Research Journal of Applied Sciences 3 (5): 369-376, 2008
ISSN: 1815-932X

Environmental Degradation and Rural Poverty in Zambia: A Silent Alliance

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Abstract: The relationship among population, environment and poverty is mediated by a number of socio-economic, cultural, political and developmental variables whose relative significance varies considerably from one context to another. This study examines the complex interrelationships between rural poverty and land degradation and attempts to explain the inefficacy of broad development programs implemented in alleviating rural poverty and reversing deterioration of land resources. The purpose of this study is to advance an integrative model to analyze the processes creating rural impoverishment and land degradation in a developing country. The case of Zambia is used to empirically substantiate and validate the framework. The model is designed to provide a vehicle for elucidating the interactions between rural poverty and land degradation, particularly deforestation. Deforestation is related positively to population pressure on cultivated land (the smaller the cultivated area per person, the higher the rate of deforestation); the rate of population growth (the higher the population growth rate, the higher the rate of deforestation due to land clearance and fuel wood provision) and policies favorable to agriculture (the more profitable the agricultural policy, the lower the rate of deforestation). Deforestation is negatively related to the use of modern farm inputs such as fertilizer (the greater the use of modern inputs the lower the need to clear more land for farming). Open-access land tenure situations were found to stimulate deforestation. The model is then used to propose a policy package to improve the living conditions of the poor people and to minimize environmental degradation in Zambia.

Key words: Deforestation, land tenure, environment, resources, biomass

INTRODUCTION

During the few years, the publications of international development agencies have highlighted the importance of the "Poverty-Population-Environment nexus", a set of mutually reinforcing links between poverty and environmental damage (Bojo and Reddy, 2001; Bosch *et al*., 2002; World Bank, 2005). The continued prevalence of poverty in most parts of the world keeps its alleviation as a central objective of economic development. Strategies for reducing poverty have begun to pay more attention to the relationship between environmental degradation and poverty. Poverty reduction and environmental protection are complementary goals. Numerous studies have suggested that environmental damage can have particular significance for the poor. Participatory Poverty Assessments, conducted in Africa reviewed a common perception by the poor that environment is an important determinant of their health, earning capacity, security, energy supplies and housing quality (Brockleshy and Hinsheiwood, 2001; Himayatullah, 2007). Rural studies often observe that poor people's economic dependence on natural resources makes them particularly vulnerable to environmental degradation (Mink, 1999). Other studies have assessed the health damage suffered by poor households that are directly exposed to pollution of air, water and land (Akbar and Lvousky, 2000; Bosch *et al*., 2000; Mink, 1999). The Poor's exposure to environmental degradation is distinctive for two reasons.

First, locations inhabited by the poor are often environmentally vulnerable or degraded. Whether erosion-prone hillsides in rural areas or urban neighborhoods with inadequate water and sanitation infrastructure, the areas to which the poor can gain access are often the riskiest for health and income generation (Duraiappah, 2004; IFAD, 2001). Second, being poor entails lacking the means to avoid the impacts of environmental degradation. A lack of resources makes it difficult for the poor to buy out of exposure to environmental risks, or to invest in alleviating the cause of environmental degradation (UN, 2001;World Bank, 2005). Poverty plays a big role in keeping people vulnerable to disasters. And in the same fashion disasters

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keep the poor in poverty by consistently wiping out the few resources they have. The purpose of this study is to advance an integrative model to analyze the processes creating rural impoverishment and land degradation, particularly deforestation, in a developing country. The model consists of a system dynamics model of a developing economy that comprises a rural sector. The study had also the following assumptions: Deforestation is related positively to population pressure on cultivated land (the smaller the cultivated area per person, the higher the rate of deforestation); the rate of population growth (the higher the population growth rate, the higher the rate of deforestation due to land clearance and fuel wood provision) and policies favorable to agriculture (the more profitable the agricultural policy, the lower the rate of deforestation). Deforestation is negatively related to the use of modern farm inputs such as fertilizer (the greater the use of modern inputs the lower the need to clear more land for farming). Open-access land tenure situations were found to stimulate deforestation.

This project is significant because in many parts of the world, population is growing at rates that cannot be sustained by available environmental resources, at rates that are outstripping any reasonable expectations of improvements in housing, healthcare, food security, or energy supplies. The issue here is not just numbers of people, but how those numbers relate to available resources. The population problem must be dealt with in part, by efforts to eliminate mass poverty, in order to assure more equitable access to resources and through education to improve human potential to manage those resources. It is hoped that findings and generalizations drawn from a local region could be used to other regions where people have the same plight. Furthermore, it is hoped that recommendations suggested will be of value to authorities involved in formulating agricultural and environmental policies.

MATERIALS AND METHODS

The purpose of this study, is to advance an integrative model to analyze the processes creating rural impoverishment and land degradation in a developing country. The case of Zambia is used to empirically substantiate the framework. One rural agricultural community (Magoye West) was used for empirical investigation and validation. To collect the necessary information the following methods were used:

Questionnaire: A questionnaire was constructed in a way that it would seek to elicit information about small scale farmers on the following: fallow lengths, crop yields and fertilizer use, cultivated areas, ways of conserving soils and forests, changes in food supply and land sufficiency. The households were randomly selected to give each household equal opportunity to be included in the sample. A sample of 50 households was selected.

Panchromatic black and white aerial photographs: Line transects were used concurrently with mapping from aerial photographs to determine the rate of deforestation and land use. Time series panchromatic aerial photographs were used to assess trends in deforestation as well as to analyze aerial expansion of vegetation recession since 1980. The 1980 aerial photographs were used as the starting point because in this year, there were no settlers in the area under study. The intervals between aerial photographs allowed for the study of changes in the vegetation cover of the area over time. For each year, the aerial photographs were demarcated into the categories; vegetation, bare land, dambo and cultivated areas. The volume of vegetation removed for each photo was determined by multiplying the area of vegetation removed by 93 tha^{-1}, which is the standard volume of wet *miombo* in Zambia (Chidumayo, 1997). A set of air photographs ZA 94/5 southern province 1: 30 000, 1994 was used during field observation as a guide to ground *truthing* to relate what was on the photographs to the actual situation in the field. The results were analyzed using a grid of squares so as to estimate the area covered by a category of each of the sets of air photos using the formula:

$$T = N \times (d \times s)2/(100)\ m^2 \qquad (1.0)$$

Where,

T = The total area,
N = The total number of square,
d = The length of the side of the square and,
s = The mean scale of the air photographs.
Source: SADCC (1993) Environmental monitoring system Vol. 2 P. 66.

The study was conducted between January and March 2007. The study area (Magoye West) is located between Monze and Mazabuka towns in Southern Province of Zambia. In terms of longitudes and latitudes, the area lies between 25 degrees 50' and 25 degrees 55' East of Greenwich Meridian and 17 degrees 05' and 17 degrees 15' south of the equator. Just like the rest of Zambia, the study area experiences a tropical type of climate. Rainfall is seasonal and erratic. In July, which is the coldest month, mean temperatures range between 15 degrees and 17.5°C, while those of October, which is the hottest month, range between 25 degrees and 27.5°C.

The settlement lies in one part of Zambia with low rainfall, unreliable and seasonal tropical regime yielding between 700 and 800 mm of rainfall over a six-month period. On account of the low rainfall and the gently undulating slopes of between 0 and 4%, Magoye settlement has a low water table and poor share of perennial rivers, both of which cannot be exploited for domestic consumption and domestic purposes. The settlement falls within the *miombo* woodland zone of Zambia, characterized by *Brachystergia* and *Isoberlinia* as the dominant genera, although, *Marquesia marcroura* is also a common upper-storey species. Dominant lower-storey species include *Diplorlylocarpen* and *Uapasa* Sp. It covers a total area of 33 km^2 or 3300 ha, based on the topographic map sheet 1627 B 2000. It is on forest reserve number 50 and was not occupied by people until after 1980.

RESULTS

Crude settlement population density: Given a gross extent of 33 km^2 and the 2000 population (latest census), of which about 530 directly benefit from the settlement area, the settlement had a population density of about 16 persons km^{-2} in January 2000. This density is over four times that of Magoye constituency (4.5 persons km^{-2}). However, when areas covered by water and those liable to floods are deducted from the total settlement area, a crude dry land of about 18 persons km^{-2} is registered.

The environmental impact of small-scale farming: The meaningful assessment of the impact of a community of people on its environment requires knowledge of the state of the environment before human settlement as well as its condition at some point during such settlement. A diachronic rather than a synchronic approach is, therefore, essential to community environmental impact analysis-an approach that monitors environmental changes due to the dynamics in community variables with a direct or indirect bearing on the use of the environment.

Pre-settlement impact on vegetation: From the interpretation of a block of aerial photographs of the study area taken in 1980, the settlement is on land that was virtually virgin. Only small patches of clearance were evident. Aerial measurements of these patches reveal that only about three km^2 (9%) of pre-settlement Magoye West forest reserve were cleared. About 30 km^2 of the study area (91%) was in a virgin state in 1980.

Post settlement impact on vegetation: By using aerial photographs, 1:50 000 topographic maps and some ground *truthing* of the area, an approximate picture of the impact of the population activities on woody vegetation can be sketched. It is estimated that 22 km^2 or 81% of the estimated 27 km^2 of *miombo* vegetation were cleared between 1980 and 2000. This represents an annual rate of woodland clearance of 1.6 km^2 or 160 ha (about three times the estimated annual rate of woodland loss in Zambia {0.5} (GRZ and IUCN, 2000,). Given an approximated population of 530 small scale farmers (CSO, 2000), a per capita cleared area of about 0.3 ha is suggested. In per household terms, assuming an average family size of 5 members, each farming family can be said to have cleared about 1.5 ha of woodland over this period.

Opportunity cost for lost biomass: An attempt was also made to translate the amount of woodland cleared during this period into crude biomass terms. The basal area method was used for this purpose by employing the following formula:

$$BA = n(g)/12.57, \quad (1.1)$$

where,

BA : Is the basal area (measure of standing wood stock).
N : Is the number of tree stems.
G : Is tree girth at breast height.
12.57 : Is the empirical constant for *miombo* vegetation. (Source: GRZ/IUCN, 2000, p. 6).

Through counting of a sample of trees on the one hectare study site selected for the study, it was established that trees with girth of less than 0.4 m (minimum standard) did not qualify to be counted. The basal area measurements were done in an area of Magoye West settlement still representative of the virgin condition. Having the count of 295 and an average tree girth of 0.5 m the calculated basal area was 11.7m^2 ha^{-2}. Therefore, pre-settlement Magoye West had a standing wood block of about 4541 m^2. Of this basal area, about 291 m^2, or 83% had been cleared by 530 small scale farmers. Indeed, the lost biomass would represent a substantial opportunity cost if it were to be translated into timber or fuel wood terms. For instance, in undisturbed *miombo*, of the above wood biomass, it is estimated that at 180 cubic m ha^{-1}, or 99 metric tones bone-dry weight. It is further estimated that a tone of bone-dry wood could produce about 6.2 standard bags of charcoal weighing 40 kg. At the current price of a bag of charcoal of ZK 40, 000 and a market exchange rate of about ZK 3800 to US$1, the cleared woody vegetation would be worth ZK44,861,580,000 or US$11,805,568 0n the open market.

Statistical analysis to explain variation in the rate of deforestation: A statistical relationship was carried out with the rate of deforestation (1980-2000) the dependent

Table 1. Coefficients of the Determinants of the rate of deforestation

Dependant variable	Independent variables				
Rate of deforestation	Agricultural policy POL	Cultivated area LAC	Population growth rate POP	Fertilizer use intensity FERT	Adjusted r^2
Coefficients T-Static	-0.195	- 1.439	0.756	- 0.003	
	-0.970	0.310	2.430	3.500	0.86

variable and cultivated area (ha) per person, fertilizer use per hectare, population growth rate and agricultural policy dummy as independent variables. The values for each variable were converted to their natural logarithm and a regression equation was applied to these data. The coefficients reported below, therefore, represent elasticities. Policy appropriateness is represented by a dummy variable having the value '1' for farmers where policies were judged to have been conducive to profitable agriculture and '0' where it is judged to have been inappropriate. The following model was used:

Model

$$DEF\ AREA = \beta_1 + \beta_2 * LAC + \beta_3 * FERT + \beta_4 * POP + \beta_5 * POL + Error\ Term \quad (1.2)$$

Dependent variable: Rate of deforestation
Independent variables: Cultivated Area (LAC), Fertilizer use (FERT), Population growth rate (POP) and Agricultural policy (POL).

Displayed in Table 1 are the values of the coefficients, which represent elasticity. Only the coefficients of the relationship between rate of deforestation and population growth rate as well as agricultural policy were significant at 0.05 level of significance. The per capita change in population growth rate was tested for its impact on the vegetation cleared and was found to be significant at 0.05 level of significance. As shown in Table 1, a unit increase in the number of people per household leads to 0.756 km^2 increase in the land cleared per capita.

Cultivated area: The hypothesis that population pressure on cultivated area increases the rate of deforestation was confirmed. The variable in Table 1 had the expected negative coefficient (-1.439) which means that the smaller the cultivated area per person, the higher the rate of deforestation. For every unit decrease in cultivated area, there is an increase of 1.439 km^2 in the rate of deforestation. In Magoye area, usufruct rights are acquired simply by clearing land without necessarily planting anything. The motivation has been strong for settlers to move into previously uncultivated forest areas and clear the land quickly in order to strengthen their claim and weaken those of others.

Fertilizer use: The use of modern farm inputs such as fertilizer as shown in Table 1 is negatively related to the rate of deforestation thereby suggesting that intensifying agriculture by applying more fertilizer would slow down the rate of deforestation. A unit increase in the amount of fertilizer used per hectare leads to a 0.003 km^2 decrease in the rate of deforestation. From this coefficient, it can be deduced that the application of more fertilizer per hectare through agricultural intensification is likely to be the most important policy available to deal with the problem of deforestation.

Agricultural policy: A favorable agricultural policy was tested for their impact on vegetation cleared and was found to be significant at 0.05 level of significant. A unit increase in agricultural policy application is associated with a decrease of 0.195 km^2 in the rate of deforestation as shown in Table 1. This suggests that pursuing good agricultural policy can reduce the rate of deforestation.

Impact of population growth on vegetation: The per capita change in population growth rate was tested for its impact on the vegetation cleared (deforestation) and was found to be significant at 0.05 level of significant. As shown in Table 1, a unit increase in the number of people per household leads to a 0.756 km^2 increase in the land cleared per capita.

The coefficient of determination of r^2 (0.86) found in Table 1 indicates that deforestation is not influenced only by four factors advanced in this study, namely; cultivated area, fertilizer use per hectare, population growth and agriculture policy. Other factors such as poverty, open-access land tenure, cutting down trees for charcoal, firewood and timber, to mention but a few; account for 14% of the rate of deforestation.

Distance to sources of fuel wood and deforestation: Wood fuels are the staple sources of household energy in rural Zambia where most of the poor are found. The need for wood fuel is one of the major causes of the reduced tree cover. Excessive lopping and felling, combined with poor regeneration capability of trees, have set in motion a down ward trend that has been sharply accelerated by prolonged periods of drought and by increasing livestock pressure on young re-growth. Since,

Table 2: Distance covered to sources of firewood

Distance covered (km)	Number of Respondents	(%)
Less than 1	8	16
1-2	12	24
3-4	21	42
More than 4	9	18
Total	50	100

a significant switch to other fuels is not likely or possible in the short or medium terms in Magoye West, population growth translates almost directly into a growth in demand for wood fuel, yet continued reliance on wood fuels is clearly threatened by unsustainable exploitation.

From Table 2 it can be deduced that 8 (16%) of the poor farmer in the study area cover less than one kilometer from their homes to sources of fire wood while 42% covered between 3-4 km. When fuel wood sources were more abundant, fuel gathering could often be combined with other activities, such as walking from the field. With increasing scarcity, fewer sources and longer distances, the loads carried by poor women become larger and heavier and the opportunity to combine wood fetching with other tasks is reduced.

DISCUSSION

Deforestation and cultivated area: For every unit decrease in cultivated area, there is an increase of 1.439 km^2 in the rate of deforestation. In the area under study, usufruct rights are acquired simply by clearing land without necessarily planting anything. The motivation has been strong for settlers to move into previously uncultivated forest areas and clear the land quickly in order to strengthen their claims and weaken those of other users. It was found that many small-scale farmers in this area clear and plough far more land than they actually intend to crop in order to establish and protect their land use right for the future. Clearing and ploughing without establishing crops may render the land ever more vulnerable to erosion.

Deforestation and fertilizer use: The use of modern farm inputs such as fertilizer as shown in Table 1 is negatively related to the rate of deforestation thereby suggesting that intensifying agriculture by applying more fertilizer would slow down the rate of deforestation. A unit increase in the amount of fertilizer used per hectare leads to a 0.003 km^2 decrease in the rate of deforestation. From this equation, it can be deduced that the application of more fertilizer per hectare through agricultural intensification is likely to be the most important policy available to deal with the problem of deforestation. It was well established that fertilizer use in this area was very low, averaging 83 g ha^{-1} compared to China, for example, where it is 2860 g ha^{-1} and there is vast scope for increasing its use Yongyuth. Poor households are most likely to increase the rate of deforestation because fertilizer is available only at high prices making it impossible for them to apply large quantities.

Deforestation and agricultural policy: A unit increase in agricultural policy application is associated with a decrease of 0.952 km^2 in the rate of deforestation as shown in Table 1. The rate of deforestation can be reduced by determined pursuit of good agricultural policies. This needs to be promoted through the use of large quantities of fertilizer, more regulation and taxation of logging as well as elimination of open-access land tenure. This finding calls for mitigating actions to retard deforestation when agricultural policies are good.

Deforestation and population growth: The per capita change in population growth rate was tested for its impact on the vegetation cleared (deforestation) and was found to be significant at 0.05 level of significant. As shown in Table 1, a unit increase in the number of people per household leads to a 0.756 km^2 increase in the land cleared per capita. The poor farmers in the study area are characterized by their vulnerability to environmental degradation and deterioration of the natural resource base that has a devastating impact on them, given that they tend to be strongly dependent on the exploitation of such resources. As population grows, the quality and quantity of renewable forest resources decline.

Fuel wood and deforestation: The need for wood fuel is one of the major causes of the reduced tree cover in Magoye West. Excessive lopping and felling, combined with poor regeneration capability of trees, have set in motion a down ward trend that has been sharply accelerated by prolonged periods of drought and by increasing livestock pressure on young re-growth. The commercialization of the fuel wood and the charcoal economy has increased the utility of rural fuel wood sources. Under subsistence conditions, local fuel wood resources were only to meet local demand, but these resources can now also be exploited for sale outside. Limited and inelastic subsistence demand is replaced by limitless and 'elastic export' demand (from the standpoint of the local economy), leading to much more rapid rates of exploitation than would be implied by local population growth alone.

Environmental degradation lowers the labor productivity of the poor farmers. For example, as fuel wood becomes scarce, due to over exploitation, poor

house holds must spend an increasing amount of time collecting it. Where family is not abundant, greater time spent on fuel wood collection takes away from other productive activities and can result in lower productivity. Women and children have to walk increasingly longer distances than would be normal and take more time to collect wood. The brunt of fuel wood crisis falls on women: they must manage household energy needs through fuel collection, preparation and use. Men on the other hand in Magoye West, do not usually involve themselves in fuel provision for the household under subsistence conditions, but there are exceptions; they usually take over only when the fuel economy becomes commercialized. Successful introduction of agro-forestation and fuel wood production on farms would significantly reduce women's work burden in fuel wood gathering.

Deforestation and land and tree tenure system: Open access land tenure situations in Magoye West can stimulate deforestation but this could not be assessed in a rigorous quantitative sense because farmers interviewed could not give measurable information. The traditional land tenure system constrains agriculture productivity and cause environmental degradation because land resources are not privately owned, but are either common property of a community, clan or ethnic group or are open access resources owned by no one. The users of such resources have no motivation to limit their consumption thereof because they cannot be certain that other users will similarly limit theirs. Households will treat available resources as an asset to be drawn in times of emergency. Lacking secure property rights, individuals are dissuaded from adopting long-term conservation, investment production strategies.

Further, customary tenure in the study area involves important intricacies; ownership, management responsibility and use rights are often not identical. Use rights to different products from the same piece of land may be vested with different individuals or groups. Pastoralists and sedentary farmers may co-exist on the same land, with farmers having cultivation rights and pastoralists grazing rights after crops are harvested. On the same plot of land, the right to the products (e.g. logs) of trees and the right to plant annual crops may be quite distinct and vested in different individuals or groups. Understanding the complexities of local tenure system is especially important for comprehending the incentive system that applies to agro forestry activities. It also often helps explain deforestation. In Magoye West, tree tenure is distinctly different from land tenure. One person or groups of persons may have rights to the land, while others have rights to the trees on it, or certain products from certain trees at certain times and this results in deforestation. In addition, tree clearing in this area has been the only way to establish uncontested usufruct rights for cultivation and this has led to massive deforestation. This deforestation affects the poor who depend on forest products for their daily living. Deforestation of open access resources is an increasing burden on the poor-a trend that leads them away from wealth.

Poverty imposes short-time horizon for the poor farmers: The very poor small-scale farmers in Magoye who are struggling at the edge of subsistence levels of consumption are preoccupied with survival on a day-to-day basis. The ability to plane ahead is often restricted to a critically short-time horizon, measured in days or weeks. Poor farmers' horizons are short partly as a result of their having, in economic terms, a high rate of pure time preference (Williamson, 1991). This lowers the ability to forego consumption today by using savings previously put aside for later consumption purposes. In terms of natural resources, the implication of a high subjective discount rate are rapid resource extractions to met present income or consumption needs and low investment in natural resources to improve future returns. Given the greater value placed on the present consumption, resources are mined at a more rapid rate. For example, with high discount rates, rural inhabitants with rights to tree resources in this area harvest them at a faster rate.

Policies to reduce rural poverty and to minimize environmental degradation: A better grasp of the relevant relationship in a complex system allows the identification of policies that will lead to the desired improved performance of a real system under study. That is, the proposed policy package is expected to improve the economic conditions of the rural poor while sustaining the agricultural land resource base for adequate food production in the long run.

- Local communities need to be empowered to participate in issues concerning agricultural and demographic causes of environmental degradation in rural areas. Without participation, people will not demand smaller families, sustainable agricultural technologies and forest conservation. Participation is more likely to result in development initiatives that respond to felt needs rather than to short-term political imperatives and expediencies. Multi-sectoral and cross-sectoral analysis is needed to solve the agricultural, population and environmental problems because of the important linkages and synergies

among them. Environmental protection will be very difficult to achieve if present rates of population growth continue.

- Land management policies should include the adoption of alternative cropping and tillage practices and the substitution of organic fertilizers, which can reduce on-and off-farm environmental damage caused by conventional practices.
- There is need to provide property rights for cleared forest land. Cultivators will not make the necessary investment to increase productivity and conserve resources unless there is some appropriate legal guarantee that they will benefit from these investment. Also, the possession of secure title to the land allows the cultivators to easier access to institutional credit needed for making such investment
- Credit and cooperative programs seek to eliminate financial and technological problems. Such programs can improve the earnings of the peasant cultivators and therefore help to reduce pressure for converting forest areas for agricultural cultivation.

CONCLUSION

The link between environment and poverty reduction is strong. Since, the Rio Earth Summit in 1992, the importance of a sound environment to sustainable livelihoods has been widely acknowledged, particularly for the rural poor in Africa, Asia and Latin America (UN, 1992, 2002). The income derived from the environment in Magoye West is a major constituent of the livelihoods of the rural poor and this direct dependence on nature does not appear to be decreasing. The environment is also a source of vulnerability. Environmental factors contribute to the burden of ill-health the poor suffer. Natural resources play an important role in the livelihood of the poor. Poor rural families make use of a variety of sources of income and subsistence activities to make their livings. Many of these are directly based on nature, like small-scale farming and livestock rearing, fishing, hunting and collecting of firewood, herbs, or other products. These may be sold for cash or used directly for food, heat, building materials, or innumerable other household needs. This "environmental income" is added to other income sources such as wage labor and remittances sent from family members who have emigrated. The decline of natural systems through soil depletion, deforestation, over exploitation and pollution represents a direct threat to nature-based income and is a contributor to increasing poverty.

Open access land tenure situations in the study area can stimulate deforestation. The traditional land tenure system constrains agriculture productivity and cause environmental degradation because land resources are not privately owned, but are either common property of a community, clan or ethnic group or are open access resources owned by no one. The users of such resources have no motivation to limit their consumption thereof because they cannot be certain that other users will similarly limit theirs. Households will treat available resources as an asset to be drawn in times of emergency. Lacking secure property rights, individuals are dissuaded from adopting long-term conservation, investment production strategies.

ACKNOWLEDGMENT

I would like to acknowledge the contribution of Professor Wu Hongjuan for her guidance and advice.

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