>
<td>67</td>
<td>50</td>
<td>67</td>
<td>50</td>
<td>0</td>
<td>83</td>
<td>17</td>
<td>17</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>All</td>
<td>222</td>
<td>2.4±0.30b</td>
<td>6.5±0.28a</td>
<td>94</td>
<td>85</td>
<td>77</td>
<td>73</td>
<td>72</td>
<td>65</td>
<td>42</td>
<td>37</td>
<td>29</td>
<td>27</td>
<td>16</td>
<td>15</td>
<td>9</td>
</tr>
</tbody>
</table>

1 For detailed description of the general characteristics of each SWCP, please refer to the text on page 87.
2 Ethnicity reported is inclusive of the major ethnic groups living within the study area. Please refer to page 60 of the text for details.
3 Whereas total SWCPs represents the average number of conservation practices, ± 95 % confidence interval (C.I.), adopted and implemented by each of the ethnic groups indicated. Entries followed by the same letter (a, b, c, . . .) are not significantly different (p ≤ 0.05).
4 Each cell value represents the percentage of the indicated ethnic population who adopted and implemented the SWCPs indicated.
<table>
<thead>
<tr>
<th>Elevation Zone (masl)</th>
<th>Sample Size (n)</th>
<th>Total SWCPs</th>
<th>Intercrop (%)</th>
<th>Contour Tillage (%)</th>
<th>Manure Application (%)</th>
<th>Agro-forestry (%)</th>
<th>Plant Residue (%)</th>
<th>Cut &amp; Carry Fodder (%)</th>
<th>Off-Stream Watering (%)</th>
<th>Grass Strip (%)</th>
<th>Fallow (%)</th>
<th>Ditch / Trenching (%)</th>
<th>Bunding (%)</th>
<th>Other (%)</th>
<th>Fanya Juu (%)</th>
<th>Micro-catchments (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (2000 to 2099)</td>
<td>18</td>
<td>8.0±0.76^cd</td>
<td>89</td>
<td>94</td>
<td>94</td>
<td>100</td>
<td>61</td>
<td>78</td>
<td>28</td>
<td>78</td>
<td>28</td>
<td>33</td>
<td>28</td>
<td>50</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>2 (2100 to 2199)</td>
<td>27</td>
<td>7.1±0.82^bcd</td>
<td>97</td>
<td>85</td>
<td>81</td>
<td>93</td>
<td>52</td>
<td>70</td>
<td>37</td>
<td>48</td>
<td>41</td>
<td>48</td>
<td>11</td>
<td>15</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>3 (2200 to 2299)</td>
<td>24</td>
<td>7.6±0.84^d</td>
<td>83</td>
<td>79</td>
<td>100</td>
<td>87</td>
<td>58</td>
<td>92</td>
<td>71</td>
<td>46</td>
<td>21</td>
<td>54</td>
<td>29</td>
<td>12</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>4 (2300 to 2399)</td>
<td>31</td>
<td>6.7±0.62^bcd</td>
<td>94</td>
<td>87</td>
<td>84</td>
<td>64</td>
<td>71</td>
<td>64</td>
<td>39</td>
<td>19</td>
<td>23</td>
<td>26</td>
<td>19</td>
<td>6</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>5 (2400 to 2499)</td>
<td>61</td>
<td>5.6±0.48^f</td>
<td>97</td>
<td>85</td>
<td>67</td>
<td>66</td>
<td>77</td>
<td>49</td>
<td>31</td>
<td>20</td>
<td>16</td>
<td>18</td>
<td>11</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6 (2500 to 2599)</td>
<td>58</td>
<td>6.1±0.51^ab</td>
<td>97</td>
<td>83</td>
<td>67</td>
<td>65</td>
<td>84</td>
<td>65</td>
<td>36</td>
<td>33</td>
<td>28</td>
<td>19</td>
<td>10</td>
<td>17</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>7 (2600 to 2699)</td>
<td>3</td>
<td>6.0±2.00^bcd</td>
<td>100</td>
<td>100</td>
<td>67</td>
<td>33</td>
<td>100</td>
<td>67</td>
<td>67</td>
<td>33</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>All (2000 to 2699)</td>
<td>222</td>
<td>6.5±0.28^ab</td>
<td>94</td>
<td>85</td>
<td>77</td>
<td>73</td>
<td>72</td>
<td>65</td>
<td>42</td>
<td>37</td>
<td>29</td>
<td>27</td>
<td>16</td>
<td>15</td>
<td>9</td>
<td>5</td>
</tr>
</tbody>
</table>

1 For details of the general characteristics of farms in the study area, please refer to the text on page 70. SWCPs are presented in order of rate of adoption, from highest or most frequently adopted to least adopted.
2 Whereas the study area is delineated into elevation zones, i.e., 100 m intervals beginning at the lower end of the study area around the village of Ngata, extending upstream to the uppermost developed areas near the villages of Sigaon and Logomon.
3 Whereas total SWCPs represents the average number of practices, ± 95% confidence interval (C.I.), adopted within the elevation zone indicated. Entries followed by the same letter (a, b, c, . . .) are not significantly different (p ≤ 0.05).
4 The values given represent the percentage of respondents at each elevation zone who adopted and implemented the practice indicated. For detailed description of SWCPs, please refer to page 87 of the text.
Figure 4.2. Average number of SWCPs adopted.
reduced frequency (42 to 5 percent); these included off-stream watering of livestock, grass-strips, fallow land, ditches/trenches, bunding, other (indigenous conservation methods), *fanya juu*, and micro-catchments.

Table 4.4 illustrates the minor differences in adoption rates based on gender. Farm size was slightly smaller for female HoHs than for male HoHs, and the total number of SWCPs and individual SWCPs adopted was on average slightly lower for women than for men. Exceptions to this were manure collection and application and off-stream watering of livestock, and fallowing land where women implement these practices at a slightly higher frequency. Table 4.5 provides an overview of the influence of other socioeconomic factors on the adoption of SWCPs. Regarding tenure status, a possible trend exists for adoption of SWCPs among all ownership categories. More SWCPs are adopted by those HoHs holding title deed than for those who did not hold title deed; this difference is statistically significant. A trend is observed whereby more SWCPs are adopted as length of residency (years on farm) increases and as farm size increases; however, neither of these relationships is statistically significant.

The data in Table 4.5 also suggest that distance to market may have an influence on the total number of SWCPs adopted; as a farmer must travel further to market, there is a trend to adopt fewer SWCPs. These values are not significantly different, however. Having access to credit resulted in slightly higher numbers of SWCPs being adopted; this was also statistically significant. Having exposure to extension services also had a minor positive influence on rates of adoption. Farmers who had been visited by an extension agent appeared to adopt more total SWCPs than those who had not, but this relationship
Table 4.4. Profile of Soil and Water Conservation Practice (SWCPs) adoption by Head of Household (HoH) gender ¹

<table>
<thead>
<tr>
<th>Explanatory Variable</th>
<th>Sample Size (n)</th>
<th>Farm Size (ha)</th>
<th>Total SWCPs ²</th>
<th>Intercrop (%) ³</th>
<th>Contour Tillage (%) ³</th>
<th>Manure Application (%) ³</th>
<th>Agro-forestry (%) ³</th>
<th>Plant Residue (%) ³</th>
<th>Cut &amp; Carry Fodder (%) ³</th>
<th>Off-Stream Watering (%) ³</th>
<th>Grass Strip (%) ³</th>
<th>Fallow (%) ³</th>
<th>Ditch / Trench (%) ³</th>
<th>Bunding (%) ³</th>
<th>Other (%) ³</th>
<th>Fanya Juu (%) ³</th>
<th>Micro-catchments (%) ³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female HoH</td>
<td>36</td>
<td>1.9±0.56⁴</td>
<td>5.9±0.62⁷</td>
<td>94</td>
<td>69</td>
<td>83</td>
<td>72</td>
<td>58</td>
<td>58</td>
<td>47</td>
<td>27</td>
<td>33</td>
<td>22</td>
<td>14</td>
<td>6</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Male HoH</td>
<td>186</td>
<td>2.5±0.34⁴</td>
<td>6.6±0.30⁷</td>
<td>94</td>
<td>88</td>
<td>76</td>
<td>74</td>
<td>75</td>
<td>67</td>
<td>41</td>
<td>39</td>
<td>28</td>
<td>28</td>
<td>17</td>
<td>17</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>All</td>
<td>222</td>
<td>2.4±0.30⁴</td>
<td>6.5±0.28⁷</td>
<td>94</td>
<td>85</td>
<td>77</td>
<td>73</td>
<td>72</td>
<td>65</td>
<td>42</td>
<td>37</td>
<td>29</td>
<td>27</td>
<td>16</td>
<td>15</td>
<td>9</td>
<td>5</td>
</tr>
</tbody>
</table>

¹ For detailed description of the general characteristics of each SWCP, please refer to the text on page 87.
² Whereas total SWCPs represents the average number of practices, ± 95 % confidence interval (C.I.), each gender group adopted and implemented. Entries followed by the same letter (a, b, c, . . .) are not significantly different (p ≤ 0.05).
³ Each cell value represents the percentage of each gender group that adopted and implemented the SWCPs indicated.
Table 4.5. Profile of Soil and Water Conservation Practice (SWCPs) adoption compared to tenure status, distance to market, access to credit, and access to extension services

<table>
<thead>
<tr>
<th>Explanatory Variable</th>
<th>Sample Size (n)</th>
<th>Farm Size (ha)</th>
<th>Total SWCPs</th>
<th>Intercrop (%)</th>
<th>Contour Tillage (%)</th>
<th>Manure Application (%)</th>
<th>Agro-forestry (%)</th>
<th>Cut &amp; Carry Fodder (%)</th>
<th>Off-Stream Watering (%)</th>
<th>Grass Strip (%)</th>
<th>Fallow (%)</th>
<th>Ditch / Trench (%)</th>
<th>Bundling (%)</th>
<th>Other (%)</th>
<th>Fanya Juu (%)</th>
<th>Micro-catchments (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenure Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>w/ TD</td>
<td>59</td>
<td>2.7±0.90b</td>
<td>7.5±0.50b</td>
<td>93</td>
<td>83</td>
<td>97</td>
<td>92</td>
<td>53</td>
<td>83</td>
<td>54</td>
<td>54</td>
<td>32</td>
<td>42</td>
<td>19</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>w/o TD</td>
<td>145</td>
<td>2.4±0.26b</td>
<td>6.2±0.32b</td>
<td>94</td>
<td>88</td>
<td>69</td>
<td>72</td>
<td>79</td>
<td>58</td>
<td>36</td>
<td>31</td>
<td>30</td>
<td>21</td>
<td>17</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>Other</td>
<td>18</td>
<td>1.3±0.48b</td>
<td>5.6±0.90b</td>
<td>94</td>
<td>82</td>
<td>78</td>
<td>28</td>
<td>83</td>
<td>67</td>
<td>50</td>
<td>28</td>
<td>6.0</td>
<td>22</td>
<td>11</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>&lt; 1 km</td>
<td>46</td>
<td>1.7±0.60b</td>
<td>7.2±0.62b</td>
<td>89</td>
<td>80</td>
<td>91</td>
<td>80</td>
<td>65</td>
<td>83</td>
<td>52</td>
<td>48</td>
<td>15</td>
<td>46</td>
<td>26</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>1 - 2 km</td>
<td>48</td>
<td>2.1±0.54a</td>
<td>6.7±0.58a</td>
<td>98</td>
<td>83</td>
<td>85</td>
<td>90</td>
<td>69</td>
<td>63</td>
<td>42</td>
<td>44</td>
<td>31</td>
<td>35</td>
<td>10</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>Distance to Market</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 - 3 km</td>
<td>65</td>
<td>3.2±0.74a</td>
<td>6.2±0.48a</td>
<td>94</td>
<td>92</td>
<td>71</td>
<td>65</td>
<td>72</td>
<td>54</td>
<td>42</td>
<td>28</td>
<td>34</td>
<td>20</td>
<td>18</td>
<td>11</td>
<td>62</td>
</tr>
<tr>
<td>3 - 4 km</td>
<td>33</td>
<td>2.4±0.48a</td>
<td>6.1±0.60a</td>
<td>91</td>
<td>71</td>
<td>66</td>
<td>63</td>
<td>71</td>
<td>63</td>
<td>26</td>
<td>40</td>
<td>34</td>
<td>14</td>
<td>17</td>
<td>9</td>
<td>2.9</td>
</tr>
<tr>
<td>&gt; 4 km</td>
<td>25</td>
<td>2.3±0.60a</td>
<td>6.0±0.92a</td>
<td>93</td>
<td>71</td>
<td>66</td>
<td>63</td>
<td>71</td>
<td>63</td>
<td>26</td>
<td>40</td>
<td>34</td>
<td>14</td>
<td>17</td>
<td>2.9</td>
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<td>Access to Credit</td>
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<td></td>
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<tr>
<td>No</td>
<td>196</td>
<td>2.8±1.66a</td>
<td>6.3±0.28a</td>
<td>94</td>
<td>84</td>
<td>75</td>
<td>71</td>
<td>73</td>
<td>62</td>
<td>40</td>
<td>35</td>
<td>29</td>
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<td>15</td>
<td>14</td>
<td>9</td>
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<tr>
<td>Yes</td>
<td>25</td>
<td>2.3±0.26a</td>
<td>7.8±0.78a</td>
<td>92</td>
<td>96</td>
<td>88</td>
<td>92</td>
<td>60</td>
<td>88</td>
<td>60</td>
<td>56</td>
<td>32</td>
<td>44</td>
<td>32</td>
<td>24</td>
<td>16</td>
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<tr>
<td>Access to Extension</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No - Agent visit</td>
<td>188</td>
<td>2.4±0.26a</td>
<td>6.3±0.30a</td>
<td>96</td>
<td>85</td>
<td>74</td>
<td>71</td>
<td>73</td>
<td>63</td>
<td>41</td>
<td>34</td>
<td>28</td>
<td>26</td>
<td>16</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Yes - Agent visit</td>
<td>34</td>
<td>2.6±1.28a</td>
<td>7.2±0.76a</td>
<td>85</td>
<td>88</td>
<td>91</td>
<td>85</td>
<td>68</td>
<td>79</td>
<td>47</td>
<td>56</td>
<td>32</td>
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<td>18</td>
<td>12</td>
</tr>
<tr>
<td>No - Off-site demo</td>
<td>99</td>
<td>2.2±0.32a</td>
<td>5.9±0.35a</td>
<td>95</td>
<td>83</td>
<td>77</td>
<td>69</td>
<td>74</td>
<td>62</td>
<td>37</td>
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<td>25</td>
<td>16</td>
<td>12</td>
<td>51</td>
<td>8</td>
</tr>
<tr>
<td>Yes - Off-site demo</td>
<td>122</td>
<td>2.6±0.48a</td>
<td>6.9±0.40a</td>
<td>93</td>
<td>88</td>
<td>77</td>
<td>77</td>
<td>70</td>
<td>68</td>
<td>45</td>
<td>43</td>
<td>32</td>
<td>35</td>
<td>20</td>
<td>76</td>
<td>11</td>
</tr>
</tbody>
</table>

1 For detailed description of SWCPs, and of the general characteristics of farms in the study area, ± 95 % confidence interval (C.I.), please refer to the text on pages 70 and 87. Entries followed by the same letter (a, b, c, . . .) are not significantly different (p ≤ 0.05).
2 The explanatory variable listed was thought to have an influence on the adoption behavior of Njoro Farmers and is shown here as an illustration of various factors possibly influencing adoption decisions of Njoro respondents.
3 Whereas total SWCPs represents the average number of practices, adopted and implemented compared to the explanatory variable listed.
4 Whereas percentage of the population at that particular elevation zone who adopted and implemented the practice indicated.
was not significant. However, a statistically significant relationship was found indicating that more total SWCPs were adopted by those HoHs who had visited official demonstration sites to learn about improving their farming practices as compared to those who had not.

Table 4.6 illustrates the variation in respondents’ perceptions of water quality that may have a slight influence on the number of SWCPs implemented. Variation in adoption rates based on perceptions of overall water quality is significant; respondents who perceived water quality as “poor” adopted SWCPs at a higher rate than those respondents who perceived water quality as being “good.” This trend is also apparent for all other variables regarding water quality; however, none of the variance between values for water quality for specific uses was statistically significant. Sources of water for people and livestock also had significant differences indicated; that is, respondents tended to adopt more SWCPs as the apparent quality of water was poor, and fewer SWCPs were adopted when apparent water quality was good. This was particularly true for those HoHs reporting roof catchment as their primary source of fresh water for household use, and borehole water for watering livestock.

Respondents’ opinions of riparian habitats environmental quality did not appear to influence rates of SWCPs adopted by farmers in the Njoro. Interestingly, the type of toilet utilized appears to have had a noticeable influence on number of total SWCPs adopted; i.e., the better the facility, the more SWCPs adopted.
Table 4.6. Profile of SWCPs adoption based on respondents’ perception of water resources, riparian zone quality, source of water, and toilet type

<table>
<thead>
<tr>
<th>Environmental Variable</th>
<th>Rank</th>
<th>Sample Size (n)</th>
<th>Total SWCPs Implemented (± 95% C.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Water Quality (WQ)</td>
<td>Good</td>
<td>53</td>
<td>5.9±0.50a</td>
</tr>
<tr>
<td></td>
<td>Mod.</td>
<td>94</td>
<td>6.4±0.40b</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>74</td>
<td>7.0±0.50b</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>55</td>
<td>6.0±0.48b</td>
</tr>
<tr>
<td>WQ for drinking</td>
<td>Mod.</td>
<td>79</td>
<td>6.4±0.46c</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>87</td>
<td>6.9±0.44c</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>191</td>
<td>6.4±0.28c</td>
</tr>
<tr>
<td>WQ for Irrigation</td>
<td>Mod.</td>
<td>17</td>
<td>6.8±1.22c</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>7</td>
<td>8.3±1.84c</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>152</td>
<td>6.3±0.32c</td>
</tr>
<tr>
<td>WQ for Bath/Wash</td>
<td>Mod.</td>
<td>48</td>
<td>6.6±0.60c</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>22</td>
<td>7.2±1.02c</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>188</td>
<td>6.4±0.28c</td>
</tr>
<tr>
<td>WQ for Livestock</td>
<td>Mod.</td>
<td>19</td>
<td>6.8±1.08c</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>11</td>
<td>7.4±1.70c</td>
</tr>
<tr>
<td></td>
<td>Borehole</td>
<td>31</td>
<td>6.9±0.72bc</td>
</tr>
<tr>
<td>Source of Water for People</td>
<td>Roof Catch</td>
<td>25</td>
<td>7.3±0.62b</td>
</tr>
<tr>
<td></td>
<td>River</td>
<td>161</td>
<td>6.3±0.32a</td>
</tr>
<tr>
<td></td>
<td>Borehole</td>
<td>14</td>
<td>7.9±0.98c</td>
</tr>
<tr>
<td>Source of Water for Livestock</td>
<td>River</td>
<td>172</td>
<td>6.5±0.30b</td>
</tr>
<tr>
<td></td>
<td>DK</td>
<td>26</td>
<td>5.3±0.64c</td>
</tr>
<tr>
<td>All</td>
<td></td>
<td>222</td>
<td>6.5±0.28</td>
</tr>
</tbody>
</table>

1 Environmental variables include water quality for various uses and source of water for the household and for livestock.
2 Entries reflect the respondents’ subjective choice of three possible answers: “good,” “moderate,” and “poor” for water quality variables, or represent the farmers’ subjective opinions and answer to the questions posed regarding the riparian zone. The remaining variables (i.e., source of water and type of toilet) represent the primary source or facility access in the household. Laboratory analysis was not performed to establish actual water quality.
3 Entries followed by the same letter (a, b, c, . . .) are not significantly different (p ≤ 0.05).
Explanatory Variables

A practical means of identifying predominant explanatory factors that influence adoption of SWCPs was provided using TREE analysis. A summary of predominant explanatory variables associated with adoption of each SWCPs is presented in Table 4.7.

An optimal tree size of three was selected to describe the total number of SWCPs adopted and implemented (see examples in Figures 4.3 and 4.4). In this example, 78 percent of adoption behavior is captured by a regression tree size of one, while an additional 20 percent of remaining variance is captured by a tree size of three (i.e., 98 percent of cross-validation results). The primary explanatory variable is length of residency (years on farm), where the binary split occurred at 19 years. That is, respondents living on their farm for greater than or equal to 19 years (n = 46, 21 percent) had a mean average rate of adoption of just under eight SWCPs per farm. The second branch of the tree (less than 19 yrs. on farm) was further sorted at the second node by the variable, total income (48,600 KSh, 694 USD). For those respondents who had resided on their farms for less than 19 years and had a total income of less than 48,600 KSh, they adopted on average five SWCPs (n = 97); whereas, those living on their farms for less than 19 years and who had total incomes of greater than 48,600 KSh (n = 78) adopted just under seven SWCPs on average.
Legend: These two graphs illustrate explanatory value of TREE analysis. The top graph represents a tree size of 3 selected using the 1-SE rule, selected for optimality; 99% of adoption behavior is indicated by the two explanatory variables, i.e., Years Living on Farm and Total Income. In contrast, the bottom tree is grown to a tree size of 4 to capture the remaining 1% of cases and is further defined by the explanatory variable, Farm Income.

Figure 4.3. TREE diagrams for total SWCPs.
Legend: This graph illustrates cross-validations (CV) for selecting an optimal tree size using the 1-standard error (1-SE) rule, (Breiman et al., 1984). The 1-SE rule represents the optimal tree size (represented by the red dot) with the smallest estimated error that is within one-standard error of the minimum error (red line). By using the 1-SE rule, much smaller trees can result based on cost-complexity (cp) for further computations. The green histogram bars illustrate the percent of CV’s that captured the explanatory variable in the corresponding tree size. In this case, 78% of all cases are explained by a tree of size 1, whereas 100% of cases are explained by a tree size of 4.

Figure 4.4. Cross-validation chart for total SWCPs.
Table 4.7. Summary of TREE Analysis.  

<table>
<thead>
<tr>
<th>Rank</th>
<th>SWCP</th>
<th>TREE Size</th>
<th>1st Explanatory Variable</th>
<th>2nd Explanatory Variable</th>
<th>3rd Explanatory Variable</th>
<th>Misclassification Error of Model</th>
<th>CV Error</th>
<th>R² Apparent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Intercrop (%)</td>
<td>3</td>
<td>Crop Type</td>
<td>Illness</td>
<td>Farm Size (ha)</td>
<td>0.049</td>
<td>0.92</td>
<td>0.31</td>
</tr>
<tr>
<td>2</td>
<td>Contour Tillage (%)</td>
<td>5</td>
<td>HoH Gender</td>
<td>Slope</td>
<td>Farm Income</td>
<td>0.113</td>
<td>1.15</td>
<td>0.24</td>
</tr>
<tr>
<td>3</td>
<td>Manure Application (%)</td>
<td>4</td>
<td>Tenure Status</td>
<td>Years on Farm</td>
<td>Farm Income</td>
<td>0.167</td>
<td>1.04</td>
<td>0.33</td>
</tr>
<tr>
<td>4</td>
<td>Agro-forestry (%)</td>
<td>3</td>
<td>Years on Farm</td>
<td>Enough Food</td>
<td></td>
<td>0.194</td>
<td>0.95</td>
<td>0.27</td>
</tr>
<tr>
<td>5</td>
<td>Plant Residue (%)</td>
<td>5</td>
<td>Years on Farm</td>
<td>Slope</td>
<td>Off-Farm Income</td>
<td>0.185</td>
<td>1.06</td>
<td>0.34</td>
</tr>
<tr>
<td>6</td>
<td>Cut &amp; Carry Fodder (%)</td>
<td>2</td>
<td>Type of Livestock</td>
<td></td>
<td></td>
<td>0.221</td>
<td>0.64</td>
<td>0.36</td>
</tr>
<tr>
<td>7</td>
<td>Off-Stream Watering (%)</td>
<td>4</td>
<td>Type of Livestock</td>
<td>Type of Livestock</td>
<td>Ethnicity</td>
<td>0.189</td>
<td>1.13</td>
<td>0.30</td>
</tr>
<tr>
<td>8</td>
<td>Grass Strip (%)</td>
<td>3</td>
<td>Ethnicity</td>
<td>Farm Size (ha)</td>
<td></td>
<td>0.284</td>
<td>0.99</td>
<td>0.23</td>
</tr>
<tr>
<td>9</td>
<td>Fallow (%)</td>
<td>2</td>
<td>Farm Income</td>
<td></td>
<td></td>
<td>0.239</td>
<td>1.12</td>
<td>0.17</td>
</tr>
<tr>
<td>10</td>
<td>Ditch / Trench (%)</td>
<td>6</td>
<td>Distance to Market</td>
<td>Official Ext. Demonstration</td>
<td>Slope</td>
<td>0.212</td>
<td>0.78</td>
<td>0.22</td>
</tr>
<tr>
<td>11</td>
<td>Bunding (%)</td>
<td>6</td>
<td>Total Income</td>
<td>Farm Size (ha)</td>
<td>Tillage Methods / Years on Farm</td>
<td>0.036</td>
<td>0.22</td>
<td>0.78</td>
</tr>
<tr>
<td>12</td>
<td>Other (%)</td>
<td>9</td>
<td>Culture</td>
<td>Total Income</td>
<td>Total Income</td>
<td>0.122</td>
<td>1.86</td>
<td>0.23</td>
</tr>
<tr>
<td>13</td>
<td>Fanya Juu (%)</td>
<td>4</td>
<td>Soil Water Holding Capacity</td>
<td>Ethnicity</td>
<td>Slope</td>
<td>0.063</td>
<td>1.33</td>
<td>0.48</td>
</tr>
<tr>
<td>14</td>
<td>Micro-catchments (%)</td>
<td>4</td>
<td>Tillage Methods</td>
<td>Ethnicity</td>
<td>Off-farm Income</td>
<td>0.045</td>
<td>1.67</td>
<td>0.17</td>
</tr>
<tr>
<td>–</td>
<td>Total SWCPs</td>
<td>3</td>
<td>Years on Farm</td>
<td>Total Income</td>
<td>Enough food / Total income</td>
<td>0.734</td>
<td>0.93</td>
<td>0.27</td>
</tr>
</tbody>
</table>

1 This table provides an overview of TREE analysis indicating the top three explanatory factors for each practice, tree size, error rates pertinent to tree size selection, and R² equivalent.
2 Rank equals the relative frequency of adopting this SWCP among farmers in the Njoro Watershed, i.e., 1 = most frequently adopted practice, 14 = least adopted practice.
3 Denotes the SWCPs in order of adoption frequency (sensu Tables 10 thru 15) from most frequently adopted to least frequently adopted. Individual analysis of each SWCP as the determinant variable was performed. The letters represent: (a) those SWCPs that were commonly implemented, (b) those SWCPs that were not commonly adopted, and (c) the TREE analysis to determine explanatory variables for the total number of SWCPs adopted.
4 Number of terminal nodes (leaves) indicated for the optimal tree that describes adoption behavior for the determinant variable indicated.
5 The primary explanatory variable from which a split occurs at the root node.
6 The secondary explanatory variable(s) from which a split occurs on the first tier of the tree.
7 The tertiary explanatory variable(s) that determines when a split occurs on the second tier of the tree.
8 Misclassification error of the model (or misclassification cost) is equal to the average prediction error of the model, i.e., the predictive performance in terms of false positive errors and false negative errors.
9 Cross-validation error represents the error associated with the method so that a more “honest” estimated of prediction error results. Cross-validation is a method of choosing an optimal tree size to classify or predict factors that determine adoption behavior.
10 This value is analogous to $R^2(1 – \text{relative error})$ as used in linear regression models and is provided here only for comparison.
Most Commonly Implemented SWCPs

Again, all TREE results are summarized in Table 4.7. The more commonly adopted SWCPs were subjectively designated as those adopted by greater than 50% of the farmers in the survey. Intercropping was described by a classification tree of size three; predominant crop was the primary explanatory variable. The primary split was based on maize, beans, wheat/barley, and potatoes as one group, and all other crops forming the second group. The secondary factor indicated was illness in the household; illness was defined as any significant period of illness that prevented the respondents from working on their farms during the year.

Leaving plant residue on farmlands was best described by a tree size of five. The root node was split based on the primary explanatory variable, years on farm (14.5 years). Marginally weaker secondary explanatory variables, slope (2.75°) and off-farm income (104,800 KSh), define the second tier splits. Perception of water quality was indicated as a tertiary variable. Likewise, adoption of agroforestry practices was explained by the variable years on farm in a tree size of three [n = 138 (69 percent) less than 13.5 years, n = 68 (31 percent) greater than or equal to 13.5 years]. For the 138 respondents having lived on their lands for less than 13.5 years, having enough food for consumption from on-farm production represented the secondary variable that further explained variation in adoption behavior (Figure 4.5).

Adoption of contour tillage practices was best described by an optimal tree of size five (Table 4.7). Gender of HoH (males v. females) was the primary explanatory factor for all respondents with male’s adoption behavior further delineated by the secondary
**Legend:** These two graphs illustrate explanatory value of TREE analysis for Agroforestry SWCPs. The top graph represents a tree size of 3 selected using the 1-SE rule, selected for optimality; 69% \( [n = 138 \text{ less than 13.5 years}] \), 31% \( [n = 68 \text{ greater than or equal to 13.5 years}] \) of adoption behavior is indicated by this explanatory variable, i.e., Years Living on Farm followed by having enough food for household consumption. This bottom graph illustrates cross-validations (CV) for selecting an optimal tree size using the 1-standard error (1-SE) rule, (Breiman et al., 1984). The 1-SE rule represents the optimal tree size (represented by the red dot) with the smallest estimated error that is within one-standard error of the minimum error (red line). By using the 1-SE rule, much smaller trees can result based on cost-complexity \( (cp) \) for further computations. The green histogram bars illustrate the percent of CV’s that captured the explanatory variable in the corresponding tree size. In this case, the majority of all cases are explained by a tree of size 1, whereas 100% of cases are explained by a tree size of 3.

**Figure 4.5.** TREE analysis for agroforestry SWCPs on farms.
explanatory variable, farm income. Slightly fewer males adopted when their farm incomes dropped below 20,040 KSh (~286 USD) per annum than when their incomes exceed 20,040 KSh. The secondary explanatory variable, slope (4.25°), was indicated for females where more females adopted contour tillage when the slope of their farmland was greater than 4.25°.

Manure collection and application was explained by an optimum tree size of five with tenure status as the primary explanatory variable. Those respondents who owned and held title deed to their lands were split into one group (n = 59, 28 percent), and those owning but not holding title deed to their lands were split into a second group (n = 155, 73 percent). For farmers’ not holding title deed, years on farm and farm income were the secondary and tertiary explanatory variables, respectively.

Finally, cut and carry fodder SWCPs was explained by an optimal tree size of two; the base node split was defined by the type of livestock held by the respondents. Of those respondents who owned ungulate livestock, most engaged in cut and carry SWCPs (76 percent of n = 186) whereas, for those holding all other types of livestock, only 12 percent (n = 26) engaged in cut and carry.

Less Commonly Adopted SWCPs

Less commonly adopted SWCPs were defined as those practices adopted by less than 50% of Njoro farmers. Rates of adoption for each were as follows: off-stream watering points (42 percent), fallowing land (29 percent), ditches or trenches (27 percent), bunding techniques (16 percent), “other” indigenous SWCPs (15 percent), fanya juu (9 percent), and micro-catchments (5 percent).
Off-stream watering of livestock was defined by a TREE size of four and delineated by type of livestock, then by ethnicity, as important explanatory factors. This may be inferred to mean that the type of livestock reared on-farm and culturally specific values are driving selection of this practice. Adoption of grass-strips was captured by a TREE size of 3 with ethnicity, with Kalenjin and Ogiek as one group and the Kikuyu and “other” as the second group. This second group was further defined by farm size with 0.51 hectares being the differentiation point. Fallowing land as a SWCP was defined by a TREE size of two, the simplest form, with differentiation based solely on farm income level of above and below 6,533 KSh.

Defining adoption of ditches and trenches as a SWCP was a little more messy. This SWCP was defined by a TREE size of six, with distance to market being the primary explanatory variable (Figure 4.6). Those living greater than or equal to 2.4 kilometers (n = 92) from market were not further differentiated in TREE analysis; however, those farmers living less than 2.4 kilometers from market were differentiated in descending order as follows: off-farm extension demonstration → slope of their farm land → having enough to eat → farm size. Likewise, bunding as a SWCP was defined by TREE analysis as having a TREE size of six with the explanatory factors with total income being the primary explanatory factor. After this split, those who had total income greater than 46,650 KSh could be more finely differentiated by farm size, tillage methods, years on the farm, and having enough to eat. However, the explanatory power of these factors were only weakly different from one another. The “other” SWCP category had a TREE size of nine, making this SWCP even more difficult to describe.
Legend: These two graphs illustrate explanatory value of TREE analysis for Ditch SWCPs. The top graph represents a tree size of 6 selected using the 1-SE rule, selected for optimality; the first node was defined by distance lived from markets (2.4 kilometers). Those living ≥ 2.4 kilometers (41%, n = 92) were not further delineated; however, for those living less than 2.4 kilometers from a market, adoption behavior was further delineated by off-farm extension, slope of their farm land, having enough to eat, and farm size. This bottom graph illustrates cross-validations (CV) for selecting an optimal tree size using the 1-standard error (1-SE) rule, (Breiman et al., 1984). The 1-SE rule represents the optimal tree size (represented by the red dot) with the smallest estimated error that is within one-standard error of the minimum error (red line), thereby much smaller trees can result based on cost-complexity (cp) for further computations.

Figure 4.6. TREE analysis for ditches SWCPs on farms.
concisely. The primary explanatory variable was culture, with 34 percent of Njoro households indicating that culture did not have a role to play in the decision to adopt “other” types of SWCPs. The remaining factors were a weakly differentiated mix of income, having enough food, access to extension, length of residence on their farms, slope, and distance to markets.

Adoption of *fanya juu* and micro-catchment SWCPs were more easily understood as both were defined by a TREE size of four. For *fanya juu*, agronomic features of the farm (soil water-holding potential) was the predominant factor with ethnic group and slope of the farm being secondary factors to adoption. Adoption of micro-catchments, on the other hand, was a bit more complicated where the first node was differentiated by tillage method (machine tillage versus animal traction), followed by ethnicity and then by off-farm income.

**Discussion**

Both the data, as well as observations made during farm “walk-about”s” indicated that adoption of SWCPs was widespread throughout the Njoro watershed. This was not expected. Widespread adoption can make identification of key explanatory variables a challenge, but some important patterns were revealed nonetheless.

Before going further, however, it is important to emphasize that I did not attempt to gain a detailed understanding of various categories of adopters per Rogers (2003). This is because the farmer population was very heterogeneous in terms of how long they have resided in the watershed, and they were also variable in terms of socioeconomic features and the agroecological parameters of their land. As previously reviewed in Chapter 1, a
population of potential adopters consists of several types of people, ranging from aggressive innovators and early adopters who can actively seek innovations, to laggards who may never take up innovations (Rogers, 2003). Data from the Njoro do suggest, however, that the population might be broadly categorized according to Rogers’ (2003) model on an empirical basis. For example, those farmers who have adopted more SWCPs than the average (6.5 per farm) could be regarded in the categories including innovators, early adopters, or early majority, while those who have adopted fewer SWCPs could be viewed as being in the late majority or laggard categories. Again, it is important to note that such a categorization is crude at best. More data on the context of farmer’s adoption decisions—especially over time—would be needed to better inform such perspectives.

The following discussion is broken out into two large sections. The first section covers the hypotheses that were examined while the second is a step-by-step treatment of each SWCP and the lessons I have learned.

Examination of Hypotheses

I hypothesized that the predominant explanatory factors for adoption of SWCPs would include level of education, income, tenure status, access to extension information, and agroecological features. Furthermore, due to the seemingly chaotic socioeconomic environment, I expected that land tenure security could emerge as the most important factor overall. My findings indicated that three of my key factors (income, tenure, and soil characteristics) were primarily responsible for explaining farmers’ adoption of any of the 14 SWCPs. The remaining two factors (access to extension and education level) were indicated as secondary or tertiary explanatory variables, respectively, for only one SWCP.
Income

Total income best explained adoption of bunding practices, and on-farm income was the primary explanatory factor for fallowing land. Total income also was a secondary explanatory variable for adoption of “other” (indigenous) conservation practices and for total SWCPs. Furthermore, total income was indicated as the tertiary explanatory variable for adopting “other” indigenous practices and for the total (number of) SWCPs adopted. Farm income was a tertiary explanatory variable for adoption of contour tillage and manure management, whereas off-farm income was an important tertiary explanatory variable for adoption of plant residue and micro-catchments.

Both on-farm and off-farm income varied widely throughout the study area. However, when correlated with distance of farm households to periurban and urban areas, a distinct pattern of income levels became apparent. Table 3.2 illustrates that higher total income levels were observed in the mid-elevations as compared to those reported in the lower- and upper-most portions of the watershed. Several factors may interact to create a positive feedback relationship with income relative to distance to market. First, both the periurban communities associated with Egerton University and Njoro town are located in this middle zone and nearer to where predominant market centers are located. Greater levels of farm income are also coincident with this middle zone; however, off-farm income follows an opposite pattern, whereby off-farm income amounts increase as the distance to market centers increases.

Second, reports of the farm providing all household food needs (Table 3.2) and characteristics of the farm (Table 3.6) appear to compare well to household income which, in turn, helps to explain farmers’ willingness to adopt SWCPs. For example,
perceived soil water-holding capacity was the primary explanatory variable explaining adoption of *fanya juu*. This variable did not appear, however, to be important for explaining adoption of any other SWCPs or for total SWCPs. *Fanya juu* is typically an arid-land soil conservation practice used on steeply sloping lands to slow overland water flow and retention of soils resources during precipitation events. Given the relatively mild climatic features, gentle slopes, and good year-round groundcover on farm fields throughout most of the watershed, it is logical that this labor-intensive practice is a context sensitive practice and would not be widely adopted in the Njoro. [Soil water-holding capacity is closely related to soil texture, soil organic matter content, slope, vegetation cover, and tillage practices (Brady and Weil, 1999; Leopold *et al.*, 1995; Schaetzl and Anderson, 2005). Generally, the more positive these features are, the better soils retain moisture. In arid and semi-arid lands, soil moisture typically is a limiting factor for growing crops. While there are many factors controlling soil hydrology and fertility, soil water-holding capacity is construed here as a proxy for general soil quality. From this perspective, higher soil quality is also seen to be connected to greater potential for growing crops and livestock, and, thus, to income generation.]

When ethnicity is considered as a variable affecting income, a subtle but distinct pattern also emerges. Although not statistically significant, total income levels for the Kikuyu appear appreciably higher than those of the other three ethnic groups. A suite of ancillary variables may provide an explanation for this difference. First, if one considers the settlement history of the area, it is evident that the Kikuyu occupy more favorable agricultural lands in the central portion of the watershed. This is in part due to the preferential distribution of prime farmlands by the first president of Kenya and partly due
to the long association that they have had with white colonialists in the area (see Chapter 2). Second, the types of crops grown by the Kikuyu are generally different from their neighbors; there tends to be more high-value crops produced such as wheat/barley, vegetables, and livestock that produce milk and eggs for sale (see Chapter 3). Third, proximity to markets and average farm size contribute to the sale of produce (rather than solely for household consumption), resulting in greater potential for income generation. Lastly, higher incomes among the Kikuyu may be due also to a greater sense of tenure security, longer tenancy on farms (farm years), and presumably greater levels of experiential learning as a result.

All of these factors contribute to a reduced sense of risk, a higher degree of interest in diversification via innovation adoption to secure household income, and greater willingness to invest in SWCPs that may require long-term commitment. Having enough food to eat also affected total number of SWCPs adopted and was linked to total income as a tertiary explanatory variable. It follows that if a person is hungry he or she is less able to work, less able to produce an income, less able to recover from illness, and so on. While this pattern of greater income levels does not translate directly into a primary explanatory factor, or constraining variable in the hierarchy of the Njoro system, it is evident that income does play an appreciable role as a secondary or tertiary explanatory variable in explaining adoption behavior. Income can thus be considered as a catalytic variable within each farm household, providing access to inputs and facilitating the adoption of SWCPs.
Land Tenure Security

Tenure status was the most prevalent explanatory variable for adoption of manure management practices. Tenure status was not significant in any other TREE analysis. A proxy variable, “years on farm,” was used as an alternative explanation for perceived tenure security. This is a logical outgrowth of sense of ownership increasing as the number of years an individual lives on the farm increases, whether they hold title deed or not. Sense of ownership may be manifested by decreased fear of losing one’s land and decreasing concern for losing the benefits that may be derived as a result of implementing SWCPs. The greater number of years on the farm also has implications for the level of experiential learning on one’s land, and therefore a greater level of understanding pros and cons of adopting SWCPs. Thus, an individual’s experiential knowledge of his/her land (soil type, soil fertility, and climate) may play as important a role in adoption of SWCPs as any other explanatory factors (Barrows and Roth, 1990; Cary and Wilkinson, 1997; Beedell and Rehman, 2000). Simply put, the greater number of years living on the farm equals higher perceived tenure security.

However, a proxy variable for tenure status, namely “years on farm,” was indicated at all three levels within TREE analysis. Tenure status and years on farm were strongly associated ($\chi^2 = 181.12$, $p < 0.0001$); thus, years on farm provided an alternative measure for a farmer’s “sense of tenure security.” In TREE analysis, years on farm was the primary explanatory variable for adoption of agroforestry practices, leaving plant residues on the field, and for total SWCPs adopted. This factor was also the most significant secondary explanatory variable for adoption of manure management practices and the most significant tertiary explanatory variable for adoption of bunding practices. It
is interesting that this variable is usually associated with some measure of income, with
whether enough food is available to the household, and with certain agroecological
features of the farm [(i.e., farm size, slope, tillage methods) Tables 3.2 and 3.6].

In other words, tenure security is a constraining factor influencing a farmer’s
decisions to adopt SWCPs whereas other factors such as income, agroecological factors,
and food availability are catalytic factors influencing a farmer’s sense of tenure security.
These results in tandem suggest a complex interrelationship of factors directly linked to
the overall welfare of the household (income, enough food to eat, etcetera) and that of
tenure security. These findings support the assertion that tenure security is a complex
issue, best served by evaluating the interactions among variables rather than examination
of single variables to explain adoption behavior (Place and Swallow, 2000; Gebremedhin
and Swinton, 2003; Asrat et al. 2004; Tenge et al., 2004; Hagos and Holden, 2006;
Kabubo-Mariara, 2006).

Extension Services

Access to extension services was not a significant primary explanatory variable
for any one SWCP, nor for total SWCPs. However, visits by farmers to demonstration
sites was an important secondary explanatory variable for adoption of ditch/trench
SWCPs. The use of ditch/trench SWCPs is common on arid lands to divert water onto
farm fields, to supplement crop water requirements, or to divert runoff to reduce soil
erosion. Arid lands occur in the lower portion of the Njoro watershed near Lake Nakuru
National Park (LNNP); correspondingly, the number of reports of ditch/trench SWCPs
adoption increased as elevation decreased. Lower elevations have lower annual
precipitation (Chapter 2).
It is important to note that the availability of agricultural extension services in the area has declined from about the mid-1980s and continues to do so (Mr. Kiuru, Kenya Ministry of Agriculture, Njoro Extension Service Officer, personal communication). The decline in services began prior to the period of degazetting and redistribution of national forest lands. This is relevant because farmers living in the lower portions of the watershed have been there for significantly longer periods of time, which logically would have facilitated access to extension prior to the marked declines in service. In contrast, those farmers living in the upper portions of Njoro gained access to their lands after the degazetting and redistribution period. This occurred after provision of extension services was in decline.

Knowledge of various soil and water conservation practices has likely been transferred among the local population via alternative means such as experiential learning as seasonal laborers, direct observation, and by word of mouth. In addition, extension services (information) have been available from institutions located in the watershed other than the Kenyan Ministry of Agriculture Extension Services. For example, Egerton University, the Kenya Agricultural Research Institute, the Swedish International Development Agency (SIDA), and the Rift Valley Institute of Technology all provide various outreach and extension-type programs where information is provided (Steve Huckett, personal observation). Typically, local farmers do not identify these institutions as “extension services;” however, the information provided is nonetheless an important source of de facto extension education and knowledge.

Finally, conservation workshops for local farmers were available during the late 1980s through the mid-1990s via the Lake Nakuru Conservation and Development
Project. This project was initiated in 1988 by the Overseas Development Agency of the United Kingdom, in collaboration with the World Wildlife Fund for Nature (WWF) and the Kenyan Ministry of the Environment. The project’s primary objective was to create public awareness of stewardship of the LNNP and associated natural resources via capacity building of the local population. Specifically, soil conservation and improved agricultural activities were taught to the local population in an effort to mollify impairments to water quality throughout the lower portion of the watershed, which ultimately would protect habitats within LNNP (Daniels and Bassett, 2002).

Level of Education

Contrary to previous findings of simple adoption models reported in the literature, level of education was not indicated as a significant primary or secondary explanatory variable for any one SWCP or for total SWCPs. Level of education was, however, indicated as a tertiary level explanatory variable for adoption of one SWCP, namely grass-strips. Several factors may help to explain this. First, farmers in the Njoro watershed appear to be relatively well educated in terms of their attendance in public schools. The average education level of the respondent population was Standard 5 to 8, or approximately six years of formal education. This degree of education is different from previous investigations and complicates making comparisons between studies due to type of data collected (bimodal, literate/illiterate, etcetera) and how those data were interpreted. Second, it is generally accepted that access to higher education facilitates an individual’s ability to recognize and incorporate new information into their daily activities. Higher levels of education infer a greater capacity to learn about new or innovative technologies (Asrat et al., 2004; Tenge et al., 2004; Bodnár et al., 2006; Anley
et al., 2007). This is pertinent in that new information about agricultural technologies may originate in the primary or secondary school system and thus be introduced to the head of household by their children who are attending local schools. Lastly, literacy is closely tied to level of education and allows farmers to learn from alternative resources (i.e., pamphlets, posters, etcetera) which may be locally posted or distributed.

Despite challenges related to differences in interpretation, it is a commonly held view that as level of education among farmers increases, a higher degree of innovation adoption results (Rogers, 2003). This is likely due to a greater capacity of individuals to engage and navigate in the process described by the simple decision model of Rogers (2003): Gain knowledge → evaluate practice → decide to adopt or not → implement practice (adopt) → confirm if net benefit (or detriment) has been realized. In this sense, level of education is a constraining factor in the hierarchy of farmer households and within the greater Njoro watershed. Since the majority of the populace in Njoro is relatively well educated, variance between household level education and adoption of SWCPs was not readily observed.

I expected that no single factor would predominate as a significant explanatory variable for adoption behavior for all SWCPs. The findings agree with this expectation, as multiple variables defined each TREE analysis. This is well described in adoption-diffusion literature (Rogers, 2003) and is related to the complex nature of the attributes of the adopter (personal experience, evaluation abilities, and sociocultural constraints), attributes of the innovations, how well innovations conform to the specific context of the adopter’s circumstances, and influences of the social system in which a farmer lives.
Moreover, this dynamic process requires constant reevaluation of biophysical and social conditions, potential costs and benefits, and appearance of unforeseen constraints.

Interpretation of results illustrating multiple-factor influences was also facilitated by grouping the 14 SWCPs into either “commonly adopted” or “less commonly adopted” categories. Again, commonly adopted SWCPs were those practices adopted by greater than 50% of the households. These SWCPs generally had a lower cost-to-benefit ratio, i.e., required fewer additional resources to implement than what was already being expended or that did not take away from short-term food production or income potential, and generally met the basic criteria for adoption, i.e., compatibility, complexity, relative advantage, trialability, and observability (Rogers, 2003). These included intercropping, contour tillage practices, collection and spreading of manure on croplands, agroforestry techniques, leaving plant residues, and cut-and-carry fodder for livestock. The second group of less commonly adopted SWCPs included those adopted by less than 50% of all households. These included fallowing, *fanya juu*, micro-catchments, bunding techniques, grass-strips, ditches/trenches, off-stream watering points, and other indigenous practices. In contrast to the commonly adopted practices, each of the less commonly adopted SWCPs require additional labor to implement, offer relatively longer time periods before a benefit is realized, and require an increased financial capacity on the part of the farmer to absorb potential economic losses from decreased food production. For the sake of brevity, detailed discussion is limited to the six most commonly adopted SWCPs, with a concise overview of the remaining eight that were less commonly adopted.
Intercropping

Ninety-four percent of all farmers sampled had implemented intercropping SWCPs with the explanatory variable “crop type” best describing adoption of this practice. This is logical in the context of the Njoro watershed where nearly all farms grew maize as their primary crop and intercropped with beans, potatoes, peas, or other food crops in the interstitial row space. This infers that relative advantage, compatibility, and degree of complexity are all favorable for the farmers to adopt this practice. On the other hand, this finding is a bit misleading in that direct observation suggested that since these are all staple foodstuffs, household subsistence was the primary reason that farmers had nearly all their cropland intercropped (Steve Huckett, personal observation). This interpretation is supported by patterns in the data which indicates that level of adoption of intercropping SWCPs is relatively uniform except in elevation zone three. This is the zone containing significantly smaller farms and typically grow more vegetables, raise smaller livestock, and occur in closer proximity to market centers (Table 3.3.)

“Illness” was a significant secondary factor for implementing intercropping. This factor was weakly related to crop type when crops were something other than maize, beans, or potatoes, such as fruits and vegetables. This implies that a more intense level of labor is required to implement and maintain the practice on lands planted with vegetable crops or having agroforestry plots. Furthermore, having an “illness” in the household suggests that implementing intercropping methods with crops other than basic foodstuffs occurs less likely as the illness causes an inhibitory effect on providers of labor. Compatibility and relative advantage of adopting intercropping for crops that do not
produce food or immediate income, in turn, do not provide the net benefit to farmers and are therefore less likely to be adopted.

Contour Tillage

Eighty-five percent of farmers had implemented contour tillage practices on their farms as a soil conservation practice. Gender was the primary explanatory variable for adoption of contour tillage practices; this factor was marginally stronger than the secondary explanatory variable slope and the tertiary variable distance to market for females, as well as the secondary variable farm income for males. Slope of farmland implies a *need*; when slope increases there is greater need implied to protect soil resources from overland water flow and erosion.

When gender and slope are considered together, an interesting finding is revealed. Female HoHs adopted contour tillage practices at a rate of 69 percent compared to 74 percent of male HoHs. A large proportion (47 percent) of women adopted contour tillage practices only when slopes were greater than 4.25°. Implementation of this practice requires periods of intense labor input and dedicated periods for maintenance. Women are the principal caregivers throughout the watershed which affects their abilities to implement terracing SWCPs. Factors such as number of children in the household, illness, fetching water, caring for livestock other than cattle, goats, and sheep, and shopping for items necessary for the household all have an effect on the amount of time and labor available. It is therefore logical that female HoHs would not be inclined to increase their workload to implement contour tillage until they deem that they would realize a relative advantage by doing so. In contrast, for male HoHs, the degree of slope
did not influence the rate of adoption of contour tillage SWCPs, suggesting that relative advantage, compatibility, and level of complexity was regarded as being in their favor.

Males, however, indicated farm income as the secondary explanatory factor for contour tillage adoption where a higher proportion of male HoHs (94 percent) adopted the practice when incomes were above 20,040 KSh, as compared to those (82 percent) whose farm income was less. When the TREE analysis was extended further, total income and off-farm income became supporting factors in explaining adoption. Farm income was a tertiary explanatory variable for adoption of contour tillage and manure management SWCPs. Therefore, both farm income and total income are catalytic variables or factors influencing farmer behavior.

Other explanatory variables indicated as important for adoption of contour tillage practices included tillage methods and having enough food. In the case of tillage methods, this variable was a primary explanatory variable for micro-catchments and reflects why the practice was not adopted, rather than why the practice was adopted. For instance, if a farmer had implemented micro-catchments, then the range of tillage methods options, and therefore compatibility, would be greatly reduced. Micro-catchments form a very uneven surface on the ground that would in effect form multiple obstacles to efficiently cultivating fields except for work done by hand. Mechanical tillage methods (tractors and associated implements) would most assuredly not be possible due to the nature of the equipment involved and complexity of implementation around the micro-catchments. The same holds true for animal-powered tillage methods, but to a lesser degree. Having enough food to feed (and fuel) the farmer has its own cohort of factors that potentially affect a farmer’s evaluation of an innovation and their
capacity to adopt and implement SWCPs. The implications of not having enough food to eat range from acute lack of energy to severe, debilitating illness that effectively prevents the farmer or his/her dependents from performing the necessary work on the farm. The ramifications of not having enough food to eat on one’s ability to work, and potential for illness (noncompatible variables), are easily understood in this context.

Managing Manure Resources

Seventy-seven percent of farmers adopted some form of manure management. Land tenure status was the most important variable for explaining adoption of manure management practices, whereas years on the farm was indicated as the most significant secondary explanatory variable. Farm income was a tertiary explanatory variable for those having lived on their farms less than 8.5 years, while type of livestock kept was the important tertiary variable indicated for those who had lived on their farms greater than or equal to 8.5 years.

Again, an interesting pattern emerges when elevation zone is considered. In zone three, 100% of farmers use manure on their farms as a soil amendment for the crops grown. This is the zone in which periurban communities, small farms, higher value croplands, and zero-grazing predominate. Furthermore, all of the lower-elevation zones indicate higher adoption rates of this practice which correlates with longer residence times (greater than or equal to 8.5 years) and poorer quality soils. Each of these factors provides evidence in support of adoption theory, i.e., level of complexity (low), compatibility with existing practices, relative advantage, and observability (Rogers, 2003). Implementing manure management practices provides the farmer with a relatively easy method of increasing soil fertility that is compatible with existing operations and
rids the farm of a concentrated source of nitrogen and phosphorous which could have serious ramifications for soil and water contamination during each precipitation event. The farmer and the community easily observe the benefit, and the practice is easily transferred to others.

**Agroforestry Techniques**

Fully 73 percent of Njoro farmers had implemented various agroforestry SWCPs. Years on farm was the primary explanatory variable suggesting that tenure security was relatively good for these farmers. The explanatory variable concerning having enough food was the secondary explanatory variable, which has its own cohort of factors and may affect farmers’ capacity to adopt and maintain agroforestry practices as discussed previously. The pattern of adoption indicates a nearly uniform decrease in adoption rates as one goes from lower to higher elevations. This is indicated by 100 percent of farmers in the lowest elevation zone having adopted agroforestry SWCPs, whereas the lowest level of adoption (33 percent) occurred in the highest elevation zone near the forest boundary. This pattern is similar to the pattern indicated for length of occupancy and supposes that lands that have been occupied and farmed for longer periods of time were more likely to have adopted agroforestry practices due to a plethora of factors (e.g., tree removal for timber, firewood, ease of tillage, etcetera). However, this too may be somewhat misleading.

This relationship of the two explanatory factors to adoption of agroforestry SWCPs is interesting. First, implementation of agroforestry practices requires intense labor inputs, which may be limited. For farmers having lived on their lands for relatively shorter periods, the need to produce food quickly is likely to outweigh longer-term goals.
of agroforestry practices. It is also likely that either the recently settled farmer will have a relative abundance of wood products still available, on the farm or from adjacent lands; therefore, their perceived need to implement this SWCP could be diminished. Not having enough food also implies that farmers would find it difficult to maintain the farm during times of duress, inhibiting their ability to generate sufficient income to carry them through a poor growing season or two. These conditions would diminish their ability to marshal the financial resources to hire the necessary labor to maintain the agroforestry practice. Therefore, for newer farmers, the relative advantage of adopting the practice is reduced.

Second, there is generally a long time lag between when an agroforestry practice is first implemented and when the benefit of the new practice is realized due to the length of time required for trees to grow to the desired level of maturity before a harvest may occur. If the goal is timber production, this may take a decade or more depending on tree species grown. If the goal is to produce nuts or fruits, then fewer years may be necessary for harvest of the first crop; nonetheless, this can be much longer than is necessary for producing grains, tubers, or vegetable crops. In this sense, stability (length of residence) begets relative advantage of adoption.

Plant Residue Management

Overall, 72 percent of farmers implemented plant residue management practices. Adoption tended to be greater at higher elevations than for those farms located in the lower portions of the watershed. Years on farm was the primary explanatory variable for adopting this SWCP and is associated with some measure of income and certain agroecological features of the farm (i.e., slope, water quality, et cetera). When allowed to
run further, TREE analysis indicated a complex array of more minor factors, all of which are implicitly linked to the overall welfare of the household (i.e., income, water quality, distance to market, having enough food to eat), as subordinate to tenure security. This further supports the idea that tenure security is a complex issue, best served by evaluating the interactions among variables rather than examining single variables to decipher whether a practice has relative advantage and compatibility, or to serve as the sole explanation for adoption behavior.

Cut-and-Carry Fodder

The average adoption rate of this SWCP among farmers was 65 percent, whereas a higher percentage of farmers in the lower elevation zones reported using this technique than did their counterparts in the higher elevation zones. Type of livestock reared on the farm was the only important explanatory variable for determining whether cut-and-carry fodder practices were implemented. This is logical because of the specific context and requirements of farmers who keep livestock.

When ethnicity is considered, the data reveals that 92 percent of Kikuyu were adopters of the practice, whereas 62 percent of Kalenjin and only 54 percent of Ogiek adopt this practice. When an etiological perspective is considered, the Kikuyu and “other” groups are historically sedentary farmers and trade-oriented peoples (Oyugi, 2000; Weinreb, 2001). They typically occupy smaller farms in better-established areas of the watershed where raising large livestock would be more difficult to manage. Instead, their focus is on raising sheep and goats, chickens, and other fowl, which can be easily confined and sold in local markets. For the Kikuyu, keeping of livestock is generally for household use such as milk and meat, and having larger flocks or herds is not considered
a measure of a person’s wealth (Steven Huckett, personal observation). Large livestock are confined by tethering or keeping them in paddocks where they are typically zero-grazed to minimize negative impacts to their local resources (Steven Huckett, personal observation). The Kikuyu rely more heavily on maintaining their soil base for crop production and sustaining livelihoods; therefore, implementing grass-strips as a conservation practice is a logical outgrowth for conserving soil resources and for fodder production for livestock. In contrast, the Kalenjin and Ogiek have historically been pastoralists and hunter-gatherers, respectively, and consider ownership of livestock a measure of household wealth, as well as a source of food (Oyugi, 2000; Weinreb, 2001). Grass is characteristically viewed as a grazing resource and not as a means of conserving soil. Livestock raised are typically grazed outside of the immediate farm boundary on forestlands, roadways, and in riparian zones throughout the watershed, being brought to and from the farm by herders daily or less frequently. This practice precludes any urgent need for fodder production on their cropland (low relative advantage, low compatibility with their customs) and, thus, no immediate need to bring fodder to their livestock.

Secondly, the Kalenjin and Ogiek are relative newcomers to farming in the watershed and predominantly occupy the upper portions of the watershed where access to forage in riparian zones and on pasturelands is still relatively easy. Moreover, it is reasonable to infer that their perception of soil erosion and the potential for soil erosion may be quite different from their Kikuyu counterparts; thus, they do not recognize soil erosion or degradation in the same way as others in the Njoro. Again, this supposes that they do not recognize the relative advantage of cut-and-carry fodder practices to the same extent as their counterparts in the watershed.
Less Commonly Adopted SWCPs

In considering the second group of less commonly adopted SWCPs (i.e., fallowing, *fanya juu*, micro-catchments, bunding techniques, grass-strips, ditches/trenches, off-stream watering points, and other indigenous practices), it was found that 42 percent or less of all households in the study adopted any of these practices. Rates of adoption for each were as follows: fallowing land (29 percent), *fanya juu* (9 percent), micro-catchments (5 percent), bunding techniques (16 percent), grass-strips (37 percent), ditches or trenches (27 percent), off-stream watering points (42 percent), and other indigenous SWCPs (15 percent). So, why were these practices less commonly adopted?

Implementation of fallowing, *fanya juu*, micro-catchment, and bunding practices are common in arid zones that are subject to limited and/or intense precipitation. Arid land conditions typically have sparser vegetation cover and hydrophobic soil conditions that can result in high rates of overland flow and, potentially, high rates of soil erosion. When coupled to vegetation removal due to cultivation or grazing, these conditions are exacerbated. Fallowing land is intended to restore soil nutrient levels after intense cultivation and, in areas of limited precipitation, provides a period of rest to restore soil moisture levels to enable crop production. TREE analysis indicated that farm income appeared to be the primary determining factor, inferring that the immediate need to produce food outweighed the benefits derived by implementation. With additional analysis, implementation of this practice was by farmers whose incomes were greater and this was further affected by ethnic group. For example, a majority of Kalenjin and Ogiek
(86 percent) chose not to implement this practice, whereas among the Kikuyu and other ethnic groups, 43 percent of these farmers chose to adopt and use this practice.

_Fanya juu,_ micro-catchment, and bunding practices are designed primarily to prevent soil erosion and/or to increase water retention and infiltration by reducing surface runoff away from, or off, farm fields. These SWCPs also trap sediment so that the nutrient and organic matter rich topsoil is not lost from the farm. In the Njoro watershed, the relative advantage of trying, then maintaining, the practice appeared to be lacking among those farmers surveyed. Nor did these practices pass the compatibility criterion in relation to the farmers’ current operations, past experiences, and perceived need for protecting their soil resources. TREE analysis revealed that adoption of _fanya juu_ and micro-catchment practices were explained by agroecological features, perceived soil moisture levels, and type of tillage used, respectively. Ethnicity was a secondary explanatory factor for both practices, and this could be explained by the person’s prior experience, culture, or place of origin. For bunding techniques, four primary factors explaining adoption of SWCPs were total income, size of farm, tillage methods, and years on farm.

Grass-strips can serve two purposes. First, they may act to reduce overland flow of precipitation so they are retained on-farm and for trapping eroded soil, thus preserving nutrient-rich sediments for redistribution on farm. They may also produce feed for livestock kept on farm either via direct grazing or as cut-and-carry fodder for animals held in confinement. In the Njoro watershed, implementation of grass-strips was best explained by the ethnic group factor. Generally, the Kalinjin and Ogiek peoples identify with being pastoralists and prefer to free graze their livestock; therefore, compatibility
with their culture is the issue and they do not tend to perceive a relative advantage and do not adopt this practice. The Kikuyu and the “other group,” conversely, were more likely to adopt this practice. The secondary explanatory factor for them was farm size. Further, those having more land were more likely to adopt grass-strips.

Installation of ditches or trenches may serve more than one purpose. On the one hand, they may divert precipitation onto farmlands to augment soil moisture conditions and crop production potential, mostly in arid land agriculture. This was observed in the lowest reaches of the study area. Ditches/trenches were observed to bring water onto farm fields from roads and runoff rills and gullies (Steve Huckett, personal observation). Arid conditions, permeable soils, and heavy rains combine to limit crop production; therefore, farmers in these more arid zones apparently did perceive a relative advantage to implementing this practice and found it to be compatible with their particular environmental context.

On the other hand, these SWCPs may be implemented to divert water away from croplands to prevent excess accumulation of soil moisture. For example, in areas where heavy (clay) soils predominate, and in areas where levels of precipitation exceed crop requirements, ditches/trenches prevents accumulation of excess water on farm fields and the subsequent water logging and crop failure during wet periods. Neither of these conditions was prevalent in the watershed, thus negating the relative advantage of implementing these practices.

Use of off-stream watering points is also a common practice in arid rangelands where ecological conditions and limited water resources demand dispersal of livestock away from riparian zones and stream banks to minimize their impacts to soils and
vegetation. While stream bank degradation and bank soil erosion was common at watering points along the river, peoples’ perception of degradation and the motivation to address the problem seemed to be lacking. From TREE analysis, we found that adoption of off-stream watering points was best explained by whether there were livestock kept on the farm and what type of livestock it was. Since no infrastructure existed that would allow piping or diversion of surface water resources to an off-stream watering point, farmers’ choices were either to take livestock to water or to carry water to their livestock. Owners of cattle in particular did not adopt this practice, instead opting to drive their animals to water sources versus carrying water back to them on the farm. Obviously, with only a 42 percent adoption rate, the relative advantage and compatibility with existing operations, in terms of labor, time, and efficiency, was lacking for farmers in the Njoro.

Adoption of “other” indigenous SWCPs was specific to an ethnic group and to their particular historic experiences and cultural perceptions of resource management. Culture, income, and having enough to eat were the three principle factors explaining use of indigenous SWCPs; however, it must be noted that specific indigenous practices related to crop production or soil and water conservation were not commonly observed or reported. This is thought to be the result of long-term access to extension and experiential knowledge of “modern” SWCPs of those farmers in the lower portion of the watershed and by those who have more recently migrated into the upper portion.

When correlated with the five attributes of innovations described by adoption theory (Rogers, 2003), it was found that none of these eight less commonly adopted SWCPs were heavily influenced by the criteria indicated for determining adoptability. In particular, the relative advantage and compatibility of the particular technology to
farmers’ current operations were missing. This issue is critical to understanding the decision process in that when farmers’ resources are limited, the incentive to accept new risks for adopting a new SWCP is necessarily a secondary factor to the immediate need for food and sustenance.

This is illustrated by TREE analysis which revealed that, of the five variables predicted to be primary explanatory factors for adoption of these less commonly adopted SWCPs, only income and agroecological features were indicated for fallowing (29 percent), bunding (16 percent), and fanya juu (9 percent), respectively. In explanation, income can be considered an internally limiting factor whereby a farmer may perceive that income generation would be reduced due to removing a portion of their lands from production, the cost of increased labor required to implement, and to their perception of limited compatibility with their farm. Soil moisture on the other hand, acts as an external limiting factor to adoption of these particular SWCPs in this situation. The relative advantage of adopting SWCPs designed for arid lands was not evident. This is probably due to the relative abundance of rainfall throughout the watershed and because of the higher labor requirements for implementation. Farmers’ perceptions of relative advantage and improvements to their level of income do not appear to outweigh their sense of risk and the burden incurred by implementing these labor intensive SWCPs.

Summary

Impairment of soil and water resources is almost never due to a simple cause and effect relationship. Application of adoption theory has revealed that SWCPs adoption decisions by impoverished farmers’ in the Njoro watershed is more involved than just
evaluating explanatory factors based on the five tenets of adoption behavior; i.e., compatibility, complexity, relative advantage, trialability, and observability. This should not be surprising. The strict use of adoption theory did not lead to clearly defined conclusions of why farmers’ did or did not adopt SWCPs; however, it has provided a good basis or lens for examining which SWCPs have been adopted and provided a framework to broadly identify the big-picture factors driving the decision process. From this, the underlying personal, biophysical, and socioeconomic conditions can be illuminated and brought to the fore in the hierarchy of the farmers’ decision process, so that a more clearly defined “explanation” for adoption can be identified.

Traditional investigations of disturbance of natural resources have been primarily by the tools in the toolbox carried by the researcher, i.e., ecologists, social scientists, and hydrologists. Each has the best intentions in mind; however, they are constrained by their academic training, by the investigation strategies they are most comfortable with, and by the motives of the source of funding for the research. Specialized bodies of knowledge result; however thorough it may be, it remains unconnected to other pertinent bodies of knowledge. This makes “fitting” new findings into well-ordered, quantifiable models difficult and impedes formulation of comprehensive management programs.

How people interact with their particular environment has a major influence on their perceptions of the world and on individual behaviors on several conceptual levels. The context of the farmer’s experiences, knowledge, and his or her particular farm landscape is likely more important to understanding why farmers adopt new SWCPs; or more simply, how well does the practice fit their farm operation? Individuals seek to optimize conditions for themselves. The data suggests that smallholder decisions were
made based on consideration of many variables across different spatial and temporal scales within the context of their socioeconomic, psychological/behavioral, biophysical, and policy environments. Thus, it is vital that researchers consider the context specific circumstance in which the farmers’ lives are embedded. This is critical to understanding their adoption behavior and, ultimately, the causes of impairment of natural resources.
CHAPTER 5
SMALLHOLDER FARMERS’ ADOPTION DECISIONS – QUALITATIVE ANALYSIS

Introduction

During the process of assessing whether small-scale farmers adopt certain soil and water conservation practices, it is not reasonable to expect that the reasons “why” would be addressed by simple statistics alone. Lynam and Stafford-Smith (2003) state, “…human processes are [at least] as important as the ecological processes” to understanding management of water resources and agricultural land use practices. In this vein, evaluation of the data now turns to the qualitative component of this watershed system in an attempt to build bridges between the social and biophysical perspectives. Through examination of the ethnographically informed qualitative data, a better definition of the problem context and patterns in the data may be unveiled. By combining the results of qualitative and quantitative data analyses, a richer interpretation and more complete understanding of smallholder farmers’ adoption behaviors may emerge (White, 2002). This will lead to a greater understanding of how various factors alter human behavior and, ultimately, to implementation of better methods to protect watershed resources.

Objectives

This chapter is composed of two types of qualitative evaluation to assist with our understanding of why small-hold farmers adopt and implement Soil and Water
Conservation Practices (SWCPs). These analyses are intended to complement our quantitative analysis shown in Chapter 4 by providing further insights into the farmers’ perceptions of their environment and “key” factors they deem important. This process complements the findings of quantitative TREE analysis by providing a more complete assessment of the factors influencing smallholders so that a more complete picture of reasons for SWCPs adoption could be revealed. By integrating qualitative and quantitative data analysis, greater richness in interpretation of findings results to improve the quality of our conclusions (Spradley, 1980; White, 2002; Liu et al., 2007).

First, farmers’ responses to ethnographically informed, open-ended survey questions were evaluated to shed light on their reasons (i.e., “why” and “why not”) for choosing to implement SWCPs. Respondents’ perceptions of their environment were examined to clarify factors that influence their understanding of the watershed systems around them, and how these factors may or may not influence their stewardship behaviors. This assessment was concentrated on the six more commonly adopted SWCPs identified by TREE analysis as discussed in Chapter 4 (i.e., intercropping, contour tillage, manure management, agroforestry practices, plant residue, and cut-and-carry fodder). Examination of the less frequently adopted SWCPs is also conducted and discussed in more general terms. Second, information from participant observation and from metadata of previous studies conducted in the Njoro was evaluated to complement the findings derived from quantitative data evaluations. The meta-evaluation was confined to those observations recorded during field visits and to studies conducted for the SUMAWA project to characterize soils and riparian zone conditions in the Njoro.
Methods

Domain/Factor Tree Analysis

This methodology allows us to elicit contextual information from real-life decisions by subjects in terms of their own analysis (i.e., comparing/contrasting, assigning value, weighing relative advantages of alternatives) of various options available to them (Gladwin, 1989; Schensul et al., 1999). The process is based on a hierarchical model which begins at the paradigm level (greatest abstraction), proceeding downward to more concrete levels of conceptualization. Subsequent levels consist of domains of interest (dependent, independent, and mediating), factors, sub-factors, variables, and items listed in increasing order of concreteness to form a conceptual tree model.

Domain analysis utilizes a hierarchical system composed of multiple levels ranging from paradigm at the highest levels, to the lower levels which are small and catalytic (variable/unit). The higher levels in the system provide the constraining “environment” in which smaller, faster levels operate (Allen and Starr, 1982). Each level is controlled dynamically by the activities within levels directly above and below it and, thus, exerts influence on individual or group behaviors within the system in question. For example, paradigms such as religion, sociocultural norms, or deeply held personal beliefs exert constraining influences on an individual’s values and risk assessment and, thus, on their personal behavior (e.g., alcohol consumption); whereas active variables such as income or peer pressure exert acute influences having a more immediate effect on riparian farmers or community behavior (e.g., charcoal making in riparian zones).
To reiterate, a system is the integration of all its parts, whereas the parts (holons) function as self-regulating autonomous entities and are at the same time a part of the various levels within the greater system(s). Hierarchies are composed of partly ordered sets of (sub)systems having nonlinear and asymmetric interactions, both spatially and temporally, which influence individual behaviors (Allen and Starr, 1982).

In domain analysis, domains are the higher-order building blocks of hierarchical models used to explore and develop theory (Schensul et al., 1999). Domain states are described as follows: an independent domain is one that remains unchanged due to changes in the state of the second, the dependent domain(s). A third type of domain, the mediating or modifying domain, comes between the dependent and independent domain and thus affects or changes the relationship between the dependent and independent domains (Schensul et al., 1999), somewhat like a catalyst or mollifier. Therefore, domain analysis involves assigning values to the responses to open-ended survey questions and to participant observations so that they may be operationalized to facilitate construction of a conceptual map of the environment under study (Spradley, 1980; Schensul et al., 1999; Kane and Trochim, 2009). This requisite allows one to describe the multiple dependent and independent domains and their associated factors and variables within a system or hierarchy. The resultant picture is a simplified depiction of the real world: a model of the processes, interactions, and product of activities as seen through the informant’s eyes. These depictions then allow the researcher to decipher and interpret how the various components of a system interact to affect behavior (Kane and Trochim, 2009).
Participant Observations - Ethnography

Evidence collected by direct observation provided an opportunity to discover the “knowable” in identifying environmental problems. However, while these facts may be observable, they may not be predictable in the strict, scientific sense. As Babbie (1999) suggests, qualitative information permits greater latitude for discovering the “unexpected” and thus provides an opportunity for understanding underlying institutional, social, and individual paradigms that may otherwise go unnoticed. By gaining a perspective of stakeholder’s values and perceptions of their reality (i.e., the context in which they live), alternative interpretations may be considered and incorporated into the synthesis and interpretation of data (Senge, 1990; Greider and Garkovich, 1994) and development of theory via operationalization and conceptualization (Schensul et al., 1999; Kane and Trochim, 2009).

Participant observation is rooted in traditional ethnographic research as a systematic observational method to help researchers learn first-hand about specific contextual perspectives held by members of the study population (Spradley, 1980; Adler and Adler, 1994). This point of view presumes that multiple perspectives exist within any given community and that each person creates their own reality. Therefore, it is of interest to the researcher to both know what these diverse perspectives are and to develop their own understanding of the relationship(s) among them. Participant observation is simply a process of learning via exposure to day-to-day activities which are central to the objectives of the research being conducted (Schensul et al., 1999). Data collection can be achieved to varying degrees through observation alone or by both observing and participating in the daily activities of the study subject. Participant observation always
takes place in community settings and is distinctive because the researcher becomes an active participant in the informant’s environment rather than having the research subjects come into the researcher’s environment (Spradley, 1980; Schensul et al., 1999).

Normally done over a long period of time, the researcher tries to learn what life is like for an “insider” while remaining, inevitably, an “outsider” (Angrosino, 2007). While in these settings, careful, objective field notes are taken describing what they see or experience, and can include informal conversation and interactions with the study population as well as observations of “actions taken” within the area of interest. However, as with all things, there is a downside to participant observation. Decreased objectivity of the researcher, unsystematic data collection, and subjective measurement are all possible. Therefore, caution must be taken to record observation in a systematic manner so as to avoid inaccuracies, researcher bias, and possible observer effects (i.e., presence of the researcher distorting the observed behavior of the research informant).

Data Collection

An etic, naturalistic observational approach was utilized whereby this investigator assumed an “observer-as-participant” position (Angrosino, 2007) during the interview process. Data collection proceeded on the premise that interaction of both ecological and social processes affects an individual’s decision to adopt or implement conservation practices (Sayre, 2004). The household survey instrument was developed to evaluate various factors that may have exerted influence on smallholder farmer decisions. Semi-structured qualitative interviews (Glaser and Strauss, 1967; Strauss and Corbin, 1990; Charmaz, 2002) were utilized due to the inherent flexibility and ability to focus on context specific features (Sayre, 2004). This method also allows “greater latitude for
discovering the unexpected” (Babbie, 1999). Socioeconomic, biophysical, cultural, and policy issues were targeted to evaluate the respondents’ incorporating this information into their adoption decision for the 14 SWCPs in question. Specifically, each bimodal question regarding adoption was followed by a semi-structured, open-ended question that allowed the respondent to more fully explain their reasons for “why” (or “why not”) they chose to adopt any of the 14 SWCPs. Approximately 1.5 hours were required to complete each interview. The semi-structured questionnaire is presented in Appendix B.

After the household interview, a farm “walk-about” was conducted with the head of household (HoH) to visually observe biophysical features of the farm and surrounding landscape and to verify that the SWCPs discussed during the interview had or had not been implemented. The “walk-about” took approximately 0.5 hours to complete and proved a valuable tool for observing the general extent and effectiveness of implemented SWCPs. This activity allowed the enumerator to observe and evaluate each RF’s actual conservation behavior and provided an opportunity to discover additional features of the extant landscape, from the farmer’s perspective, that may have been overlooked during the interview process. See the map and data form used in the “walk-about” process on page three of the semi-structured survey questionnaire in Appendix A.

Results and Discussion

Innovation Adoption - Why, Why Not?

Field observations indicated that adoption of SWCPs was widespread in the Njoro watershed. This supports the findings of quantitative data analysis discussed in Chapter 4. Quantitative analysis suggested that adoption behavior was related to context-specific
factors such as environmental conditions particular to location, ethnic grouping, socioeconomic factors, and external factors which affect well-being of the household. Domain analysis was conducted to provide supplemental information to better enlighten the findings and interpretations of statistical analyses. As previously noted, these findings are presented as a more detailed evaluation and discussion of the six most commonly adopted SWCPs (intercropping, contour tillage, manure management, agroforestry practices, plant residue, and cut-and-carry fodder); whereas, assessment of the less commonly adopted SWCPs was more cursory and described in more general terms.

Intercropping

Intercropping was adopted throughout the Njoro watershed by 209 of the 222 (94 percent) smallhold farmers interviewed. While this is a very high rate of adoption, domain analysis reveals, however, that only three of these farmers (1.4 percent) indicated that their primary intent for adoption was to protect soil or water resources. In contrast, 144 respondents (69 percent) indicated that their primary reason was to maximize use of available farmland and to optimize their crop yields. Factors influencing their decisions were a desire to improve food security in the household and to increase fertility of their soils by use of legumes (beans and peas) as a complementary crop to improve maize production. Thirty-eight (18 percent) of the remaining households indicated that adoption of intercropping was either a routine or intuitive practice learned from childhood or from observing others in their community. A few smallholder farmers indicated that it was a labor-saving method (seven percent) or that they did not know why they used the technique (two percent). See Plates 5.1 (illustration) and Figure 5.1 (domain analysis).
Plate – 5.1 (a, b). Examples of intercropping of various crops and agroforestry practices.
Figure 5.1. Domain Analysis Tree illustrating explanatory factors at different levels in smallhold farmers decision process that influence adoption of intercropping as a SWCP.
Of the 15 respondents who did not implement intercropping, more than half (53 percent) indicated that competition between crops was the main reason for planting monocultures. The rest indicated several reasons for adopting the practice, including lack of money to purchase seed for multiple crops, that their soils were still fertile—hence there was no need, and that their farms were either too small to intercrop or that they grew nothing but vegetables, thus there would be no benefit from adopting the practice.

Contour Tillage

Contour tillage was adopted by 189 (85 percent) of the respondents in this study. Of these farm households, 149 (79 percent) indicated that the primary reason for adoption was to reduce or prevent soil erosion. Seven (13 percent) expressed that they did not know why they adopted contour tillage, and the remaining farmers indicated that they adopted because it made tillage easier. Another factor was that by tilling/planting across the slope, their maize crops would not be blown down by wind. One respondent spoke of adopting the practice so that his cows would not be injured on hill slopes. These findings indicate that respondents considered contour tillage a soil and water conservation practice and their reasons are to protect or conserve these resources at the farm level.

For those respondents indicating nonadoption of the practice, their primary reason given was that tillage of their farm was easier when they followed the slope of the land. Considering that nearly all tillage on smallholder farms in the Njoro is done by hand with a jembe (hand hoe), this would be a logical way to reduce labor. A few respondents (n = 8) did not know why they did not use the technique, inferring that this was what they knew or had learned as a young person. See Figure 5.2.
Figure 5.2. Domain Analysis Tree illustrating explanatory factors at different levels in the smallhold farmers decision process that influence adoption of contour tillage as a SWCP.
Manure Management

There were many reasons given by respondents for using or not using manure on their farm fields. Of the 181 respondents indicating that they had implemented manure management on their farms, the majority (123 or 68 percent) referred to increasing/improving soil fertility as their primary purpose, while 37 (20 percent) of those adopting this SWCP indicated that restoration or enrichment of soils was their main objective. The distinction between “increasing” and “restoring” soil fertility is difficult to discern. Ultimately, an improved crop yield is the likely goal of the respondents, regardless of their answer. However, a subtle nuance separates these two responses and is important for understanding the motivation for adopting this SWCP.

First, adding manure to improve or increase fertility implies that the farmer is supplementing existing conditions only with the intention of changing an outcome (i.e., increased yields, food production, and income); in this case, stewardship of the land is not implied. Some respondents reported amending commercial fertilizer with manure to facilitate increased crop yields, and their intention was to do this regularly. From this, their primary intent is to increase crop yields and not land stewardship.

Second, the intent to restore or enrich soils implies that there is an awareness that some amount of degradation to soils on their farms has occurred, and that manure provides the material substance to replenish that which has been depleted (i.e., organic matter, nutrients, biotic matrix, etcetera). Restoration implies that soil health may be re-established to a former state and maintained through stewardship, as opposed to periodically replacing that which was lost (e.g., humus, fertility). Also, a number of
respondents indicated that by adding manure to their farm fields, they were improving the ability of soils to retain moisture or that they were improving soil health. These factors suggest that these smallholder farmers are aware of the complex nature of soils and imply that these factors are important considerations in their decision to adopt and implement this SWCP. See Plate 5.2 and domain Figure 5.3.

Of the respondents indicating that they did not adopt the practice, 25 individuals indicated that the primary reason for not using manure was that they did not own or have access to livestock and therefore had no manure to spread. However, they knew of the practice and would apply manure to their fields if they had access to the resource. Ten informants indicated that they used only commercial fertilizer, while four individuals indicated that their lands were still fertile and did not need any supplementary fertilizer. The remainder indicated a variety of reasons including they did not know why they had not adopted this SWCP, or that manure spreads weeds, therefore it was not a good option.

Agroforestry

One hundred sixty-five (75 percent) respondents indicated that they had adopted and practice agroforestry on their farms. Beyond this simple fact, a multitude of factors played important roles in the reasons for adopting or not adopting this SWCP and was the most complex to interpret of the six commonly adopted SWCPs. See Figure 5.4. Of the 165 individuals who adopted this SWCP, 73 (44 percent) referred to improving the environment as their primary reason for implementation. Farmers’ cited several important factors that influenced their decision: i.e., trees provided windbreaks and thus soil loss by wind erosion was reduced; trees helped to reduce soil erosion via slowing runoff from the farm; and trees helped attract rain/precipitation to the area and therefore helped to keep
Plate – 5.2 (a, b). Manure management collection and composting practices.
Figure 5.3. Domain Analysis Tree illustrating explanatory factors at different levels in the smallhold farmers decision process that influence adoption of manure management as a SWCP.
Figure 5.4. Domain Analysis Tree illustrating explanatory factors at different levels in smallhold farmers decision process that influence adoption of agroforestry as a SWCP.
water resources from being “finished” or dried out. Fifty-eight (35 percent) respondents practiced agroforestry to produce firewood and timber, apparently for home use or commercial sale. Other factors included their interest in forming windbreaks and improving the immediate environment (e.g., clear air, attraction of rain) as a result. Finally, twenty individuals (12 percent) in this group indicated that planting trees provided boundaries that demarcated their farms. This is an important factor for some ethnic groups as trees planted on the border of the property provide tangible evidence of ownership, and thus infers primacy for the use and occupancy of said lands in lieu of a recorded title deed.

Of the remaining 57 nonadopting respondents, most indicated that they did not have tree seedlings or that they had no money to purchase seedlings to plant. Nine individuals stated that they would not plant trees because they competed with crops, reducing yields and therefore food security, or that there would be no benefit to practicing agroforestry. Eight respondents suggested that tenure insecurity was their reason for not adopting agroforestry practices, and the remainder either did not know or had no comment as to why they did not implement this SWCP.

Plant Residues

One hundred sixty-four respondents (74 percent) implemented some form of plant residue management on their farms in the Njoro watershed. Only two individuals (three percent) indicated that plant residue management was implemented to reduce runoff, prevent soil erosion, or protect water resources. Eighty-five (52 percent) indicated that improving or increasing fertility was the main reason for leaving plant residue on their fields, while 52 (approximately 32 percent) indicated that restoring or enriching soils was
their primary reason. Further, there were 13 respondents who chose to leave crop residues to facilitate retention of soil moisture. Restoration of soils as a reason for adoption of this practice implies a holistic view of their farms and may be described in similar terms as previously discussed. For the remaining smallhold farmers, their reasons for adopting this SWCP varied from feeding some of the crop residue to livestock within the field and for making tillage easier, presumably because of the added organic matter which provides better soil structure and tilth. See Plate 5.3 and Figure 5.5.

Of the 58 respondents indicating nonadoption, fully 72 percent (n = 42) choose to feed all plant residues to their livestock rather than leave them on the ground surface. Of the remaining, 11 respondents burn what residue is left to make land preparation (tillage) for the next crop easier.

Cut-and-Carry Fodder

The TREE analysis in Chapter 4 clearly indicated that cut-and-carry fodder management was delineated by whether the smallholder kept livestock on their farms or not, i.e., 144 in favor versus 78 nonadopters (65 percent to 35 percent, respectively). When asked to explain why they had adopted this practice, the obvious reason was to feed livestock; however, the underlying reason or factor for practicing this method was to protect crops and fodder plants from trampling by livestock while they grazed. By doing so, soil compaction is avoided, soil structure is maintained (and may be improved by the addition of organic matter), and soil erosion potential is reduced (Leopold et al., 1995; Brady and Weil, 1999; Schaetzl and Anderson, 2005). Interestingly, many respondents indicated that they adopt this practice so that their livestock can rest and thus be more
Plate - 5.3 (a, b). Example of leaving plant residues on crop fields to provide protection against soil erosion.
Figure 5.5. Domain Analysis Tree illustrating explanatory factors at different levels in the smallhold farmers decision process that influence adoption of leaving plant residue as a SWCP.
productive (i.e., milk, meat, wool). Other factors for implementing cut-and-carry were that unproductive crop plants such as maize, beans, and vegetables could be cut and utilized as supplemental livestock feed during the growing season, or when respondents did not have access to grazing lands, they had no time to free-graze, or that free-grazing was too tedious. These people preferred to zero-graze their livestock and thus had no choice but to cut-and-carry fodder. See Plate 5.4 and Figure 5.6.

Of the 78 respondents who did not adopt the practice, 29 did not own livestock so had no need for the practice. Thirty-five percent of nonadopters felt that cut-and-carry took too much time and energy to implement (too tedious), and the remaining 28 percent indicated that they had access to grazing lands, and there was no need for them to adopt this practice. Minor factors influencing these nonadoption decisions were that their livestock were used to free-grazing and would not adjust to confinement.

Less Commonly Adopted SWCPs

In considering the second group of less-commonly adopted SWCPs (i.e., fallowing, *fanya juu*, micro-catchments, bunding techniques, grass-strips, ditches/trenches, off-stream watering points, and other indigenous practices), it was found that these SWCPs were adopted by 42 percent or less of all households in the study area (Chapter 4). The overall rates of adoption for these eight practices were as follows: fallowing land (29 percent), *fanya juu* (9 percent), micro-catchments (5 percent), bunding techniques (16 percent), grass-strips (37 percent), ditches or trenches (27 percent), off-stream watering points (42 percent), and other indigenous SWCPs (15 percent). So, why were these SWCPs not more commonly adopted?
Plate 5.4 (a, b). Example of cut-and-carry SWCP where farmer brings fodder to livestock.
Figure 5.6. Domain Analysis Tree illustrating explanatory factors at different levels in the smallhold farmers' decision process that influence adoption of leaving cut-and-carry fodder as a SWCP.
When considered in light of the five attributes of innovations described by adoption theory, it was determined that none of these SWCPs were heavily favored by the criteria indicated for favoring adoption. In particular, the relative advantage and compatibility of the particular practice or technology to farmers’ current operations were missing. This issue is critical to understanding the decision process when farmer’s resources are limited; whereby, the incentive to accept new risks for adopting an unknown SWCP is necessarily a secondary factor to the smallholders immediate need for food procurement and sustenance.

This is illustrated by TREE analysis which revealed that, of the five variables predicted to be primary explanatory factors for adoption of these less commonly used SWCPs, only income and agroecological features (soil moisture) were indicated as influential for fallowing (29 percent), bunding (16 percent), and fanya juu (9 percent), respectively. In explanation, income can be considered an internally limiting factor whereby a farmer may perceive that income generation would be reduced due to removing a portion of their lands from production, the cost offset of increased labor required to implement, and to their perception of limited compatibility with their farm. Soil moisture, on the other hand, acts as an external limiting factor to adoption of these particular SWCPs in this watershed. The relative advantage of adopting SWCPs designed for arid lands was not evident. This is thought to be due to the relative abundance of rainfall throughout the watershed, and because of heavy labor requirements for implementation. Farmer’s perceptions of relative advantage and improvements to their
level of income do not appear to outweigh their sense of risk and the burden incurred by implementing these labor intensive SWCPs.

Another important factor to consider is to know that fallowing, *fanya juu*, micro-catchment, and bunding practices are more common in arid zones that are subject to limited and/or intense precipitation. Arid land conditions typically have sparser vegetation cover and hydrophobic soil conditions that can result in high rates of overland flow and, potentially, higher rates of soil erosion (Leopold *et al.*, 1995; Schaetzl and Anderson, 2005). When coupled to vegetation removal due to cultivation or grazing, these conditions are exacerbated.

Fallowing land is intended to restore soil nutrient levels after intense cultivation and in areas of limited precipitation, and provides a period of rest to restore soil moisture levels to enable crop production. The TREE analysis indicated that farm income appeared to be the primary determining factor, inferring that the immediate need to produce food outweighed the benefits derived by implementation. With additional analysis, election to implement this practice was by farmers whose incomes were greater and was further delineated by ethnic group. For example, a majority of Kalinjin and Ogiek (86 percent) chose not to implement this practice, whereas among the Kikuyu and other ethnic groups, 43 percent of these farmers chose to adopt and use this SWCP.

*Fanya juu*, micro-catchment, and bunding practices are designed primarily to prevent soil erosion and/or to increase water retention and infiltration by reducing surface runoff away from, or off, farm fields. These SWCPs also trap sediment so that the nutrient and organic matter rich topsoil is not lost from the farm. In the Njoro, the relative
advantage of trying, then maintaining, the practice appeared to be lacking amongst those farmers surveyed. Nor did these practices pass the “compatibility test” in relation to the farmers’ current operations, past experiences, and perceived need for protecting their soil resources. The TREE analysis revealed that adoption of *fanya juu* and micro-catchment were explained best by agroecological features: perceived soil moisture levels and type of tillage used, respectively. Ethnicity was indicated as the secondary explanatory factor for both practices that could be explained by the person’s prior experience, culture, or the place where they came from originally.

For bunding techniques, four primary factors explaining adoption of SWCPs were total income, size of farm, tillage methods, and years on farm. This methodology is labor and resource intensive. In areas where rainfall is less severe and where soil types allow for adequate infiltration rates, the perceived relative advantage of adoption (cost/benefit) in this watershed was perceived to be low.

Grass-strips can serve two purposes. First, they may act to reduce overland flow of precipitation waters so they are retained on-farm, and for trapping eroded soil and thus preserving nutrient-rich sediments for redistribution on the farm. They may also produce feed for livestock kept on the farm either via direct grazing by livestock or for cut-and-carry fodder for animals held in confinement. In the Njoro, implementing grass-strips was best explained by the ethnic group. Generally speaking, the Kalinjin and Ogiek peoples identify with being pastoralists and prefer to free graze their livestock; therefore, compatibility with their culture is the issue, and they do not tend to perceive a relative advantage and do not adopt this practice. This also suggests that for these peoples, the
concept of carrying fodder to their animals is not well accepted. For the Kikuyu and “other group,” a secondary explanatory factor for adoption was that where farm size is more limited, adoption of this SWCP was more likely; i.e., those having less land were more likely to adopt grass-strips as they had limited access to grazing lands, and they could afford to have some portion of their lands devoted to fodder to support their animal holdings or for erosion control on limited crop lands. Under conditions of limited land resources, this is a reasonable method of protecting limited soil resources for sustaining food production and for feeding livestock.

Installation of ditches or trenches may serve more than one purpose. On the one hand, they may be used to divert precipitation waters onto farmlands to augment soil moisture conditions and crop production potential, mostly in arid land agriculture. This was observed in the lowest reaches of the study area. Ditches/trenches were observed to bring water onto farm fields from roads and runoff rills and gullies. Arid conditions, permeable soils, and heavy rains combine to limit crop production; therefore, farmers in these more arid zones apparently did perceive a relative advantage to implementing this practice and found it to be compatible with their particular environmental context. On the other hand, these SWCPs may be implemented to divert water away from croplands to prevent excess accumulation of soil moisture. For example, in areas where heavy (clay) soils predominate, and in areas where levels of precipitation exceed crop requirements, ditches/trenches prevent accumulation of excess water on farm fields and the subsequent water logging and crop failure during wet periods. Neither of these conditions was prevalent in the watershed, thus negating the relative advantage of implementation.
Use of off-stream watering points is also a common practice in arid rangelands where ecological conditions and limited water resources demand dispersal of livestock away from riparian zones and stream banks to minimize their impacts to soils and vegetation. While stream bank degradation and bank soil erosion was common at watering points along the river, peoples’ perception of degradation and the motivation to address the problem seemed to be lacking. From TREE analysis, we found that adoption of off-stream watering points was best explained by whether there were livestock kept on the farm and what type of livestock it was. Since no infrastructure existed that would allow piping or diversion of surface water resources to an off-stream watering point, farmer’s choices were either to take livestock to water or to carry water to their livestock. Owners of cattle in particular did not adopt this practice, instead opting to drive their animals to water sources versus carrying water back to them on the farm. Obviously, with only a 42 percent adoption rate, the relative advantage and compatibility with existing operations, in terms of labor, time, and efficiency, was lacking for farmers in the Njoro.

Adoption of “other” indigenous SWCPs was found to be specific to an ethnic group and to their particular historic experiences and cultural perceptions of resource management. Culture, income, and having enough to eat were the three principle factors explaining use of indigenous SWCPs; however, it must be noted that specific indigenous practices related to crop production or soil and water conservation were not commonly observed or reported. This is thought to be the result of long-term access to extension and experiential knowledge of “modern” SWCPs of those farmers in the lower portion of the
study area and by those who have more recently migrated into the upper portion of the study area.

Farmers’ Perceptions of Their Environment

Culture/Religion

Regarding the influence of culture on respondent views of the environment, 144, or approximately 65 percent, of those interviewed felt that their culture had provided lessons and did have a positive influence on their use of natural resources. Sub-factors related to culture could be delineated generally by ethnic groups. The Kikuyu are traditionally farmers and have a strong leaning toward protecting soil resources and using sustainable farming methods. The Kalenjin and Ogiek, on the other hand, tended to be more concerned with protecting grazing lands and the forest, with the Ogiek being particularly interested in forest resources. The general views of each ethnic group on protecting water resources was, however, quite different. Whereas the Kikuyu were generally neutral on this matter, the Ogiek indicated a strong affinity toward protecting water resources and coupled their concern to protecting the catchment and riparian forests that serve as the source of the river. They expressed strong opposition to the practice of washing clothes and felt that bathing in or near the river (or springs) surface waters were “bad.” On the other hand, the Kipsigis, a sub-group of Kalenjin, felt that washing and bathing in the river was not detrimental to the resource.

Religion played a role in shaping perspectives of the environment with 124 respondents (56 percent) indicating that their religion had provided lessons or teachings. These lessons could be categorized generally as caring for the land (farming), care of
water, and lessons about the virtues of hard work. A plethora of sub-factors and variables were indicated for each category including, most prominently, that water is the source of life and that it should be protected. Common expressions relayed during household interviews were “do not pollute,” “do not wash or bath in the river,” “protect the trees near the river so that the water will not be finished or dried up.” Other factors related to the influence of religion included practicing good farming and soil management methods so that good harvests would result and, in some cases, so that tithings to the church could be made. Religious teachings also taught lessons in diversification of their farms (crops and livestock) to ensure that they would always have enough food to eat and that they would have a source of income.

Water Quality

We asked each respondent to describe water quality in their own words to broaden our understanding of their views of the environment and how they may or may not affect the quality of the resources available to them. Informants were asked to “Please describe what very good quality water for use by people is?” Five general categories were identified and included “other” definitions, rain water, boiled/treated, flowing water, and borehole or well water. The group of “other” definitions composed an assortment of general descriptor terms describing their impressions of what good water meant to 67 respondents (approximately 30 percent). These included the terms “clean,” “unpolluted,” “colorless,” “clear,” and “water coming from the forest.” These qualities of good water were further defined by sub-factors and included water that was undisturbed, without dirt, cool, and without germs. Rainwater was the second most prominent category of good
quality water, indicated by 58 respondents (26 percent), and was associated with water that is clear, clean, or that had not been contaminated with dirt or other pollutants such as soap or effluents. Many respondents captured rainwater from their rooftops and stored it in barrels outside the home. Third, 40 informants (18 percent) indicated that water that had been boiled or otherwise treated with chemicals was considered fit for consumption. The source of these waters did not appear to be significant as long as treatment had taken place. Fourth among the categories was “flowing” water, including the river, tributaries, and spring water. This observation was made by 38 HoHs (17 percent), and further qualification of why this constituted good water was not offered. Lastly, borehole or well water was identified by 20 individuals (9 percent) as being good and acceptable for human consumption.

When asked, “Please describe what is very bad quality water for use by people?” runoff water was identified by 80 respondents (36 percent) as being “bad.” Factors offered to qualify this opinion were that runoff water had been contaminated by soil or dirt (and were therefore colored, not clear), road contaminants, soap from washing and bathing, and finally by feces and germs originating from both humans and livestock. Some variations on this concept of dirt included soap, mud/sediment, insects, and that water had been polluted by the discharge of wastewater from brewing of the local distilled alcohol, “changaa.” Second, stagnant water was identified by 46 people (about 21 percent) as being “bad” and was closely aligned with runoff waters, road pools, and standing water with a foul odor. Third, waters polluted by human and livestock activities were indicated by 40 respondents (18 percent) and was further associated with trampling
by people and livestock, sewage or factory effluent, and wash water (soap). Thirty-three respondents (15 percent) identified the river as the fourth category of water that was considered to be “bad” for human consumption. Finally, water that caused illness was the fifth major category of bad water; nearly eight percent (n = 18) reported this.

Riparian Zone

When asked to describe the activities that have resulted in “the number of trees and other vegetation has changed along the river . . . ,” an overwhelming majority of 135 respondents (61 percent) indicated that riparian forests were being removed for making charcoal and for fuel/firewood. This included household use and for commercial sales in market centers and in the city of Nakuru. Minor factors associated with charcoal making and firewood removal were accidental fires that spread unabated, cutting timber for fence posts and other building materials, and clearing land for agricultural fields. Second, 44 informants (12 percent) indicated that riparian zone vegetation was being removed to make way for agricultural activities. The trees cut during the clearing operation were then used for building materials for homes, as fuel wood, and for making charcoal. Third, 18, or approximately 8 percent of respondents, indicated that the main reason for removal of riparian vegetation was for timber sales via both legal and illegal operations, with minor factors being charcoal making and collection of firewood. Clearly, the lines of distinction between these three categories are blurred at best, and interpretation could easily group these into one category: the harvest of wood products.

Interestingly, 22 of those interviewed (10 percent) did not believe that there had been a reduction in the amount of riparian vegetation or trees in the recent past. Their
reasoning was founded on a belief that community appointed monitors were on patrol and that they prevented trees from being cut. There were also a few people who believed that for each tree cut down, a new tree seedling was being planted, sometimes at a rate of two or more to one! This may be so at their particular location, but was not widely observed.

When asked what could be done to protect riparian zone trees and vegetation, 115 respondents (52 percent) suggested that more trees should be planted, either via government reforestation programs or by providing seedlings to community members to plant independently. Factors supporting this suggestion were to provide fencing to prevent grazing livestock access to the area, prevent people from doing their washing in the river, and provide security forces to prevent misuse of riparian lands. Second, 67 or about 30 percent of smallholder farmers’ expressed their desire to have the government or local chiefs provide security (monitors, police) to patrol and enforce the law against destroying riparian zones. They also wanted officials to encourage community participation in monitoring and protecting these lands. Education by means of extension or local chiefs was indicated by 22 respondents (10 percent) as a means of encouraging protection of the riparian forest, and the remaining 15 or so respondents (7 percent) felt that demarcation of these lands would result in adequate protection. Again, a clear distinction between these observations is difficult to draw.

Participant Observation

Roads and Paths

Remembering that the population within the study area is approximately 6,500 people and, when the entire watershed is accounted for, the overall population is very
large (≥ 250,000), there are virtually no improved roadways in the watershed save the one paved highway from the city of Nakuru, through the towns of Njoro, Egerton, and south onward to Mau Narok. Instead, dirt roads, footpaths, and livestock trails are abundant and serve as the de facto transportation network. The most common means of travel and transport are by foot, bicycle, and donkey carts, with automobile traffic on the larger roads. Major dirt/gravel roads are graded once or twice per year; however, there appears to be no organized maintenance of any minor roads or foot trails in the watershed. Virtually the entire network of roads and paths, including the paved highway, are grazed by livestock throughout the year without restriction.

As indicated previously, most respondents access the river for their daily household (72 percent) and livestock (77 percent) water needs. This has resulted in the formation of a network of human-caused hardened pathways, or paths of “least resistance,” directly to the main stem and tributaries of the Njoro. Since livestock are regularly grazed along these “roads,” foot trails, and pathways, higher levels of soil compaction restrict infiltration, resulting in high levels of overland flow and runoff throughout the network. Examples of the effects of roadside grazing leading to erosion and down-cutting along roads and pathways are illustrated in Plates 5.5 to 5.7.

Riparian Zone Impairments

In many areas of the watershed below the forest boundary, the riparian forest provides the only source of firewood, charcoal, and timber. Other plant materials for sustenance and medicinal use are also harvested from the riparian forest. The result is a reduction in large proportions of above ground vegetative biomass (Enanga, 2007) which
Plate – 5.5 (a, b). Example of livestock trails to the water access points on River Njoro.
Plate – 5.6 (a, b). Roads and trails that provide primary transportation routes through the watershed.
Plate – 5.7 (a, b). A second example of roads and trails in the watershed. Note the severity of down-cutting and volume of soil loss due to erosion.
protect soils from rain-drop impact, slows overland flow, promotes infiltration, and provides storage of water resources. This also reduces the volume of root biomass which increases soil bulk density, hardens the soil surface, and reduces water infiltration. With the removal of forests and conversion to croplands, the deep roots of trees, which promote deep infiltration of rainwater for storage in the sponge-like soils and near-surface groundwater, are effectively removed. Additionally, as regular cultivation continues, soils are oxygenated and warmed, increasing the rate of decomposition of organic materials which reduces soil organic matter content (Brady and Weil, 1999; Schaetzl and Anderson, 2005). These conditions facilitate rapid overland flow and surface runoff during storm events, which accelerates down-cutting and soil erosion. Examples of these are illustrated in Plates 5.8 and 5.9.

In addition to more obvious down-cut, eroded roads and pathways leading to the river and its tributaries, riparian habitat has been encroached upon in general (Enanga, 2007). Livestock watering points have been identified in 17 discrete sections of the river, not withstanding the multiple access points evident in the upper watershed’s forested and grassland regions where pastoral grazing practices are common (Enanga, 2007; SUMAWA, 2003-2004). This leaves riparian vegetation severely reduced in density due to browsing and trampling, leaving the soils barren and deeply incised. Field observations suggest that the number of livestock watering points may in fact be greater than reported, and those that are free-grazed are typically watered several times daily.

These observations are relevant to understanding the importance of the riparian zone in mollifying impairment of water resources. Past studies have indicated that
Plate – 5.8 (a, b). Impacts of human activities on riparian zone habitats (e.g., access for laundry, access to water, and livestock watering).
Plates – 5.9 (a, b). Impacts of human activities on riparian zone habitats (e.g., charcoal making, clearing for crop production, access to water, and livestock watering).
riparian zone ecosystems are far more complex than their upland counterparts (Lowrance et al., 1984; Brooks et al., 1991). Riparian zones regulate the nutrient flux from upland sources to the stream and may act as a source or sink for nutrients in watersheds (Peterjohn and Correll, 1984; Mulholland, 1992). Significantly reduced concentrations of nitrates in both surface water and groundwater flow, coupled with significant reductions in particulate matter, have been reported after traversing the riparian zone (Peterjohn and Correll, 1984; Mulholland, 1992). Factors controlling the source/sink attributes of riparian zones depend on the extent of nutrient input from uplands, the reduction-oxidation (redox) potential of riparian soils and groundwater, soil microbial activity, and calendar season (Mulholland, 1992). Microbial activity and the redox potential in soils and near-surface groundwater are indicated as being primary factors in controlling ammonium and nitrate concentrations within riparian zones (Atlas and Bartha, 1987). Factors controlling phosphorus concentration and movement through riparian zones are less clear but are thought to be linked to redox potential and microbial activities (Peterjohn and Correll, 1984; Mulholland, 1992).

Soil Characteristics

It was anticipated that erosion from farm fields would be observable and significant due to deforestation and because farmlands tend to have higher bulk density and less soil organic matter than their native counterparts, two key components that promote infiltration and retention of soil moisture. Soil aggregate stability is an indicator of the stability of soils to resist surface crust formation and erosion. Soil aggregates refer to groups of soil particles that bind to each other more strongly than to adjacent particles
and have a pore-space in between that provides for exchange of atmospheric gases and retention of soil water. Aggregate stability effects erosion potential, movement of water through the soil, and plant root growth; thus, it is a measure of stability against degradative forces of wind, rainfall, and water movement (Six et al., 1998). When aggregates do break down, individual soil particles are released which clog soil micro-pores, creating soil crusts that seal off the primary pathways for water infiltration and atmospheric gas exchange. The stability of aggregates is affected by soil texture (percent of sand, silt, and clay), the predominant type of clay, extractable iron, extractable cations, the amount and type of organic matter present, and the type and size of the microbial population. Soils having high organic matter content typically have greater aggregate stability primarily due to by-products of decomposition of organic materials by microorganisms, soil macro-fauna, and earthworms (Six et al., 1998). Therefore, the stability of soils generally declines when land is placed under agricultural production where regular tillage and mono-cropping systems disrupt aggregate stability.

Soil aggregate stability analysis was performed by the SUMAWA project under five different vegetation cover types: agriculture with maize and bean intercropping, grazed land, deforested land, plantation (exotic) forest, and indigenous forest (SUMAWA, 2003-2004; Mainuri, 2006). Indigenous forest lands had the lowest value for bulk density (0.74 g/cm³) compared to agricultural lands which had a bulk density of (0.85 g/cm³), most probably a by-product of high organic matter content and the network of plant root system which maintains pore space and enhances infiltration (SUMAWA, 2003-2004). Additionally, it has been reported that mean surface runoff rates are much
greater from agricultural lands than from indigenous forest which suggests that negligible erosion occurs from indigenous forest lands while agricultural and grazed land experience higher erosion rates (SUMAWA, 2003-2004). Grazing land, on the other hand, exhibited the highest bulk density (1.05 g/cm³) which was explained as being the result of lack of deep soil root mass and soil compaction due to trampling by animals.

However, contrary to expectations, soil erosion from farmlands was not widely observed during household surveys and farm walkabouts. I believe this is due to several factors. First, tillage of farm fields was predominantly done by hand using a *jemba* (hand hoe) and *panga* (machete). In contrast to mechanical tillage, which typically chops the overlying vegetation and soils into small uniform pieces, hand tillage typically incorporates the overlying vegetation or crop materials as clumps, leaving coarse organic materials largely intact. Hand tillage also leaves a very rough ground surface that results in larger pore spaces and a relatively more tortuous path for overland flow of surface water during precipitation events. The coarse organic material facilitates infiltration by providing channels and flow-paths into sub-surface soils and groundwater. In contrast, mechanical tillage typically finely chops organic materials and surface soils into small, uniformly textured overburden that tend to “melt” during rainfall events to create a soil crust, thus sealing the surface to infiltration (Appendix A).

The climate of the Njoro supports the cultivation of multiple crops during any given year. Coupled to the finding that farmlands were infrequently fallowed (29 percent) or left bare, it is suggested that vegetation is present during most of the year. Vegetation cover protects the soil surface from raindrop impacts, slows surface runoff, and root
biomass promotes organic matter content and infiltration. These conditions are augmented by the rapid regrowth of wild vegetation or the “weediness” typical of these smallholder farms. Additionally, given the relative recent conversion of forested lands to agricultural lands, substantial oxidation and loss of endemic soil organic matter has not likely yet occurred. When considered together, these conditions suggest that soil aggregate stability is being maintained due to the high level of endemic organic matter (from recently converted forested lands), the relatively high input of organic materials due to sloughing of dead root material and foliage, the by-products of decomposition, and by a healthy population of soil biota.

Geology

Observation and assessment of geologic features in the Njoro suggest that retention of water resources is limited; soil moisture drains and is expressed to the river relatively rapidly throughout the study area and lower portions of the watershed. This supposition is based on the frequency of observing exposed bedrock and rock outcrops along the length of the valley; these are common features in fault-block derived geologic formations (i.e., Rift Valley). As reported by the SUMAWA research effort, the soils of the watershed are of volcanic origin and highly variable throughout the watershed. They range from poorly drained to very well drained, and with depths ranging from very shallow to deep (SUMAWA, 2003-2004; Mainuri, 2006). This variability was particularly evident in the middle and lower portions of the study area.

From these field observations, it is suggested that the Njoro is bedrock-confined and that soils along the valley are shallow, lying atop impermeable material. Coupled
with the reduced riparian vegetation, the capacity to absorb and retain precipitation
waters is therefore impaired along the entire reach of the river from the forest boundary
to the mouth of Lake Nakuru. These conditions likely contribute to the multiple
comments reported to this investigator that the river system is more prone to flash flows
and flooding (“flashy”) than was previously observed (Steve Huckett, unpublished data;
SUMAWA, 2003-2004). Ramifications of this condition include a reduced capacity to
filter sediments, nutrients, and fecal coliform coming from overland and near-surface
flow of waters from farmlands and, more specifically, from the road/pathway network, all
of which contribute to water quality impairments (see Plates 5.10 and 5.11).

Message to Decision-makers

As an adjunct to the main question, riparian farmers were asked, that if possible,
what message they would like to convey to decision-makers if given the opportunity.
Decision-makers were defined as those persons in charge of making policy and laws or
those who could provide services that would benefit the public in general. Five general
categories of concern were identified with a multitude of variation on these general
themes. Most prevalent of their concerns was their desire for additional education about
the environment, environmental protection, and stewardship of water resources. This
included interest in learning about the importance of trees for protecting catchment
resources (i.e., reforestation) and why it is beneficial to protect against impairments to the
environment. Seventy-one respondents (32 percent) expressed their desire that the
government provide training locally so that people would be better informed about the
importance of trees, soil conservation, and the riparian zone/river complex. Reductions in
Plates – 5.10 (a, b). Example of underlying geologic conditions in River Njoro valley bottom and thalweg (e.g., (a) located at livestock watering point; (b) upstream of watering point).
Plates – 5.11 (a, b). More examples of underlying geologic conditions in River Njoro valley bottom and thalweg.
logging activities (legal and otherwise) and protection of the riparian zones from clearing for agriculture, grazing, and washing/bathing were the primary factors suggested.

Protection methods focused on demarcation of a buffer zone so that it would become an “official” protected area, and providing scouts or monitors to patrol this zone were recommended. Second, respondents expressed a strong desire to have more law enforcement, more specific laws developed, or the appointment of monitors/committees to oversee protection and maintenance of the river. Sixty-nine respondents (31 percent) believed that enforcement of existing laws that specifically focused on preventing illegal logging, clearing of the riparian zone for agricultural purposes, and pollution from washing/bathing, improper toilets, and effluent from sewage and factory waste systems would make a difference.

Third among messages to decision-makers, 31 respondents (14 percent) suggested that the government provide seedling trees to replant, and that they implement reforestation projects to restore catchment. Some factors mentioned to support this message were that the government should provide job opportunities so people would stop cutting trees for wood/charcoal/fuel, prohibit grazing along the river, and provide title deeds to their properties so that smallhold farmers could feel empowered to protect and maintain riparian lands. The fourth category of messages offered by 22 respondents (10 percent) included demarcation of riparian lands for protection (at some distance of 50 steps, 50m, 50 feet), to provide title deeds to these lands, provide compensation for giving up farmlands within this protected zone, and to make protecting these lands compulsory for the entire populace of the Njoro. Lastly, a hodgepodge of messages were
offered by 21 informants (10 percent) including providing boreholes and infrastructure to make drinking water accessible, providing off-stream watering points for livestock to prevent trampling of surface waters and riparian vegetation, providing market protection for agricultural produce (price supports) and for inputs such as fertilizers, herbicides, insecticides, and improved crop variety seeds, and to provide access to funding for farmers’ to invest in agroforestry practices and soil conservation measures on their farms.

Conclusions

The main hypothesis in Chapter 4 predicted that the predominant explanatory factors explaining adoption of SWCPs would be level of education, income, tenure status, access to extension information, and agroecological features. Statistical analysis further suggested that the interaction of multiple factors would best describe adoption decisions and behavior among smallholder farmers in the Njoro watershed. Furthermore, it was predicted that due to a relatively chaotic socioeconomic environment and highly altered landscape, adoption of SWCPs in the Njoro would be low and soil erosion from farmlands would therefore be widespread.

Adoption of various SWCPs was, in fact, widespread throughout the study area. More specifically, adoption rates on farms located in the more recently settled, higher elevation areas (between 2,400 and 2,699 masl) was only marginally lower (5.9 SWCPs) than the average of 7.3 SWCPs adopted in the study area below 2,400 masl (see Chapter 4). This is particularly interesting when SWCP adoption was evaluated in relation to tenure status. Of those farmers interviewed and living above 2,400 masl, only five individuals (4.1 percent) reported that they actually held title deed to the lands they
farmed; however, when asked about how long into the future they would be farming their lands, most respondents indicated that they believed that they would be there for 10 or more years. On the other hand, in elevations below 2,400 masl, there were 58 individuals (58 percent) reporting ownership by holding title deed. So, does evaluation of qualitative information provide an alternative explanation of this high rate of adoption?

Underlying Explanatory Factors

Examination of respondents’ reasons for adopting or not adopting any of the six more commonly adopted SWCPs reveals that conservation or stewardship of natural resources clearly was not a primary concern. In fact, only three of the six SWCPs were adopted for reasons related to conservation of soil resources (i.e., contour tillage, manure management, and agroforestry measures). As indicated by nearly 80 percent of respondents, the farmers understand that conservation tillage methods reduce soil erosion and provide increased infiltration and protection against overland flow during precipitation events. Secondarily, farmers indicated that this is an easy practice to implement, implying that little additional effort or resources are necessary. This compares well with the TREE statistical analysis where it was established that approximately 85 percent of respondents adopted this practice.

Implementing manure management as a SWCP was, on the other hand, not so clear as to motivations. First, the number of farmers indicating why they had adopted the practice was slightly different than that indicated by the quantitative analysis (82 percent versus 77 percent). Also, the distinctions between using manure to restore or enrich their soils versus using manure to increase/improve soil fertility was a subtle nuance that
added definition to the reasons why an individual might adopt the practice, and improved our understanding of their motivations for adoption. As discussed earlier, adding manure to improve or increase fertility implies that the farmer is only supplementing existing conditions with the intention of increasing yields; thus, stewardship of the land is not implied. On the other hand, when manure is used to restore or enrich soils, some amount of degradation is implied and manure provides the material substance, i.e., organic matter, fertility, etcetera to restore soil health; thus, stewardship is assumed. Several respondents also indicated that adding manure helps to improve soil moisture retention and overall soil health, suggesting that they possessed a heightened awareness of the complex nature of soils and that there was a tangible need to protect this resource from degradative farming practices.

Adoption of agroforestry practices was indicated by 165 respondents, which nearly equaled the number indicated by statistical analysis (Chapter 4). However, qualitative analysis provided a multitude of factors to describe farmer reasons for adoption or nonadoption. Of the 165 individuals, only 73 referred to environmental protection as their primary rationale for implementation. The reasons given for adoption included: trees provided windbreaks—thus wind erosion was reduced and crops were protected from blow-down; trees reduced soil erosion; and trees helped attract rain/precipitation to the area. Other factors inferring protection of resources included improving the immediate environment by making the air clean, that trees attract rain to the farm, and they provide shade. From a more practical perspective, the respondents indicated other important factors in favor of adoption including that trees produced
firewood and timber products and they were used to establish property boundaries via
demarcating their farms in lieu of holding a recorded, and thus legal, title deed.

Two SWCPs (cut-and-carry fodder and plant residue management) make up an
in-between category of adoption. Whereas 144 respondents adopted the practice and
recognized the benefit to their soil resource by implementing the cut-and-carry fodder
practice, farmers’ primary concerns were directed more towards providing feed to their
livestock than to improving the fertility or restoration of their soils. However, I argue that
cut-and-carry fodder is a proxy SWCP because by carrying fodder to their livestock, soil
compaction by livestock trampling while they graze is prevented, thus reducing soil
erosion potential. Additionally, soil organic matter and general soil health is maintained
or improved. Farmers were also able to utilize their unproductive crops as livestock feed
and, interestingly, many respondents indicated that their livestock could rest and thus be
more productive by having fodder brought to them. Each of these factors reduces the
number and frequency of free-grazing livestock in the watershed, leading to fewer
opportunities for soil compaction, de-vegetation along roads and foot paths, and
degradation of riparian areas to occur.

Of the 160 respondents indicating that they manage their crop/plant residues, only
three indicated that they did this to prevent erosion. However, 52 individuals suggested
that restoration or enrichment of their soils was their main reason, and 13 respondents
said that they chose to leave crop residues on farm fields to improve soil moisture
retention. These responses imply that at least some smallhold farmers take a more holistic
view of their farms and suggest that, by managing their plant residues, their soils resources will be improved or protected from degradation.

Of the entire sampled population of Njoro farmers, only three individuals (1.4 percent) indicated protection of soil or water resources as their main reason for adopting intercropping as a SWCP. For the majority, the primary reasons given for adopting this practice were to maximize use of available farmland, to optimize crop yields via double cropping, and for improved soil nitrogen and thus fertility as a by-product of legumes. A desire for better food security, coupled to the fact that implementing intercropping was both a routine, intuitive behavior, appeared to be a driving force behind adoption decisions.

When evaluating smallholders’ reasons for adopting or not adopting SWCPs, it is also important to take into account underlying cultural and religious teachings that influence their general behaviors and decision-making processes. Regarding cultural influence, 144 respondents felt that their culture had provided lessons which influenced their perception of the environment and their use of natural resources, with delineation along ethnic lines generally possible. For example, the Kikuyu are traditionally farmers and have a strong leaning toward protecting soil resources, whereas the Kalenjin tend to be more concerned with protecting above-ground resources such as grazing lands and the forest, and the Ogiek are particularly concerned for forest and water resources. Religion, on the other hand, was cited by 124 respondents as playing an important role in shaping their perspectives on environmental stewardship. Caring for the land (farming), caring for water resources, and lessons about the virtues of hard work were central to their beliefs.
Most prominently, water was of concern because it is seen as the source of life and should be protected; common expressions to describe their values and perception of the importance of water in their lives included: “do not pollute,” “do not wash or bathe in the river,” “protect the trees near the river so that the water will not be finished or dried up.” The general views of each ethnic group on protecting water resources were, however, quite different.

When asked to describe their perceptions of good water quality—that is, acceptable for human consumption—respondents identified that rain water, boiled/treated, flowing water, and borehole or well water were “good” water. A group of “other” definitions was also offered, composed of general descriptor terms such as “clean,” “unpolluted,” “colorless,” “clear,” and “water coming from the forest,” which were related to the degree of impairment by disturbance, dirt, germs, and whether it was cool. It is interesting that borehole or well water was not recognized as generally having the best water quality. Perhaps this is due to the lack of exposure to or access to borehole water, and thus it was not considered a possibility in their households. The source of water also did not rise to be a significant factor when describing good water, as long as it was boiled or treated, flowing, or otherwise clear.

When asked to “Please describe what is very bad quality water for use by people?” respondents expressed a definite awareness of specific factors that contribute to poor water quality; these included factors such as soil or dirt, road contaminants, soap from washing and bathing, germs, and waters polluted by human and livestock activities such as bush toilets and livestock feces. Likewise, stagnant water was closely aligned
with runoff waters and road pools. It was interesting that only 33 respondents identified the river being “bad” and unfit for human consumption; this may be related to the generally held view that if water is flowing and/or if it is cool in temperature, then the water therein is of good quality. This is analogous to the waters of the Ganges River, which are revered by millions in India as a symbol of life and spiritual purity, or more directly as “Mother Ganga” the earthly incarnation of the deity Ganga and gift from the gods as described by ancient Hindu scripture (Kinsley, 1998).

Awareness of why the riparian forest was impaired was generally good across the respondent population. A majority recognized that removal of forests for making charcoal and for fuel/firewood was a primary cause and that riparian zone vegetation removal for agricultural activities was also a large problem (see Plate 5.12 as an example). For the sake of clarity in analysis, removal of riparian forests and other vegetation can be grouped into one general category entitled “harvest of wood products.” It was interesting that about 10 percent of those interviewed did not believe that riparian zones were being impaired and actually believed that community appointed monitors protect against deforestation and that new trees were being planted as old ones were removed.

Most respondents expressed awareness that protection or improvement of riparian forests and vegetation could be accomplished by planting trees, either by government implemented reforestation programs or by having seedlings provided to them to plant independently. They also suggested having the government provide or install fencing to prevent access to the area as a means of protection. Provision of security forces to patrol and enforce the law, and education of the public by means of extension or local chiefs
Plates – 5.12 (a, b). Wood resources extracted from the River Njoro watershed being transported to Nakuru for resale, and encroachment into the riparian zone for grazing livestock.
were also offered as a means of encouraging protection of the riparian forest. A few respondents (seven percent) felt that demarcation and provision of title deeds would provide sufficient protection because, through tangible ownership, land owners would be empowered to act to protect these lands. Participant Observation

As indicated previously, most people in this study access the river for their daily household and livestock water needs. The lack of improved roadways in the watershed, save one paved highway, coupled with the very large population, has led to establishment of many hundreds of kilometers of dirt roads, footpaths, and livestock trails which serve as the de facto transport network. Virtually the entire network of roads and paths, including the paved highway, are also grazed by livestock. I suggest that the number of livestock watering points may in fact be greater than reported. In addition, the riparian forest, in many cases, provides the only source of firewood, charcoal, timber, and other plant materials for sustenance and medicinal uses. With access to the river being primarily via passage through the riparian zone, many documented and undocumented pathways through the riparian zone have resulted, which leaves riparian vegetation compromised due to removal, browsing/grazing, and by trampling. These exposed and barren soils are prone to accelerated down-cutting and soil erosion.

Preliminary research results suggest that the hydrologic response within the watershed has been altered to favor increased annual runoff with higher intensity because of forest conversion to small-scale agriculture which reduces canopy cover, thus exposing soils (Baldyga et al., 2005). As a result, soil resources and water quality (and quantity) within the River Njoro have been negatively impacted due to increased pressure over the
past twenty years or so. Precipitation water once intercepted by the forest and native vegetation canopy now exceeds infiltration rates during heavy rain events, which contributes to river flow flashiness and altered flow regimes. These conditions are further exacerbated by a general change in climate creating longer dry spells and facilitation of more hydrophobic soil conditions.

Impairment of water resources in the Njoro watershed is known from historical information, by the numerous studies conducted (Kenya Forest Working Group, 2006; SUMAWA, 2003-2004; Baldyga et al., 2004; SUMAWA, 2004-2005; SUMAWA, 2005-2006; Baldyga et al., 2007; Enanga, 2007) and, most importantly, it is readily observable. Through field observations and general assessment of geologic features, I suggest that the Njoro is bedrock-confined and that soils along the valley are shallow, lying atop impermeable material. Due to reductions in riparian vegetation along the river course, I suggest that the capacity to absorb and retain precipitation waters is impaired along the entire reach of the river from the forest boundary to the boundary of LNNP. Ramifications of this condition include a reduced capacity to absorb and store surface waters, reduced ability to filter sediments and nutrients from farmlands and, specifically from the road/pathway network, all of which contribute to water quality impairments.

Soil erosion and impairment of water resources in the Njoro are a fact. However, the degree to which smallholder farms contribute to this is uncertain because observation of excessive or severe soil erosion from farmlands during household surveys and farm walk-abouts was rare. Without empirical data to determine erosion rates from farms, and systematic and comprehensive runoff data for the Njoro, detailed information on numbers
of animals grazing the watershed, number of livestock watering points, and erosion-sediment-contaminant output from roads and footpaths, effective quantification or modeling of the impacts of smallholder agriculture is difficult or impossible to gauge.
CHAPTER 6
SYNTHESIS AND EPILOGUE

Introduction

Investigations into the causes of impairment of natural resources are characteristically incomplete. Traditionally, investigations have focused on specific biophysical symptoms (i.e., hydrologic, wildlife, erosion). Conversely, social science research related to impairment of natural resources regularly focuses on social, economic, or political issues. Professional exclusion, turf protection, and the complexity of integrating these different bodies of knowledge have impeded efforts to vulcanize these more traditional methods to develop well-informed models for environmental problem solving. Unfortunately, this state of affairs is common and points to the need to establish vigorous integrative studies of socioecological systems. This position is well argued by Place et al. (2007) and White (2002) in their studies of poverty and agriculture in rural Africa, and by Wu and David (2002) in the context of modeling nested hierarchical ecosystems and landscape dynamics.

The lack of integration restricts the quality of information provided to decision-makers and thus hinders the development and implementation of more effective land use policy, environmental conservation measures, and resource management activities. In the Njoro watershed, problem assessment began with an evaluation of biophysical features and hydrologic dynamics to identify sources of impairment, while studies of socioeconomic characteristics of smallhold farmers and their contribution to natural
resource impairment proceeded in virtual isolation. This has reinforced my view that an interdisciplinary approach is required to effectively integrate data from biophysical studies (i.e., agroecology, watershed hydrology, and remote sensing, etcetera) with socioeconomic investigations (i.e., policy, income, and land rights, etcetera) to address environmental degradation and to develop comprehensive, effective long-term solutions.

The research herein has endeavored to take a multidisciplinary approach to evaluate quantitative and qualitative factors influencing smallhold farmers’ contributions to water quality and soil resources impairment. I wanted to determine whether soil and water conservation practices (SWCPs) had been implemented and what explanatory factors exist to help us assess smallholders’ adoption behavior. This information will help to identify vital linkages between human behavior and impairment of watershed resources. Using adoption theory as a foundation (i.e., relative advantage, compatibility, observability, trialability, and complexity), I utilized a combination of descriptive statistics, classification and regression tree (TREE) methods, domain analysis of ethnographically derived data, and participant observations to identify conditions and constraints experienced by smallhold farmers’ when considering adoption of soil and water conservation practices (SWCPs).

Among the 222 riparian farm households in the sample population, adoption of SWCPs was common and widespread. On average, six and one half SWCPs were implemented per farm with a minimum of two and maximum of 12 SWCPs adopted. It was predicted that five factors would be important in explaining adoption of SWCPs. These were income, tenure security, agroecological features, level of formal education,
and access to extension information. My findings confirmed that income, tenure security, and agroecological features were indeed important factors in the adoption decision process within the context of the Njoro; however, none were universally critical to explain all 14 SWCPs considered. What did become evident was that adoption of individual SWCPs had its own unique set of circumstances and determining factors to explain adoption. The theoretical pre-conditions for adoption did rise to a more prominent level, (in particular, relative advantage, compatibility, and complexity; Rogers, 2003) and appeared to factor strongly into the smallhold farmers’ decision process (Chapter 4).

In contrast to quantitative analysis, ethnographically derived information and participant observations provided direct access to the “knowable” physical and social characteristics of smallhold farms in the watershed. Despite all the difficulties faced by farmers in the Njoro, they seem to be adopting many SWCPs, as was revealed by my walk-abouts on each farm visited and throughout the watershed, especially concerning soil erosion. Resource conservation and protection, however, was not typically the main reason SWCPs were adopted. Rather, the need to sustain their farms to feed their families was paramount and manifested in their efforts to protect their soil resources. Thus, in some cases there were serendipitous “win-win” outcomes as a result of farmers adopting certain SWCPs for reasons other than resource management or conservation. These findings point to a need for greater understanding of the individual’s perception of multi-scale systems and the issues affecting them therein.
These insights provided valuable evidence for enriching our understanding of why farmers adopted SWCPs and the root causes of impairment to resources at the watershed scale. Interestingly, soil erosion on riparian farms was not widely observed during household surveys or farm walk-abouts, as anticipated. In fact, the on-farm conditions observed suggest that soil stability is being maintained by low impact hand tillage methods and the high level of endemic organic matter contributed by recently converted forested lands, relatively high input of organic materials due to multi-crop farming methods, manure amendments, and endemic weediness of farm fields. This evidence did not fully support the assertion that smallhold farms were the major source of impairment to Njoro watershed resources.

What did stand out from participant observation was the general abundance and condition of the network of trails, poorly maintained roads, and lack of infrastructure for providing water and sanitation services. When coupled to a rapidly expanding population and the pressures to obtain water, food, and fuel, exacerbation of soil erosion from these conduits is easily understood. Additionally, the underlying biophysical and geologic conditions suggest that ecological services are impaired and will continue to degrade unless pressure to utilize the road and path networks to the river is reduced.

Synthesis

Ultimate versus Proximate Factors

My results suggest that many seemingly unconnected factors influence individual adoption decisions and actions to protect or conserve natural resources. A useful
framework for drawing conclusions about degradation of Njoro watershed resources lies in an ultimate versus proximate causal model or framework (Diamond, 1999). Ultimate causes, on one hand, are the typically bigger-picture issues that define parameters of the watershed. For instance, the bio-geomorphic and ecological conditions which form the landscape and impart physical limitations and constraints of the land which define the natural stability or predilection of soils to erode. Another example is the historical political decisions of the area that have united various factors to create a foundation in which current population pressures, ethnic tensions, and seemingly chaotic social conditions exist. On the other hand, proximate causes of watershed-scale resource degradation relate to the local political history, recent immigration and surge in population, lack of economic development, and specific landscape conditions (due to land use changes) that have led to a congestion of farms, expansion of travel routes, and lack of infrastructure.

Another way of thinking about these two views is by equating the ultimate / proximate cause concept to hierarchy theory. Ultimate causes represent the large constraining features that form the parameters or conditions in which a system operates. These ultimate causes are defined by the long-term evolution of the [large scale] social or biophysical conditions in which smallhold farmers are constrained; in other words, ultimate factors are comprised of features that formed over long periods via geologic processes, of climatic features, and sociopolitical features that are outside the purview of man’s immediate influence. In contrast, proximate causes are representative of the smaller, more catalytic features which act as drivers of a system and have to do with the
more short-term influences on one’s perceptions and the acute reaction; or simply as the
direct, bouncing billiard ball like causation decisions. By examining both ultimate and
proximate causes, we are better equipped to reveal the interactions of factors that explain
behavior so that realistic solutions may be found for the issues under study.

In the Njoro, the interaction of ultimate and proximate causes that shape
individual’s decision-making to adopt or not adopt SWCPs is complex. In Figure 6.1, I
have tried to create an illustration of some basic key factors that form the conditions and
constraints acting on smallhold farmers’ decision processes to adopt or reject SWCPs.
Notice that these factors cut across a wide range of fields of study (i.e., ecology,
sociology, politics, geology, economics, etcetera) and are not confined by neat constraints
of finite time or space. An acute example of how tenure security and the unsettled local
political environment have important roles on a farmer’s decision to adopt and maintain
SWCPs was particularly evident during the lead-up and aftermath of the Kenyan
presidential election in 2008, when ethnic violence erupted due to politically inspired
antagonism. This upheaval was rooted in who has rights to local political and economic
power, how rights of access to resources were distributed during Kenyan independence
(thus, who has community-level power), and how income differentials influence
community dynamics within the watershed. These likely all contributed to individual
farmers’ sense of tenure security and their willingness to adopt SWCPs.

Ethnic tensions that emanate from political decisions made decades previously are
still just below the surface and will influence long-term resource management solutions
for some time (Ahluwalia, 1996; Kahl, 1998; Daniels and Bassett, 2002). Therefore, it is
important to take account of the history and the series of decisions that have led to conflict over land ownership, access to soil and water resources, cultural differences, and political environments that shape an individual’s will to implement conservation measures. This perspective is fortified by considering two additional perspectives.

Tyranny of Small Decisions

The reasons for environmental impairment are almost never due to simple, one-cause / one-effect scenarios. Instead, most environmental problems are the result of an aggregation of many, mostly unconsciously made, small decisions. The “Tyranny of Small Decisions” concept first introduced by the economist Alfred E. Kahn illustrates the cumulative power of a series of seemingly unrelated decisions that alter events to create future conditions (Kahn, 1966; Odum, 1982). Individual decisions generally are made in order to optimize a stakeholder’s then current condition; e.g., to vote for something which improves an individual’s situation. However, to vote for something is concurrently a vote against something else. Most stakeholder decisions are made within the narrow context of one’s immediate surroundings, without the benefit of a broader knowledge of history or potential outcomes (Kahn, 1966; Odum, 1982). Individuals tend to optimize conditions for themselves without regard for the collective community around them and without an awareness of the ultimate risks or costs. The temporal and spatial qualities of an individual’s domain make it difficult to see the cumulative effect of small decisions, because with each small decision comes a new reality.

The result is that nonoptimal outcomes are common due to how stakeholders view the incremental changes in their environment temporally and how their decisions affect
their domain of influence, which leads to another reality and then another series of small decisions to optimize the new conditions. Only when an aggregation of decisions accrues to a threshold or tipping point, whereby conditions change and become “knowable,” is the cumulative effect realized and a big decision made (i.e., the new economic environment, water pollution, loss of services, health concerns, etcetera) for change (Kahn, 1966; Odum, 1982). Environmental services are particularly difficult (or impossible) to recover once this threshold is surpassed. Thus, if policy makers endeavor to keep the bigger picture in mind and to examine environmental issues from many perspectives, better policy will result. By gathering information from many perspectives, policy makers will be better prepared to inform stakeholders and to compel them to make different, better choices in order to avoid ramifications of the “big decision” (Hardin, 1968).

This “tyranny” scenario can be described for one component, the sociopolitical component, of the Njoro watershed. Beginning from the time of Kenyan independence in 1963, we can see that current conditions of life for smallhold farmers and their interaction with natural resources were shaped by events decades earlier. The then-new Kenyan government distributed lands favorably to members of the Kikuyu ethnic group after the British left, causing a power vacuum in the Central Rift Valley. Land settlement schemes, degazetting of large tracts of public forestlands associated with political elections of 1992 and 1997, and inequitable distribution of these newly privatized lands led to establishment of five acre (~ two ha.) tracts on previously forested lands (Daniels and Bassett, 2002). Many of the farms established did not come with title deed and,
therefore, are not legally owned. Some of these lands were taken from one group (Ogiek) and given to others (Kikuyu and Kalenjin), which further raised ethnic tensions. Additionally, this watershed was historically part of Maasai common lands where they employed a well-managed rotational livestock grazing system that dispersed people and livestock widely across the landscape, both temporally and spatially (Daniels and Bassett, 2002). Naturally, disenfranchisement of some ethnic groups in the watershed resulted in widespread tensions that lie just below the surface today.

As new lands became available, the pressure on farmers to support themselves drove these new settlers to harvest the trees on their lands and elsewhere, thus rapidly converting forestlands into farmlands. With settlement came demarcation of farm boundaries, a large population increase of both sedentary people and livestock, and the creation of a network of hundreds of roads and footpaths for fetching water, access to markets, and movement of resources (i.e., wood products, labor, livestock and crops, etcetera). Water resources were now being accessed year-round for all household uses and for watering livestock. With the protective vegetation cover severely reduced, the soil environment changed, reducing both water infiltration and retention, resulting in more “flashy” stream flow. Moreover, since there is no infrastructure to supply water or sanitation services to individual households, the axiom *all roads lead to the river*, holds true. When the effects of poverty, climate change, and the political uncertainties at the local and national level are considered in combination with these features, there is little wonder that the water resources in the River Njoro are impaired.
Context Matters

Historically, investigations of disturbance of natural resources have been limited by the tools or perspective of the researcher, i.e., ecologists, sociologists, and hydrologists. Each may have the best intentions in mind; however, they are constrained by their academic training, by the investigative strategies they are most comfortable with, and by the motives of funding sources for the research. Specialized bodies of knowledge do result; however thorough they may be, it remains unconnected to other pertinent bodies of knowledge. This makes “fitting” new findings into well-ordered, quantifiable models difficult and impedes formulation of more effective environmental management.

Understanding the contextual settings of the individual, the social group, or the landscape is vital for successful problem solving and development of viable solutions for addressing environmental concerns (Susskind et al., 2001). In this vein, developing a context map (sensu Honadle, 1999) of the subject is beneficial for providing the investigator a comprehensive set of tools to conceptualize the various factors that influence or create a problem and then to discover possible solutions. This context map should include two components: first, the “problem context,” or relationship between system variables and the threat to the resources of concern; and second, the “social context” of the system should be developed so that the qualitative questions (why? when? how? and what?) of stakeholder behaviors may be deciphered and incorporated into developing plausible solutions. To facilitate context mapping, it is important to understand what Domains of Influence are interacting and acting on the stakeholder or social group in question (see Figure 6.2).
Figure 6.2. General illustration of Domains of Influence on people and the importance of accounting for the context in which individuals' decisions are made.\textsuperscript{11}

\textsuperscript{11} The concept of “Domain” is used here to describe the sphere of influence under which stakeholders live and operate and which influence their SWCPs adoption decisions. Domains influence individual behavior by constraining or facilitating actions taken (Paul and Elder, 2006), thus create the contextual environment or matrix in which smallholders operate. Ultimately, the particular matrix of domains that influence decisions also shapes their behavior and forms the parameters of consequences of their behavior (\textit{sensu} Chance, 1999; Pierce and Cheney, 2004).
Segregating systems into discernable levels or into a hierarchy provides a useful framework for examining domains influencing individuals or systems. From this, observation across (sub)systems and over multiple spatiotemporal scales is facilitated. By utilizing a hierarchical system, multiple levels ranging from higher (constraining) levels to lower (catalytic) levels may be examined; higher levels in the system provide the “environment” in which smaller, faster levels operate (Allen and Starr, 1982). Common characteristics then can be identified and used to define the levels of organization and degree of influence on various levels within the hierarchy, i.e., stakeholders, communities, or the whole system.

By developing an understanding of the contextual setting, we are better able to define what the biophysical and social conditions are, why they got to be that way, and what potential there may be for restoring things to a preferred condition or state (Susskind et al., 2001). This exercise also presents policy makers’ and researchers’ pertinent knowledge of what is possible given the current and/or prevailing circumstances. With this understanding of constraints and options available to the stakeholder, shared concerns may be cultivated to build a foundation for problem solving that is sensitive to cultural concerns and to temporal and spatial variation. From this base, adjustments to successful programs may be introduced so they can be adapted to different or changing settings; in this way cookie cutter solutions can be avoided.

In the Njoro, an example of why context matters was illustrated by examining the relationship people have to their water resources. For most riparian farmers, the river is their primary source of water for household and livestock use. Water is fetched daily and
taken back to their farmsteads for cooking, washing, and bathing, and livestock are taken
to the river for water. Most ethnic groups recognize that washing and bathing in the river
pollutes their resources with dirt and soap and makes it unsuitable for human
consumption. However, at least one ethnic group regularly bathes in the river because
they believe that the river is provided by God and gives life; therefore it is clean. This
group seems not to recognize the gravity of concern expressed by their counterparts who
do not bathe in the river, nor of their connection to downstream users. Addressing this
issue, however, is complicated by boundaries. The river itself forms one boundary where
the Kikuyu occupy one side of the river valley upstream of Nessuit village, and the
Kalenjin the other. The Kipsigis are a sub-group of the Kalenjin and like to bathe in the
river. Kikuyu and main-stem Kalenjin in general do not approve of bathing in the river,
which seems to make them potential allies on this subject. However, there is a long
history of conflict between the Kikuyu and Kalenjin ethnic groups such that if the Kikuyu
approach the Kipsigis to try to stop them from bathing, the main branch of the Kalenjin
will come to the defense of the Kipsigis, to the point of bloodshed if needed, even though
they recognize that bathing in the river is bad. Further complicating this issue is a district
(governmental) boundary which splits the community into upstream and downstream
users, each being governed by a different chief and different district officials. Territory
becomes a problem further constraining things. Livestock watering complicates the issue
of bathing in the river even further by the historic differences between tribes and their
livestock, i.e., pastoralists versus sedentary farmers, large versus small stock, and
perceptions of what constitutes “dirty” or polluted waters. This situation is underlain by historic disputes over land and rights of access to land and water.

Addressing this issue is not as simple as going to the Kipsigis and asking them not to bathe in the river! Without taking account of the underlying contextual issues, true progress will come grudgingly. Context matters.

Future Research

Integration of multiple perspectives into coherent explanatory constructs is difficult, but absolutely necessary. The inadequacy of discipline-specific research and practice to inform adoption theory, policy, decision-making, and development practices is made clear by our appreciation of proximate and ultimate factors (causes) in watershed investigations. Only through connecting key features of geology, ecology, social science, and economics, etcetera, will investigations be able to identify effective solutions to watershed-scale environmental problems. By taking an interdisciplinary approach, the underlying issues can be identified and will facilitate creative solutions that will be long-term solutions. Studies of landscape level change have made tremendous progress in recent decades; however, as population pressure and resource utilization increase, we face new problems and difficult challenges.

New applied research initiatives for studying natural resource management are needed and should include studying landscape change across social and biophysical boundaries, considering conditions and constraints of adoption and implementation of conservation practices, investigation of temporal and spatial rates of change from the
household level to the landscape level, and a focus on context as a precursor for investigating cause-effect mechanisms.

I suggest that future research to inform adoption theory and to advance environmental management strategies, especially in developing nations, requires an interdisciplinary (or trans-disciplinary) approach so that better informed information is available and integration of various perspectives is accomplished. From this perspective, we will be better positioned to cross-pollinate between basic and applied research to inform conceptual and theoretical development and improve education and training of policy makers. This will lead to improved recognition of the importance of interdisciplinary research and the role it plays in developing effective land management policy and practices. With this new knowledge, outreach and communication between the public, decision-makers, and natural resource professionals will be enhanced.

Conclusions

How people interact with their particular environment has a major influence on their perceptions of the world and on individual behaviors on several conceptual levels. Consideration of explanatory variables on different and potentially dynamic spatial and temporal scales within the context of their socioeconomic, psychological/behavioral, biophysical, and policy environments is critical to understanding adoption behavior and, ultimately, for understanding the conditions and causes of natural resources impairment. Adoption and implementation decisions are often context specific, both concerning the specific site in which the practice will be implemented and in regards to the circumstance in which the smallhold farmers’ lives are embedded. This suggests that adoption
decisions may be made based on the context of the farmer’s experiences, knowledge, and on the particular landscape of the farm or, simply, how well the practice “fits” their farm operation due to underlying personal, biophysical, and socioeconomic conditions. This should not be surprising. In fact, lessons from the fields of human ecology, social and behavioral psychology, and organizational and management theory inform us that people make decisions based on a complex relationship of perceived needs, past experiences, and perceptions of rewards and/or consequences of the decision. This complex yet important task is necessary if more holistic and effective programs are to be developed which take account of the various key reasons people adopt SWCPs.

In Lewis Carroll’s “Through the Looking Glass,” Alice ponders what the world is like on the other side of a mirror (the reflected scene displayed on its surface) and, to her surprise, is able to pass through it to experience an alternate view of the world. How one views the world through their own “looking glass” results in actions and behaviors particular to that person or group of persons. What is needed is to develop our own looking glass through which we study the intricate interface of people and nature. This will facilitate how the message of environmental protection is packaged and may well be more important than understanding the mechanics of the ecosystem or the methods of implementing good SWCPs.

On a broader scale, as the world becomes more and more interconnected, the need to address issues of poverty and the ripple effect this has on natural resources, the need to address resource management and protection in developing regions of the world is, undoubtedly, becoming everyone’s concern. Poverty increases the potential for conflict
on all scales as basic natural resources such as water, soils, and forest products become scarcer and/or impaired. Increasing our understanding of how scarcity of natural resources affects individuals and communities, from the local to global levels, will become an important factor to consider. Through better understanding of local power structures in determining how resources are controlled and allocated, and who the beneficiaries and victims are, we will be better able to understand regional and national issues and, ultimately, to develop more effective policies for alleviating poverty and allocating natural resources.

Epilogue

During the summer of 2009, I returned to the watershed to see how the local clashes related to the 2008 presidential elections may have affected land ownership patterns and watershed conditions. Conflict in Kenya gained worldwide attention, and one of the epicenters of this was exactly this study area. What I learned was that, while certainly violent clashes between members of competing ethnic groups had occurred, these were mostly evident in the upper portions of the watershed (Steven Huckett, unpublished data). Moreover, these contentious events did not appear to have resulted in a long-term shift in ownership patterns or access to resources. Encroachment into the Mau Forest did continue, especially in the area around Sigotek school and Logomon village where large tracts of land had been cleared and prepared for agricultural crop production. Accompanying this expansion was evidence of widespread removal of large trees from the Mau forest (Steven Huckett, unpublished data).
Additionally, there was a new land management scheme taking root and being widely practiced on lands upstream of the village of Nessuit; this reportedly involved trading labor to stump and prepare farm fields for mechanical cultivation in exchange for three years rights of access to grow crops on these lands. This practice was being promoted by the local moneyed Asian (Indian) and Kikuyu communities and was targeted primarily at lands owned by the Ogiek and Kalenjin who did not have access to the financial or labor resources necessary to prepare their lands for mechanized agricultural production. One unfortunate effect of this practice was the near complete removal of riparian zone vegetation so that cultivation could be done continuously across the watershed. Degradation of water resources was acute in these areas.

Furthermore, there was an unanticipated temporary occupation of large portions of the middle and upper portions of the watershed in search of grazing lands. It was reported that these large herds of livestock belonged to Maasai herders who moved into the watershed due to drought conditions in other parts of the country. For a three-month period between November 2008 and February 2009, Maasai herders occupied much of the upper portions of the study area. The result was severe degradation of riparian forests and adjacent grazing lands due to the very large numbers of livestock brought into the watershed by the Maasai. The results of these two practices were clear: stream integrity and water quality were being negatively affected through large reaches of the middle and upper portions of the study area.

On a positive note, the SUMAWA project had successfully established two off-stream livestock water troughs to reduce livestock grazing pressure on the riparian zone,
and several tree nurseries had been started by local farmer cooperatives to supply farmers’ tree seedlings for rehabilitating the riparian zone forest on or near their farms. Several farmers reported that riparian lands near these watering points were beginning to rebound or regenerate native vegetation and that water quality was slowly improving. This was specifically mentioned for the riparian lands immediately adjacent to the watering trough at Nessuit Bridge, which had been a key watering point for livestock for many years and had experienced exceptionally heavy grazing pressure by Maasai herds. Additional changes to the watershed were taking shape in the form of subdividing large tracts of land in the middle portion between Njoro Town and the village of Nessuit. Large farms were being broken into small tracts of one-quarter to one-acre in size as a means of real estate speculation to take advantage of the burgeoning populations around Egerton University. The effect that these new residential areas will have on riparian zone vegetation and water quality is as yet unknown.

Not much change to the landscape or land ownership patterns was observed in the lower portion of the study area where out-migration due to the politically motivated clashes was not reported or observed during my visit. This was expected where the long history of title deed land ownership and lack of large tracts of grazing or forested land provide a relative stable land ownership situation. There was one particularly innovative approach to mollifying the political tensions of the area. The chief of Baruti community has collaborated with the SUMAWA project to establish several tree nurseries. He divided the community into four groups of people in order to improve the potential for success of the tree nurseries in his area. By separating his community along ethnic and
cultural lines, ethnic clashes experienced in other parts of the watershed did not materialize in his area. Apparently, his grasp of the different stations of peoples’ lives has resulted in more harmonious relations within his community.

Message to Decision-makers from Njoro Farmers

As an adjunct to the main questions of the household survey, riparian farmers were asked what message they would like to convey to decision-makers if given the opportunity [decision-makers were defined as those persons in charge of making policy and laws, or those who could provide services that would benefit the public in general]. Five general categories of concern were identified that had high variability in content. Most prevalent of their (greater than 50 percent of farmers) concerns was a desire for additional education about the environment, environmental protection, and stewardship of water resources. This included a particular interest in learning about the importance of trees for protecting catchment resources (i.e., reforestation) and why riparian forests are beneficial for protecting against impairments to water and the environment. Seventy-one farmers interviewed (32 percent) also expressed their desire that the government provide training locally so that people would be better informed about the importance of trees, soil conservation, and the riparian zone/river complex. Reductions in logging activities (legal and otherwise) and protection of the riparian zones from clearing for agriculture, grazing, washing/bathing were the primary factors suggested. Protection methods focused on demarcation of a buffer zone so that it would become an “official” protected area and providing scouts or monitors to patrol this zone were recommended.
Second, 69 farmers (31 percent) expressed a strong desire to have more law enforcement, more specific laws developed, or the appointment of monitors/committees to oversee protection and maintenance of the river. They believed that enforcement of existing laws that specifically focused on preventing illegal logging, clearing of the riparian zone for agricultural purposes, and pollution from washing/bathing, improper toilets, and effluent from sewage and factory waste systems would make a difference.

Third, 31 respondents (14 percent) suggested that the government provide seedling trees to replant, and that they implement reforestation projects to restore catchment. Some factors mentioned to support this message were that the government should provide job opportunities so people would stop cutting trees for wood/charcoal/fuel, prohibit grazing along the river, and provide title deeds to their properties so that RFs could feel empowered to protect and maintain riparian lands.

Fourth, 22 respondents (10 percent) said that riparian lands should be demarcated and protected (at distances of 50 steps, 50m, 50 feet), and provision of title deeds to these lands was necessary. Further, they indicated that compensation is necessary to give up these farmlands within this protected zone, and such land protection should be compulsory for the entire populace of the Njoro watershed.

Lastly, a hodge-podge of messages were offered by 21 informants (10 percent) that included providing boreholes and infrastructure to make drinking water accessible; providing off-stream watering points for livestock to prevent trampling of surface waters and riparian vegetation; providing market protection for agricultural produce (price supports); inputs such as fertilizers, herbicides, insecticides, and improved crop variety
seeds; and, access to funding to invest in agroforestry practices and soil conservation measures on their farms.
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APPENDICES
Appendix A.

Importance of Intact Riparian Zone Ecosystem
Soil Erosion and Nutrient Depletion

Soil erosion is a natural function of every landscape due to physical forces (wind, water, and disturbance by animals and root action) and biogeochemical forces (chemical weathering). However, soil erosion due to anthropogenic activities is largely a result of de-vegetation of landscapes by harvest of forest resources, over-grazing by domestic livestock and confined wildlife herds, agricultural activities, and removal of riparian forests. The severity of soil erosion is largely a function of soil type, slope, wind or water speed, and density and type of vegetative cover (Brooks et al., 1999; Naiman, 1992). The erosion problem is greatest on marginal lands, such as the hill slopes and de-vegetated areas, and arid landscapes. Soil erosion is manifested in successively more severe forms from sheet flow (overland flow) to rill erosion and finally, gully erosion. If rills and gullies become well established, revegetation may be nearly impossible on marginal lands due to the loss of organic soil layer and soil organic matter which promotes water infiltration and aerated soil conditions, and maintenance of soil fertility. Additionally, these losses are detrimental to formation and maintenance of a beneficial micro biotic community create beneficial metabolic by-products, i.e., root exudates, associated fungi and bacterial communities, which encourage cohesive soil structure and promote infiltration and decomposition of large particulate organic matter into available soil nutrients. All of these losses inhibit plant root establishment, thus leaving soils bare and subject to further degradation. The severity of wind erosion is strongly related to plant density, climate, and soil type; however, it is not thought to be of major concern in the R. Njoro watershed and will not be discussed here.
Moreover, as soil erosion progresses, sediment loading can result in impaired aquatic habitats, eutrophication, and negative changes to channel morphology and hydrologic characteristic (Molles and Dahm, 1990). Natural levels of sediment inflow to streams inherently have relatively elevated nutrient concentrations and increased water holding characteristics, which improves substrates for plant and aquatic habitats (Brooks et al., 1999; Naiman 1992). A diverse and dense stand of vegetation retards the progression of soil erosion by increasing water infiltration rates and reducing surface flow velocities by creating a more tortuous pathway across the entire soil surface (Brooks et al., 1999; Naiman 1992). However, within the R. Njoro watershed, land use change and reduction in vegetation (forest and riparian zones) has lead to excessive sedimentation of streams resulting in elimination of native fisheries, impairment of aquatic habitats, and negatively impacting water quality (Shivoga, 2001).

Influence of Healthy Riparian Zone

The importance of riparian zones ability to sequester nutrients is illustrated by the work of Peterjohn and Correll (1984), who studied a small watershed (16.3 ha) in Maryland occupied by a 10.4 ha agricultural field (maize). They calculated that approximately 89 percent of total nitrogen (tot-N) input to the riparian zone from upland agricultural fields was retained versus retention of about 8 percent of the total nitrogen inputs to the farm field. Furthermore, they calculated that about 80 percent of total phosphorous (tot-P) was retained in the riparian zone compared to 41 percent in croplands. It must be noted that these numbers may be somewhat misleading in that export of tot-N and tot-P in crop biomass was not determined for these summaries.
Further studies on the filtering effect of riparian ecosystems indicate that riparian zones act as a net sink for nutrients exported from agricultural areas (Lowrance et al., 1984). These studies focused on nitrate (NO$_3^-$-N), ammonium (NH$_4^+$-N), organic nitrogen (org.-N), total phosphorus (tot-P), and particulate matter exported from the cropland into and through the riparian zone, and finally into stream waters via surface and groundwater movement. After traversing the first 19 m of the riparian zone Lowrance et al. (1984) reported the following reduction of nutrients; 75 percent NO$_3^-$-N, 73 percent NH$_4^+$-N, 62 percent org-N, and >90 percent of particulate organic matter. Concentrations of total P did not change significantly, and an increase in organic C concentrations after this interval was reported. After 50 m traversed, concentrations of all inorganic constituents had decreased further, except for total P, which remained approximately constant. However, the organic components of nutrients in particulate materials had increased in concentration, likely due to assimilation of dissolved organic compounds (e.g., by-products of decomposition of leaf litter) from the riparian zone. Analysis of near surface groundwater also indicated that concentrations of NO$_3^-$-N had decreased by as much as 90 to 95 percent in the first 19 m of the riparian zone traversed. Concentrations of all other nutrients increased however. After 50 m, the same general trend was observed with additional slight increases observed (Lowrance, et al., 1984).
Appendix B.

Household Survey
**River Njoro Farmer Survey**

HuJambo! I would like to speak to the head of the household, or his or her representative, that farms this land. My name is _________________ and I am a student at Egerton University working with Steven Huckett of the SUMAWA project. I am conducting research with small-scale farmers along the River Njoro to learn how farmers use their land and how farmers perceive the landscape along the River Njoro. The information you share will help us to understand better how to help farmers protect your land and your water. I also want to walk with you on your shamba to see your situation, and may want to take some photos of your farm if that is OK. Neither you nor the photos taken of your farm will be personally identified or shared with anyone. My visit with you should take about two hours. We at SUMAWA and Egerton University appreciate your help.

Date: RF0002  Location: RF0003
Sub-location: RF0004  Village: RF0005

1. Who is the Head of Household or *primary decision maker*? __________________________ (name)  RF0006

2. Can you tell me a little about you and any other persons that will sit in on the interview?

<table>
<thead>
<tr>
<th>#</th>
<th>Interviewee's Name</th>
<th>Relation to HoH</th>
<th>M/F</th>
<th>Age</th>
<th>Level of Education</th>
<th>Still in School? Y/N</th>
<th>Length of time living on this farm or village?</th>
<th>1st Language (mother tongue)</th>
<th>2nd Language</th>
<th>3rd Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HoH</td>
<td>RF0007</td>
<td>RF008</td>
<td>RF009</td>
<td>RF0010</td>
<td>RF0011</td>
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<td>RF0015</td>
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<td>3</td>
<td>RF0025</td>
<td>RF0038</td>
<td>RF007</td>
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<td>RF0013</td>
<td>RF0014</td>
<td>RF0015</td>
<td>RF0016</td>
<td>RF0017</td>
</tr>
</tbody>
</table>
3. Please tell me about all other people in your household who primarily depend on the household for food and shelter:

<table>
<thead>
<tr>
<th>#</th>
<th>Name</th>
<th>Relation to H/H</th>
<th>M/F</th>
<th>Age</th>
<th>Level of Education</th>
<th>Still in School Y/N</th>
<th>Years living on this farm or village?</th>
<th>1st Language (mother tongue)</th>
<th>2nd Language</th>
<th>3rd Language</th>
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</tbody>
</table>

Total or Average
Number of Persons in HO =

4. How long has this shamba been farmed by you or this family? ________________________________ years

5. What is the size of this shamba? __________________________ acres (- or - __________ feet * __________ feet)

6. Does this household depend on this shamba for all its food needs? Y / N

7. If yes to question #6, has this shamba produced enough food to feed the household each of the past three years?
   (a) Yes in all three years   (b) Yes in 2 of three years   (c) Yes in 1 of three years   (d) never   (e) don’t know
Please Sketch the approximate dimensions and features of the shamba.

PROMPTS

1. Please estimate the % of shamba under crop or grass
   (1) 100-75, (2) 50-75, (3) 25-50, (4) 10-25, (5) 0-10.

2. Is there Fallow Ground?
   [please indicate where]
   Y/N

3. Is the shamba irrigated or rain fed?

4. Where are Livestock watered?

5. Where is the Corral?

6. Is manure collected? Y/N

7. Indicate directions of the land slopes?

8. Is there evidence of soil erosion? Y/N

9. Indicate any SWCB or prominent slopes.

10. Where is the Latrine or defecation area?
8. In the past year, what crops or other important plants have you grown on this shamba?  
*Maize, beans, millet, sorghum, potatoes, cabbage, vegetables, grass/fodder, seedlings, other

<table>
<thead>
<tr>
<th>Rank</th>
<th>Crop or other plants grown?</th>
<th>Acres?</th>
<th>What is the use of this crop? (tick all that apply – ((\checkmark))*)</th>
<th>Annual Cash Income</th>
<th>Ksh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most important</td>
<td>RF0112</td>
<td>RF0113</td>
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<tr>
<td>2nd most important</td>
<td>RF0116</td>
<td>RF0117</td>
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<tr>
<td>3rd most important</td>
<td>RF0120</td>
<td>RF0121</td>
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<tr>
<td>4th most important</td>
<td>RF0123</td>
<td>RF0125</td>
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<td>5th most important</td>
<td>RF0128</td>
<td>RF0129</td>
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</tbody>
</table>

9. For the past year, what important livestock or other animals have you raised on this shamba?  
*Cattle, sheep, goats, pigs, camel, chicken, donkeys, rabbits, birds, others

<table>
<thead>
<tr>
<th>Rank</th>
<th>Livestock or other animals?</th>
<th>How Many?</th>
<th>What is the use of this livestock? (tick all that apply – ((\checkmark))*)</th>
<th>Annual Cash Income</th>
<th>Ksh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most important</td>
<td>RF0132</td>
<td>RF0133</td>
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<tr>
<td>2nd most important</td>
<td>RF0136</td>
<td>RF0137</td>
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<tr>
<td>3rd most important</td>
<td>RF0140</td>
<td>RF0141</td>
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<tr>
<td>4th most important</td>
<td>RF0144</td>
<td>RF0145</td>
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<tr>
<td>5th most important</td>
<td>RF0148</td>
<td>RF0149</td>
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</tbody>
</table>
10. Are the livestock you raise on this shamba zero-grazed/confined to a Corral? Y / N / Don’t know  RF0152
   10b. If yes, What time of day are the livestock are confined? RF0153

11. Considering the past 3 years, does this household earn off-shamba income (i.e., casual labor, wood,charcoal sales, salaries, kiosk)? Y / N RF0154

12. If yes, please estimate how much off-shamba income this household earns annually (wages/or?) ______________________ Ksh RF0155

13. Do you access loans or credit from a bank or a community credit union to help you farm? Y / N / Don’t know RF0156
   13b. If yes, approximately how much do you borrow each year to help you farm? ______________________ Ksh RF0157

14. Has your shamba ever been visited by an extension agent to teach about resource management practices? Y / N / Don’t know RF0158

15. If the answer to #14 is yes, how often is your shamba visited by an extension agent? RF0159
   (a) once (b) once per year (c) more than once per year (d) don’t know

16. Have you or a member of this household ever visited an official demonstration (community baraza, official site, other) to learn about resource management practices? Y / N / Don’t know. RF0160
   16b. If yes, how many times has a member of this household visited an official demonstration? RF0161
       (a) once (b) once per year (c) more than once per year (d) don’t know

17. Have you or a member of this household ever had formal training (school, vocational training, extension course) to learn about good resource management practices? Y / N / Don’t know RF0162
   17b. If yes, where was this formal training given? RF0163
18. Do you expect to be farming this shamba in: (a) 1 to 5 years (b) 5 to 10 years (c) >10 years (d) don’t know

19. Considering the past three years, have you ever had a labor shortage on this shamba? Y / N / Don’t know

19b. If yes, how often is there a shortage of labor? (a) seasonally (b) often a problem (c) always a problem

19c. If yes, why do you think you have a shortage of labor?

20. Does your culture affect how you care for your land or water? Y / N / Don’t Know
   Explain your answer

21. Does your religion affect how you care for your land or water? Y / N / Don’t Know
   Explain your answer

22. Please describe your land tenancy/ownership situation. (circle one)
   (a) farmer owns the land and has a title deed to this shamba
   (b) farmer owns the lands but does not have a title deed to this shamba
   (c) farmer rents this shamba and pays the owner cash
   (d) farmer rents this shamba and pays the owner a portion of the crops grown
   (e) farmer is borrowing this shamba
   (f) farmer is a squatter on this shamba
   (g) don’t know
Now, I would like to shift our focus to the river and the vegetation along it.

23. Please describe what is very good quality water for use by people

________________________________________________________________________________________________________________________________________________________

24. Please describe what is very bad quality water for use by people

________________________________________________________________________________________________________________________________________________________

25. Do members of your household ever become sick with an illness of the stomach or diarrhea? __________ Y / N / Don’t Know __________

25b. If yes, how often does this occur? (a) once per month (b) once per year (c) once every five years (f) don’t know

25c. If yes, what do you think causes these illnesses?

1. ____________________________________________________________________________________________________________

2. ____________________________________________________________________________________________________________

3. ____________________________________________________________________________________________________________

26. Are there other illnesses that affect your ability to farm your shamba as you would like? __________ Y / N / Don’t Know __________

Please Explain _______________________________________________________________________________________________________

________________________________________________________________________________________________________________________________________

27. In your opinion, what is the overall quality of water in the River Njoro near your farm? (a) Good (b) Moderate (c) Poor (d) don’t know

27b. What is the quality of water in the River Njoro for irrigation? (a) Good (b) Moderate (c) Poor (d) don’t know

27c. What is the quality of water in the River Njoro for drinking? (a) Good (b) Moderate (c) Poor (d) don’t know

27d. What is the quality of water in the River Njoro for bathing/washing? (a) Good (b) Moderate (c) Poor (d) don’t know

27e. What is the quality of water in the River Njoro for watering livestock? (a) Good (b) Moderate (c) Poor (d) don’t know
28. In your village, are there activities that you believe affect water quality?

29. If yes to question 28, please tell me what you think these activities are that affect water quality in the River Njoro.

Most important activity
2nd most important activity
3rd most important activity
4th most important activity

30. What are the source(s) of water for people in this household?

Most important
2nd most important
3rd most important

31. What are the source(s) of water for livestock on this shamba?

Most important
2nd most important
3rd most important

32. What type of latrine/toilet do you have on your shamba?

32b. How far from the most important water sources listed above is this latrine or toilet? Meters

33. Do you know of other types of latrines?

Y / N

Please explain.
Shamba “WALK-ABOUT” with the farmer

GPS reading at farm: _______________ N RF0309 _______________ E RF0301 Altitude: ________ meters RF0302
Slope (%): _______________ RF0303 Range Finder distance to River: _______________(meters or feet) RF0304

34. Can you describe the texture of the soil on your shamba? Y / N / Don’t know RF0305
   Please specify: ____________________________ RF0306

35. Are there unusual characteristics of the soil on your shamba? Y / N / Don’t know RF0307
   Please specify: ____________________________ RF0308

36. Is there soil erosion on this shamba? Y / N / Don’t know RF0309
   36b. If yes, please circle the type(s); a) Sheet b) rill c) gully d) footpath/road e) mass movement, RF0310

37. How is the soil on your shamba tilled? a) Manually b) Animal c) Machine d) other ____________________________ RF0311

38. Observe and ask the farmer to describe the predominant soil characteristics on this shamba (Please tick the appropriate answer).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>1 - High</th>
<th>2 - Average</th>
<th>3 - Low</th>
<th>4 - Don’t know</th>
<th>Please Explain</th>
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</thead>
<tbody>
<tr>
<td>Potential for the soil to be washed away</td>
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<tr>
<td>Soil productivity without fertilizer amendments?</td>
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<tr>
<td>Water retention</td>
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</tbody>
</table>

Page 9 of 16
39. Do you use commercial fertilizers on your shamba? \( Y / N / \text{Don't know} \)

39b. If yes, how much do you use on your shamba?

40. Do you use commercial pesticides on your shamba? \( Y / N / \text{Don't know} \)

40b. If yes, how much do you use on your shamba?

41. **Observations of Soil and Water Conservation Practices during Walk-About:**

<table>
<thead>
<tr>
<th>Conservation Practices</th>
<th>Do you know of? Y/N</th>
<th>Do you implement? Y/N</th>
<th>Specify WHY and HOW the farmer implements these conservation practices.</th>
<th>Specify WHY the farmer DOES NOT implement conservation practices.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inter-cropping</strong></td>
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<tr>
<td>RF9319</td>
<td>RF9320</td>
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<tr>
<td><strong>Fallow fields</strong></td>
<td>RF9321</td>
<td>RF9324</td>
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<tr>
<td><strong>Terraces (Fanya jini)</strong></td>
<td>RF9327</td>
<td>RF9328</td>
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<tr>
<td><strong>Micro-catchments (Mutenge)</strong></td>
<td>RF9331</td>
<td>RF9332</td>
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<tr>
<td><strong>Plant residue left in field</strong></td>
<td>RF9335</td>
<td>RF9336</td>
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<td></td>
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<tr>
<td>Conservation Practices</td>
<td>Do you know of? Y/N</td>
<td>Do you implement? Y/N</td>
<td>Specify WHY and HOW the farmer implements these conservation practices.</td>
<td>Specify WHY the farmer DOES NOT implement conservation practices.</td>
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<td>----------------------------------------------</td>
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<tr>
<td>Banding</td>
<td>RF0339</td>
<td>RF0340</td>
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<td>RF0341</td>
</tr>
<tr>
<td>Agro-forestry</td>
<td>RF0343</td>
<td>RF0344</td>
<td></td>
<td>RF0345</td>
</tr>
<tr>
<td>Grass strips (specify type and location)</td>
<td>RF0347</td>
<td>RF0348</td>
<td></td>
<td>RF0349</td>
</tr>
<tr>
<td>Contour tillage (across the slope)</td>
<td>RF0351</td>
<td>RF0352</td>
<td></td>
<td>RF0353</td>
</tr>
<tr>
<td>Ditches or trenches to direct water</td>
<td>RF0355</td>
<td>RF0356</td>
<td></td>
<td>RF0357</td>
</tr>
<tr>
<td>Manure application to soils</td>
<td>RF0359</td>
<td>RF0360</td>
<td></td>
<td>RF0361</td>
</tr>
<tr>
<td>Cut and carry fodder</td>
<td>RF0363</td>
<td>RF0364</td>
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<td>RF0365</td>
</tr>
<tr>
<td>Conservation Practices</td>
<td>Do you know of? Y/N</td>
<td>Do you implement? Y/N</td>
<td>Specify WHY and HOW the farmer implements these conservation practices.</td>
<td>Specify WHY the farmer DOES NOT implement conservation practices.</td>
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<td>-------------------------------------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>Off-stream watering point for livestock</td>
<td>RF9367</td>
<td>RF9368</td>
<td>RF9369</td>
<td>RF9370</td>
</tr>
<tr>
<td>OTHER (Indigenous) SWCBs??</td>
<td>RF9371</td>
<td>RF9372</td>
<td>RF9373</td>
<td>RF9374</td>
</tr>
</tbody>
</table>

42. Compared to when you first started to farm here, the **number of trees and other vegetation** along the rivers edge in your village today is:

(a) More     (b) about the same     (c) Fewer     (d) Don’t know

43. If the number of **trees and other vegetation has changed** along the river, please tell me **what you think** the reasons are.

1. 
2. 
3. 

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44. **Would you agree** to have a protected strip of land (riparian zone) next to the river? Y / N / Don’t Know

   44b. If yes, **how wide** should this protected strip of land be? Steps or paces from the river bank

   44c. **Do you think it is possible** to protect a strip of land next to the river? Y / N / Don’t Know

   44d. If **no**, please explain **why you feel** this way

45. If you are willing, **what could be done** to help you protect a strip of riparian land next to the river?

   1. 
   2. 
   3. 
   4. 

46. If you had **three messages for decision makers** about how to improve the **health of land and water along the River Njoro**, what would **you** tell them?

   1. 
   2. 
   3.
47. Ethnicity Code: ____________________________ (to be filled in after the survey)

48. Overall, this farmer is scored as an adopter of SWCBs: (please circle one)
   (a) adopter of SWCBs
   (b) non-adopter of SWCBs

49. Based on the following KEY, the RF strength of SWCB is scored as:
   (a) Strong adopter of SWCBs
   (b) Moderate adopter of SWCBs
   (c) Weak Adopter of SWCBs
KEY – Farm Walk-About

* The ONE MOST IMPORTANT reason that this farmer **HAS IMPLEMENTED** a practice is

1) It was observed on another farm and (a) It is profitable (b) it is required by the authorities (c) it is good for the land and water (d) other
2) It was observed in an extension demonstration and (a) It is profitable (b) it is required by the authorities (c) it is good for the land and water (d) other
3) It was observed in a school and (a) It is profitable (b) it is required by the authorities (c) it is good for the land and water (d) other
4) It was observed elsewhere and (a) It is profitable (b) it is required by the authorities (c) it is good for the land and water (d) other
5) It was thought of by this farm family to be (a) profitable (b) required by the authorities (c) good for the land and water (d) other

** The ONE MOST IMPORTANT reason that this farmer **HAS NOT IMPLEMENTED** a practice is

1) The farmer is **not aware of it**, has never heard of, or seen it, before. No idea if it is needed or not.
2) The farmer is aware of it, but feels the SWCB is **not needed** (NO PROFIT) for the shamba
3) The farmer is aware of it, but feels the SWCB is **not needed** (NO OTHER BENEFIT) for the shamba
4) The farmer is aware of it, but feels the SWCB is **not needed** because s/he has too many other problems to worry about
5) The farmer is aware of it, feels the SWCB is **needed**, but thinks it is too complicated
6) The farmer is aware of it, feels the SWCB is **needed**, but thinks it cannot be tried on a small scale
7) The farmer is aware of it, feels the SWCB is **needed**, but thinks the results are UNRELIABLE or RISKY
8) The farmer is aware of it, feels the SWCB is **needed**, but **lacks time, labor, or health to implement**
9) The farmer is aware of it, feels the SWCB is **needed**, has time/labor/health, but **lacks money to implement**
10) The farmer is aware of it, feels the SWCB is **needed**, has time/labor/health/money, but **does not own the land**
11) The farmer is aware of it, feels the SWCB is **needed**, but has another constraint—please specify

DEVELOP A DECISION MATRIX TO SCORE THE RF!!!
CURRICULUM VITA

Steven P. Huckett

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EDUCATION

Ph.D. Candidate (successfully defended 1 May 2009). Human Dimensions of Ecosystem Science and Management, Department of Environment and Society, Utah State University, Logan, Utah.


Major emphases were placed on: the political ecology, bio-physical features, and socio-economic factors that influenced adoption of soil and water conservation practices in an impaired dryland watershed. Through integration of the concepts of context-systems theory and adoption theory, I examined linkages between the social/ecological systems to better understand the individual’s contextual setting and how various factors influence small-scale farmers’ adoption decision processes. My findings provided valuable information to allow evaluation of the impact of small-farms and for identification of other prominent sources of impairment to the River Njoro watershed. This research has furthered our base understanding of resource management decisions by small-hold farmers’ so that more effective programs and policy may be developed which focus on improving conservation of natural resources and improving livelihoods and human well-being.

M.S. in Biology (Ecosystems Ecology) (1997), University of New Mexico, Albuquerque

Concentrations: Arid Environments and Riparian Ecosystems Ecology: Restoration ecology, watershed management and planning, and habitat restoration.

B.S. in Agronomy (1983) - Kansas State University, Manhattan

Concentration: Soil science (ecology and chemistry) and cereal grain crop production practices.
PROFESSIONAL EXPERIENCE

**Project Manager** – Texas AgriLIFE Research, Texas A&M University, Temple Texas. 
August 2009 to Present

Provide management and supervision on a USAID funded Mali Livestock and Pastoralist Initiative (MLPI) project in Mali that aims to improving productivity and income of livestock producers in Mali by enabling them to access technologies and build capacity for the development of an extensive livestock information system. This effort is to introduce technologies and tools previously developed and implemented in East Africa and transfer them to Mali to establish a livestock market information system (LMIS) that provides real time price and volume information. I also assist with projects in East Africa that focus on combining a livestock early warning systems product (LEWS) with a NASA/USGS water monitoring technologies to provide near real-time information to livestock producers, government agencies, and non-governmental organizations to help avert famine to improve livelihoods.

**Field Crew Supervisor** – SWCA Environmental Consultants, Logan Utah. 
May to October 2008

Supervised a 5-12 person crew of biological survey technicians in the Uinta Basin, Utah.

- Conducted a large-scale biological survey.
- Enumeration of threatened and endangered cactus, avian and other species.
- To satisfy regulatory requirements for enumeration and protection of undeveloped lands in preparation for oil and gas exploration activities.

**Graduate Research Assistant** – Utah State University, College of Natural Resources. 
April 2001 to present

Responsibilities were inclusive of

- Undergraduate level teaching assistant.
- Design research program including international travel and accommodation, household survey design, analytical methods, budget, and timely submission of progress reports.
- Developed and organized field survey activities, supervised field enumerators.
- Complete protocols for Institutional Review Board (IRB) for the protection of human research subjects.
Professional Experience Continued

General Manager - Covered Wagon Ranch, Big Sky, Montana

1999 – 2001

Managed a small, vibrant guest ranch operation on the Gallatin River, Montana in the shadow of Yellowstone National Park, where guests enjoyed horseback riding, fly-fishing on world-class trout rivers, hiking, bird-watching, and many back-country recreational activities.

- Managed all ranch operations (budget, payroll, purchasing, livestock care, etc.) and performed all necessary facility maintenance; supervised up to 14 seasonal employees.
- Oversaw entire guest accommodations (lodging, dining, recreation, safety, and comfort).
- Directed horseback riding operations and other organized recreational activities.

Protected Areas Preserve Manager – San Pedro River Preserve, The Nature Conservancy, Arizona Chapter.

1996 – 1999

Original manager of the 2,650 hectare preserve located in the Sonoran Desert at the confluence of the San Pedro and Gila Rivers for the protection of critical riparian habitats for the Southwestern Willow Flycatcher (WIFL), an endangered neo-tropical avian species. The preserve encompassed approximately three and one half miles of riverine/riparian habitat and about 2,200 ha of desert shrub and mid-elevation grasslands. Initial duties were to convert a working cattle ranch, pecan farm and aquaculture operation via habitat restoration and facilities reorganization into a successful protected area.

- Managed the preserve budget, organized all purchases and contracted services, and wrote annual and quarterly reports to The Nature Conservancy and involved agencies.
- Assisted in developing a habitat restoration and conservation program for the preserve and local riparian zone, and provided oversight of reclamation of pre-existing facilities.
- Liaised with numerous agency personnel (Bureau of Reclamation, U.S. Fish and Wildlife Service, Arizona State Game and Fish, etc.), community groups including ranchers and miners, environmental groups, and universities.
- Supervised construction of 6.5 miles of exclusion fence to prevent local livestock and off-road enthusiasts from entering the riparian zone habitat.
- Constructed and operated an on-site greenhouse to produce endemic vegetation species for use in habitat restoration on this and other Nature Conservancy preserves, and on private lands participating within the overall conservation program.
Professional Experience Continued

- Hosted seasonal employees of the State of Arizona and U.S. Fish and Wildlife Service while they conducted field monitoring and evaluation of the WIFL.
- Hosted potential donors and served as the liaison to local communities and agencies.
- Initiated public outreach to provide environmental education and understanding.
- Hosted university and high school science students and provided unique educational opportunities to learn about natural resources management issues.
- Converted existing aquaculture ponds (catfish and bass) to grassland and riparian habitats.
- Produced pecan nuts (from existing orchard) to generate supplemental funds.
- Purchased a small cattle herd to graze the upland portion of the preserve. Created an upland grazing management plan in cooperation with neighboring ranches whereby herds were combined to better utilize and restore upland desert habitat.
- Assisted other Conservancy preserves as needed i.e., labor, firefighting, materials, etc.

Environmental Specialist – Surface Water Quality Bureau, New Mexico Environment Department, Santa Fe.

1993 – 1996

Assisted local citizens groups to develop watershed watch programs to provide oversight and management to improve natural resources and riparian habitats.

- Facilitated public meeting to bring diverse parties together for issue identification and conflict resolution.
- Provided expertise for evaluating the ecology and habitat restoration potential.
- Developed capacity building training program for local water quality monitoring team.
- Supervised development of community-based conservation management plans.
- Wrote grant applications on behalf of citizen lead watershed watch groups for U.S. Environmental Protection Agency 319(h) funding.

Environmental Consultant - Junior Project Manager (Western Technologies, GZA Geo-Environmental, and Geo-Test) - New Mexico and Arizona

1990 – 1993

- Investigated petroleum and hazardous chemical contamination of soils and groundwater.
- Identified and proposed soil and water remediation strategies.
- Performed Phase I Environmental Site Assessments pertaining to real estate and development transactions.
- Liaised with multiple state and federal government agencies, contractors, and public and private sector clientele.
Professional Experience Continued

During the period, August 1987 to November 1989, I lived in West Germany while my wife completed her post-doctoral program in chemistry at the Max-Plank Institut für Kohlenforschung, Mülheim. I was a stay-at-home father, raising two children and attending the local community college to learn Deutsch.

Pilot Hybrid Seed Production Manager – Garst Seed Company/ICI Chemicals, Iowa 1983 – 1987

Supervised and actively participated in all aspects of experimental hybrid seed maize production activities in close collaboration with our research team. This included establishment of a new seed processing facility and state of the art bio-technology laboratory.

- Located appropriately isolated farm fields and negotiate contracts with local area farmers to produce experimental hybrids on plots of 0.1 to 10 acres in size.
- Supervised production activities (land preparation, planting, rouge & detassle, harvesting, drying and cleaning, inventory) for producing approximately 175 different experimental maize varieties on more than 500 acres in about 125 fields.
- Collected field performance data in support of plant breeding efforts.
- Managed seed inventory (>+$10m) and distribution of hybrids for field trials.

PUBLICATIONS AND PAPERS


Publications and Papers Continued


RELATED SKILLS AND EXPERIENCES

- Skilled in design and administration of household surveys and data analysis.
- Classification and Regression Tree, descriptive, and $\chi^2$ methodologies and analysis.
- Well versed in MS Office programs, S+, SPSS, and R statistical packages.
- Moderate proficiency with ArcGIS.
- Competent with operation of field instrumentation such as GPS, water quality, soil sampling, small mammal and invertebrate sampling equipment.
- Proficient operator of a wide variety of farm machinery, construction/heavy equipment, OHV, and 4X4 vehicles.
- I have lived and worked in a wide variety of locations and diverse environments in the U.S. (Kansas, Iowa, New Mexico, Arizona, Montana, and Utah) and abroad; Germany (1987-1989) and Kenya (2005-2006), plus I have worked in the border town of Juarez, Mexico. I welcome the challenge of living and working in culturally diverse places and with people from all walks of life and am very comfortable adapting to the many nuances new and challenging environments offer.

LANGUAGES

- English – Mother language.
- German – I lived in Germany from 1987 to 1988 and spoke fluently. With practice, I would become conversational again.
- KiSwahili – Basic skills and understanding.

MEMBERSHIPS

- International Association of Society and Natural Resources
- Ecological Society of America
- Society of Range Management


**HOBBIES**

Hiking, camping, fishing
Auto mechanics and restoration
Photography
Travel
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