Poverty and natural resource management in the Central Highlands of Eritrea

Araya Tesfamicael, Bereket

Chapter 2

Agricultural Intensification, Agricultural Productivity and Land Degradation in Africa

2.1 Introduction

Extreme poverty is the general characteristic of most countries in sub-Sahara Africa (SSA). Low levels of per capita income, low levels of literacy, malnutrition and high levels of infant mortality are the rules rather than exceptions in this region. Despite concerted efforts by the governments of these countries and the international community, these dimensions of poverty and deprivations are still increasing in many parts of SSA (IFAD, 2002).

In addition to the high levels of poverty, Africa also suffers from a vast inequality in income. Inequality is particularly notable between the rural and urban areas of the continent. More than 80 percent of the extremely poor in SSA are found in the rural areas and about 85 percent of the poor depend on agriculture for their livelihoods. Thus, while high and sustained levels of economic growth may be helpful to reducing the number of poor people, in economies characterized by high levels of inequality, economic growth alone may not be sufficient to eliminate poverty. It is necessary to focus efforts on policies that will have direct impact on the poor.

The poor people in the rural areas rely heavily on their environment for most of their needs and are affected by the deterioration in the quality and quantity of these resources. The condition of the majority of the rural poor in many developing countries is a vicious circle between environmental degradation and poverty. Poverty influences farmers' ability and willingness to control land degradation and land degradation leads to lower agricultural productivity and, therefore, more poverty (WCED, 1987, 1993; Dasgupta, 1992; Barbier, 1999). The relationship between agricultural growth, poverty alleviation and sustainable land management is, however, complex and a subject of much controversy. The links between these issues are conditioned by various factors including demographic, economic, institutional, and policy conditions. It is, thus, essential to find policies, technologies and institutions that reduce land degradation and poverty at the same time.

This chapter is organized as follows. In the following section we will briefly discuss the performance of agriculture in Africa in the past few decades. Next we will discuss the nature and extent of land degradation in the continent. Section 3.4 will discuss the process of agricultural intensification and the reasons why African farmers fail to intensify (invest on) their agriculture. Finally we will briefly discuss the theoretical links between population growth, poverty and land tenure on the one hand and land degradation on the other.

2.2 Performance of agriculture in Africa

Most countries in Africa heavily depend on agriculture that is dominated by subsistence production. The performance of Agricultural sector in SSA was the worst in the third world countries in the last quarter of the last century. Agriculture is still based on traditional methods of production with little use of modern inputs. The low level of productivity in this sector is exhibited in the fact that while the sector employs about 67 percent of labour force in Africa, it contributes for only 17 percent of the total gross domestic product (World Bank, 2000). The majority of the farmers are smallholders cultivating 0.5 to 2 hectares of impoverished lands highly susceptible to erosion with little external inputs. Thus crop yields in Africa are extremely low – about 33 percent and 50 percent of the yields in Asia and South America respectively. Africa is also the only region where average food production per person has been declining over the past 40 years (Sanders *et al.,* 1996). In addition, high degree of production and price variability, low proportion of irrigated land, low levels of fertilizer use and high dependence on primary exports are common features of African agriculture. Table 2.1 shows that SSA lags far behind most regions in terms of agricultural indicators such as proportion of irrigated land, per capita cereal production, crop yield and fertilizer use.

Table 2.1 Agricultural indicators by region

	Africa	Sub-Sahara Africa	Near east and North Africa	South Asia	East Asia and Pacific	Latin America and Caribbean	Middle income countries	High income countries	World
Proportion of arable land irrigated	7.0	3.8	28.7	39.3	31.9	11.6	19.9	11.9	20.0
Per capita cereal production kg/year	147	128	128	224	336	259	339	746	349
Cereal yield kg/ha	1225	986	1963	2308	4278	2795	2390	4002	2067
Fertilizer use kg/ha	22	9	69	109	241	85	111	125	100

Source: FAOSTAT

Poor resource endowments and adverse policies that continued for a long period are identified as the major causes of low and declining performance of the agricultural sector in SSA. Continuing environmental degradation, high population growth, low levels of investment in agricultural infrastructure also aggravate the resource limitation of African agriculture (Sanders *et al.,* 1996; Binswanger and Townsend, 2000; Ehui and Pender, 2003).

Most soils in SSA are inherently poor with low organic content. They tend to drain poorly and are easily susceptible to both wind and water erosion (Wong *et al.,* 1991; Weight and Kelly (1998) cited in Nubukpo and Galiba, 1999). Weight and Kelly (1998) identify four primary soil types in SSA, each with different implications for restoring soil fertility. Fifty seven percent of the total land area was classified as marginally suitable for cultivation with soils characterized by limited organic matter and water retention capacity and 28 percent is low to medium potential land, which is very vulnerable to a decline in organic matter and fertility when few inputs are applied.

Low and poorly distributed rainfall is another major bottleneck for agricultural development in large areas of SSA. Much of Africa is too dry for the new high-yielding varieties that worked so well in Asia. Average rainfall in the dry semi-arid areas of SSA is less than 700 mm/year[2]. The rainy season is also very short: 90-100 days and periods of more than 10 days without rainfall are frequent. The region is also characterized by high temperature that accelerates the degradation of organic matter, which, in turn, reduces the water holding capacity of the soils and makes them deficient in nitrogen and phosphorus. Drought-resistant crops such as millet and sorghum dominate this region (Marter and Gordon, 1996; UNCTD, 1998).

Pricing and exchange rate policies in many SSA countries as well as high direct and indirect taxes on agriculture also led to loss of competitiveness of the agricultural sector and discouraged investment in agriculture and soil conservation measures. Public investment in rural roads, irrigation structures and other rural services are also very low. Agricultural marketing and input supply systems are often dominated by highly unreliable and inefficient public sector. As a result of poor infrastructure and poorly developed input markets, key inputs are not available at the right time and place. As a result of these constraints agriculture in SSA makes use of little external inputs and remains mainly subsistence oriented (Sanders *et al.,* 1996; Binswanger and Townsend, 2000; Pender *et al.,* 2003).

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[2]There is a wide range in the definition of semi-arid areas in the literature. See Sanders *et a*l. (1996) for a brief discussion of these definitions.

2.3 Land degradation

Land degradation in Africa is a serious problem with a considerable impact on the economies of many countries in the continent. A study by Oldeman *et al.* (1992) shows that about 25 percent of the world's degraded lands is located in Africa. It is estimated that 65 percent of Africa's agricultural land is degraded because of water and soil erosion and/or chemical and physical degradation. In addition, 31 percent of the pasturelands and 19 percent of the forests and woodlands in Africa are classified as degraded (Table 2.2). Forest and woodland areas in the continent have decreased by 2 percent in the last 15 years while croplands increased by more than 10 percent (Barbier, 1999).

Table 2.2 Global estimates of soil degradation, by region and land use

	Agricultural land			Permanent pasture			Forests			All used land	
Region	**Total**	**Degr.**	**%**	**Total**	**Degr.**	**%**	**Total**	**Degr.**	**%**	**Degr. %**	**Seriously degr.%**
	millions of hectares			millions of hectares			millions of hectares				
Africa	187	121	65	793	243	31	683	130	19	30	19
Asia	536	206	38	978	197	20	1273	344	27	27	16
South America	142	64	45	478	68	14	896	112	13	16	9
Central America	38	28	74	94	10	11	66	25	38	32	31
N.America	236	63	26	274	29	11	621	4	1	9	7
Europe	287	72	25	156	54	35	353	92	26	27	20
Oceania	49	8	16	439	84	19	156	12	8	17	1
World	1475	562	38	3212	685	21	4048	719	18	23	14

Source: Scherr (1999).

Nutrient depletion is more widely found and is of more serious concern to food security in SSA than in any other part of the world (Smaling, 1993; Cleaver and Schreiber, 1994). Soil fertility depletion is considered as the main biophysical limiting factor for raising per capita food production for most of small African farmers. Some authors maintain even in the Sahelian region, availability of nutrients is a more important constraint than water supply (Penning de Vries and Djiteye, 1982; Sanchez *et al.,* 1997). Stoorvogel and Smaling (1990) quantified nutrient depletion at the national and sub continental scale for most countries in SSA. They showed that nutrient balances are only partially compensated for by natural and man-made inputs and that the annual NPK balances are negative for SSA. The average annual nutrient balance for the region for the period 1983 – 2000 was estimated to be minus 22-26 kg N, 6-7 kg P, and 18-23 kg K per hectare. If nutrient balances on only actual harvested land are considered, i.e., without fallow and fallow inputs, nutrient depletion rates may be double the above figures (Drechsel *et al.,* 2001).

When no external inputs are used, long periods of fallow are required to replenish nutrients taken up by crops. Even assuming much higher nutrient inputs from fallow than current estimates, Drechsel *et al.* (2001) argue that only 20 percent of the arable land can be cultivated each year for a sustainable land management, which is considerably lower than the FAO estimate of 60 percent of the arable land actually cultivated each year. This is practically impossible given the current and increasing population pressure in SSA.

Overgrazing, expansion of agricultural lands and lack of external inputs are the major causes of land degradation in the continent. This is because many African farmers and pastoralists respond to declining land productivity by abandoning existing degraded land and moving to new land (Barbier, 1999). Farmers in SSA did not sufficiently improve their land management practices to the conditions of continuous cultivation and shorter fallow periods, which were caused by increasing population pressure. Irrigated area and the adoption of inorganic fertilizers and other new technologies such as high-yielding varieties are still very low. As a result crop yields in the region in the last few decades were stagnant or even declined. In contrast, irrigation and the use of inorganic fertilizers and other new technologies in Asia have dramatically increased in the last three decades of the last century resulting in more than 80 percent increase in crop yield (Sanders *et al.,* 1996).

A number of studies have been undertaken to estimate the economic costs of soil erosion in terms of lost agricultural production. Countries like Zimbabwe, Ghana and Ethiopia were found to be losing five to nine percent of their agricultural output every year due to land degradation (Bojo, 1996; Barbier, 1999). Barbier (1999) suggests that the loss can even be higher because the estimates refer only to the loss of few crops whereas the agricultural output refers to the value added in crop production and livestock, forestry, hunting and fisheries.

The decline in land productivity is further aggravated by the removal of crop residues and animal manure, which were traditionally important means of nutrient recycling. A study by Ethiopian Forestry Action Program (EFAP, 1992), for example, estimates that the loss of productive croplands and grazing lands from soil erosion in the Ethiopian highlands between 1985-2010 at more than 10,000 sq. km and 3000 sq. km respectively. The study also indicates that the loss of production attributable to the removal of crop residues and dung exceeds soil erosion-induced losses by a factor of 35 to 80 percent. Similar findings were also reported for Eritrea (see Section 3.4).

2.4 Agricultural intensification

Agricultural intensification has been defined as the use of an "increased average inputs of labour or capital on smallholding, either cultivated land alone or on cultivated and grazing land, for the purpose of increasing the value of output per ha" (Tiffen *et al.,* 1994: 29). For agricultural intensification to occur, an increased demand for output or a fall in the availability of key factors such as land, labour or water is needed. Demand for output may increase due to an increase in population, in-migration of people, expansion of markets and increased income. However, while the above conditions are necessary for agricultural intensification to take place, they are not sufficient. We will discuss the theoretical debate on the relationship between population growth and agricultural intensification later in this section. We will first discuss briefly the nature and processes of agricultural intensification.

The nature and processes of agricultural intensification

The process of agricultural intensification may take different forms, which may have different impacts on livelihoods of the rural people and on the environment. These changes include expansion of agricultural land, intensification of labour per unit of land using traditional methods (shortening of fallow cycles), adoption of more labour-intensive methods of production, labour-intensive investment in land (e.g., soil and water conservation structures), adoption of capital-intensive methods, change in product mix, migration and a change in household fertility decisions (Carswell, 1997; Pender, 1999).

Reardon *et al*. (1999) distinguish between sustainable and unsustainable types of agricultural intensification. They appraise the sustainability of agricultural intensification by the following two criteria:

- An environmental criterion: the technology protects or enhances the farm resource base and thus maintains or improves land productivity; and
- An economic criterion: the technology meets the farmer's production goals and is profitable.

They differentiate between "capital-led intensification" and "labour-led intensification". While the latter, also termed as "capital-deficient intensification", refers to intensification that involves excessive dependence on labour as a variable input to production, the former refers to intensification based on substantial use of non-labour variable inputs that enhance soil fertility (such as inorganic fertilizers) and quasi-fixed capital, particularly land and water conservation infrastructure that increase labour productivity.

"Labour-led agricultural intensification" strategy, which makes little use of chemical fertilizer and other chemicals and emphasizes the use of organic matter and land conservation structures, is considered less sustainable from the viewpoint of the two sustainability criteria stated above. It is argued that given the increasing cropping intensity (due to the declining fallow periods) and declining number of livestock, sufficient manure is not available to substitute inorganic fertilizer. Similar observations were also made in the West African semi-arid tropics, that the amount of manure and compost produced in the farm is not sufficient to replace the major nutrients mined from the soil by crop production (Nagy *et al.,* 1988; Reardon *et al.,* 1999). Moreover, labour-led intensification is not sufficiently productive to meet the needs of the fast growing population. It has also been argued that while rural population in Africa is growing at about three percent per year, Low External Input Sustainable Agriculture (LEISA) has the potential of increasing output by only one percent per year. This will lead to soil mining and yield decline in the long run (Sanders *et al.,* 1996). Thus capital-deficient intensification meets neither the economic or economic criteria required for a sustainable agriculture.

Population growth and agricultural intensification

The conceptual debates surrounding agricultural intensification often set in the context of population environment debate. The relationship between population growth, and land degradation has been a subject of debate for a long time. Malthus (1798) argued that while population grows exponentially, production, due to diminishing returns, increases only arithmetically, leading to a decline in per capita output. As population increases, the per capita area of arable and grazing land decreases, and cultivation extends into marginal lands leading to a lower per capita income. Land already cultivated is cultivated more intensively. The increased demand for cultivable land, firewood and construction materials and an increase in the supply of labour that clear trees leads to environmental deterioration.

In contrast to the Malthusian view, others saw population pressure as the major stimulus for intensification. The theory of induced innovation states that reductions in the availability of a resource or an increase in demand for goods will force people to develop and adopt new technologies, which offset the decline in the available land (Boserup, 1965; 1981). In other words, the development and dissemination of new technologies and institutions is directed by relative factor scarcity, as reflected in market prices. While the change in relative prices is the major factor that leads to an endogenous agricultural intensification, the exogenous factors that cause a change in relative prices may be increased population pressure, increased access to markets (which may result from the development of roads and other infrastructure) and/or government policies (Ruttan and Thirtle, 1989; Ruttan and Hayami, 1990; Binswanger and McIntire, 1997).

Others argue that increased demand for goods and services resulting from population growth or a decline in the availability of key factors such as land, labour or water are necessary but not sufficient conditions for agricultural intensification. An endogenous intensification by farmers often fails to take place due to absence or imperfection of the markets for inputs and outputs, institutional arrangements concerning land rights, policy environments that discourage investment on land improvement, absence of suitable technologies and poverty. Farmers may lack the willingness and/or ability to adopt technologies that enhance land productivity and maintain the quality of their land that endogenous investments that are predicted by the theory of induced innovation may not take place or, if they occur, not necessarily occur at the right time and extent (Reardon and Vosti, 1995; Shiferaw and Holden, 1998).

The empirical evidences on the relationship between population growth, agricultural intensification and land degradation are mixed. Several studies have shown that farmers in developing countries responded to increasing population density by fostering technical and social changes, which helped to avoid Malthusian outcomes of declining productivity and land degradation (Pingali *et al.,* 1987; Tiffen *et al.,* 1994; Arnold and Dewees, 1995). For example, despite a five-fold increase in population between the 1930s and 1990s in the Machakos district of Kenya, a comparison of agricultural development and land management in the two periods showed no signs of environmental and economic catastrophes (such as land abandonment and widespread deforestation) in the region. In fact, agricultural output per head increased three fold and the main indicators of land resource management have shown substantial improvements (English *et al*, 1994; Tiffen, 1994). Scherr (1995) also attributed high interests in agroforestry in western Kenya in the 1980s to the rapidly expanding markets for tree products in that area. Godoy (1992) provides 21 regional examples of farmers in Africa, Asia and Latin America who responded to high forest product prices by planting trees. Patel *et al.* (1995) examined the impact of increased population density and land subdivision on tree planting using data from small holders in Tanzania and Kenya. They found that as population density increases, the observed decline in tree cover would reverse and begin to improve. Thus they concluded that the decline in tree cover in those countries was one side of a U-shape relationship between population density and land degradation rather than a secular trend of environmental degradation.

However, others have argued that agricultural intensification does not necessarily follow population growth (Binswanger and Ruttan, 1978; Turner *et al.,* 1993). Despite high population growth, adoption of new technologies remains low in Africa resulting in declining yields and deteriorating environments. Blaikie and Brookfield (1987) warn that despite its historical validity Boserup's argument may not necessarily hold for today's developing countries. They underline that over-exploitation of land, overgrazing of pasture, man-made erosion and deforestation are common phenomena in areas of high population pressure. Pingali *et al.* (1988) maintain that endogenous technical changes by farmers in response to population growth are sufficient to support slow and steady population growth but not rapidly rising population. Even Tiffen *et al.*'s findings of successful agricultural intensification in Machakos district were challenged in that many people in the area were experiencing deteriorating livelihoods (Murton, 1997). Murton argues that although in the early stages of population growth, labour-intensive path of intensification had positive impacts on livelihoods and the environment, at later stages, farmers' lack of access to capital has forced them to proceed along the pathways of declining yields and diminishing returns. Dewees (1995) argued that households do not necessarily respond to declining fuelwood availability (resulting from increasing population pressure) by planting more trees. He reveals that various studies found that households respond to fuelwood scarcity by increasing labour time for fuelwood collection, using a lower quality of fuelwood, increasing reliance on dung and agricultural residues and purchasing fuelwood, which could have adverse environmental and economic impacts.

The foregoing discussion shows that while population growth may induce agricultural intensification, such process may be delayed or fail to take place due to lack of suitable technology, as well as economic, institutional and policy conditions that influence farmers' willingness and ability to adopt those technologies. On the other hand, high population density does not necessarily lead to environmental degradation and declining incomes.

2.5 Understanding farmers' decisions for agricultural intensification

Despite the availability of technologies with demonstrated technical efficiency that have beneficial effects on yields and the natural resource base, and despite all the efforts by governments of developing countries and donor organizations to promote their adoption, the adoption of these technologies by farmers remains very low in many African countries. Scientists from various disciplines have been investigating the process by which agricultural technologies are adopted by farmers for decades (Feder et al., 1985; Swanson *et al.,* 1986; Smit and Smithers, 1992; Rogers, 1995). These studies are broadly classified as sociological models that emphasize factors such as awareness and perception and economic models that emphasize access to markets, risks involved and liquidity constraints, which affect farmers' willingness and ability to invest on new technologies.

The sociological models consider adoption as a psychological process in which the potential adopter is assumed to move through several stages: awareness, interest, evaluation, trial and adoption. The characteristics of the new technology as well as personal and social factors are considered to be among the most important factors in the adoption process. These models emphasize education, extension and demonstration programs. Effective communication methods for disseminating information are emphasized as crucial components in promoting adoption (Hansen, 1987; Napier, 1991).

The economic models of technology transfer emphasize the impact of economic variables on the adoption of new technologies. These models are based on the premise that farmers do not adopt new technologies either because they do not have the necessary economic resources or because the practices are not profitable. Profitability of the technology, risks associated with its adoption, land tenure arrangements, and availability of credit are considered among the major factors that influence farmers' decisions.

In the remaining sections of this chapter we will discuss the theoretical and empirical links between poverty and land tenure on the one hand, and investment on NRM technologies on the other.

2.5.1 Poverty and land degradation

Poverty is cited as a major factor behind land degradation in many developing countries. This is because the rural poor in many developing countries depend heavily on their natural resources and lack access to alternative sources of income. Moreover poor households are usually marginalized to less fertile and steeper slopes, which are prone to high risks of soil erosion and could not be cultivated sustainably without the use of appropriate conservation measures. However, these farmers do not have the resources to undertake investments that enhance long-term productivity of their land (Blaikie and Brookfield, 1987; Mink, 1993; Cleaver and Schreiber, 1994; Barbier and Bishop, 1995). Poor households are also thought to have short time horizon due to lack of ability to forgo present consumption to maintain the quality of their natural resource base and ensure future consumption (Grepperud, 1996; Holden *et al.,* 1996; Prakash 1997).

Poverty is also believed to affect NRM indirectly through its effects on levels of education, population growth, and off-farm employment (Dasgupta, 1992). Poor households, for example, usually have higher family sizes because they live at a subsistence level and may consider children as an investment for their old age. They also have little or no access to education and, therefore, no access to information about birth control methods. Poverty, therefore, accelerates population growth among the rural poor and thereby the pressure on land.

The links between poverty, agricultural intensification and the environment are, however very complex and are conditioned by many factors (Ekobom and Bojo, 1999; Lee *et al.,* 2000). Reardon and Vosti (1995) maintain that the links between poverty and land degradation were not systematically explored. They introduce the concept of "investment poverty" and show that the links between poverty and land degradation are determined by the type of assets held by the rural poor and the type of environmental degradation they face. According to this theory, for example, "welfare-poor" household may not be necessarily "investment-poor", if they own abundant labour to build stone bunds from locally available materials but will still be "investment-poor" if the materials needed for stone bunds must be transported from afar and if this involves cash expenditures. Thus whether poor people in a given locality will adopt a given NRM technology depends on the type of poverty they suffer (lack of labour, capital etc.) as well as the type of technology in question.

Empirical evidences indicate that poor farmers respond in different ways to increased pressure on natural resources from population growth or market access. While some studies find that poorer households cope with the situation by expanding their cultivated land to more fragile areas, harvesting more trees etc. (Grepperud, 1996), which have adverse impact on the environment, others found that farmers adopt technical and institutional innovations, which protect or improve the natural resource base (Forsyth *et al.,* 1998 cited in Scherr 2000)[3].

2.5.2 Land tenure and land degradation

The way property rights are defined and enforced is a fundamental issue in the way land and other resources are utilized. Absence of secure right to their land is considered an important hindrance to investment on land and hence a cause of land degradation. Overexploitation of resources occurs because while the benefits from using resources under communal ownership accrue to individual users, the cost is shared by the community in general. This is termed as the "Tragedy of Commons" by Hardin (1968). Proper definition and enforcement of property rights is believed to facilitate efficient use of natural resources by internalizing the externalities associated with the use of the resource (Demestz,

[3] See Ekobom and Bojo (1999) for various hypotheses on how poverty and environments are linked and for some empirical evidence.

1967). Traditionally, nationalization and privatization have been two main solutions suggested to address the problem. Extremely high information and monitoring costs have discounted the success of nationalization and state management of resources (Edmonds, 2000).

Many economists maintained that privatization of common resources could be the solution to the overexploitation of resources (Coase 1960; Demestz 1967). The absence of clearly defined and enforceable property rights and associated externalities result in a sub-optimal investment in the management of the resources. Randal (1987: 154) summarized the characteristics of an adequate set of property rights as: "exclusive ownership including the right to use and to determine who, if any and under what condition can use the property; complete specification of the rights of owners and non owners and penalties for violation; transferability of rights including leasing and selling of rights to the highest bidder; and complete enforcement of property rights as rights which are not enforceable are not effective."

Private ownership of land is often considered to be superior to other land tenure systems in terms of its effect on the management of natural resources. The argument is that the security of tenure associated with private ownership of land encourages farmers to undertake long-term investments such as soil conservation structures and planting of trees (World Bank, 1992). Pearce and Warford (1993), however, have argued that private ownership of land may not be necessarily superior to communal ownership with respect to conservation of natural resources in developing countries for three reasons. First, the absence of documented land rights in developing countries does not necessarily mean that land rights do not exist. Many developing countries have historically evolved land rights that provide the security private ownership provides. Second, secure property right is a necessary but not sufficient condition for conservation of natural resources. In developing countries, where poverty is dominant and farmers have no access to credit, private ownership may be associated with unsustainable land use practices. Finally, title to land is largely meaningless unless it is effectively enforced. Due to the long-established traditional land ownership systems and the limited financial and administrative capacity of the governments in the developing countries, it is difficult to implement and enforce the land titling programs. Moreover, concerns about distribution of income and the extremely high costs associated with defining, enclosing and enforcing private patches of grazing and croplands proved to be the major constraints to the introduction of individual rights on communally owned lands in many developing countries (Bojo, 1991).

Recently communal management of common property resources has risen as a popular alternative system of property rights (Ostrom, 1990). The Earth Summit (United Nations Conference on Environment and Development, 1992) has emphasized that community management of resources is vital for sustainable development (Leach *et al.,* 1999). It is argued that communities with communal property relations usually develop a system of resource management that exhibit their concern and sense of responsibility. Pearce and Warford (1993), for example, observed that rural people in developing countries have impressive knowledge of their environment and are able to establish elaborate rules and regulations that enhance sustainable use of their resources. They, however, maintained that the communal management systems broke down as population pressure on natural resources increased with population growth and technological change.

Empirical evidences on the effect of land tenure on NRM show mixed results. Using field data from 8 villages in Burkina Faso, Kazianga and Masters (2002) studied the determinants of investment in field bunds and micro catchments and computed the elasticity of adoption and intensity of use of these technologies. They found that farmers who have more ownership rights over a farmland tend to invest more on soil conservation and concluded that clearer property rights over croplands and pasture could help to improve the management of those resources.

Gebremedhin and Swinton (2000) examined the management of private and communal lands in Tigray, a northern province of Ethiopia. Using data from 250 farm households, they found investments in stone terraces to be highly sensitive to discount rates, the pay back period varying from 5 to 14 years. This was much longer than the period farmers expect to cultivate their land in the area. They also found that land tenure security (which was measured by the expectation of bequeathing the land to children and the length of period from the last land redistribution) was the most important determinant of adoption of soil conservation technology on private land.

Edmonds (2000) examined the impact of government-initiated community institutions on local resource management in Nepal in which the government transferred accessible forests over to local communities. By comparing household's fuelwood extraction between areas that have received forest groups to areas that have not, they found that government-initiated community institutions to manage local resources were associated with a significant reduction in resource extraction.

Kundhlande and Luckert (1998) argued that there may be key differences between tenure types all termed communal and a meaningful analysis of the impact of tenure on investment incentives requires a closer look into the wide range of arrangements in each type of tenure. Thus they developed taxonomy for describing property rights to natural resources and applied it to the Zimbabwean case study from which they concluded that promotion of tree planting may work on some tenure types but fails on others. Warner (1995), in a study of the patterns of tree growing in East Africa, observed that the idea that farmers will not make long-term investment in their holdings unless there is a degree of security associated with private property was not borne in the region where most land is held under customary law and ultimately owned by the state. She notes that most farmers in the area feel secure about their holdings and this is exhibited in the large number of trees they planted. She acknowledged that the number of trees increased with the introduction of new individual tenure rights in Kenya. However, she argued that the main reasons for the increased tree planting were the need to establish a boundary for their land and reduced access to off-farm resources as nearby areas were privatized and not improvement in security of tenure.