Agricultural and Forest Landuse Changes, and the Environmental Kuznets Curve for Deforestation: An Intertemporal Dynamic Equilibrium.

Dr. Madhu S. Bhattarai, Kathmandu, Nepal
Phone: 977-1-4770181
Email: m.bhattarai@cgiar.org

Michael D. Hammig
Professor and Chair
Department of Applied Economics and Statistics
220 Barre Hall
Clemson University
Clemson, SC 29634
Phone: (864) 656 3225
Fax: (864) 656 5776
mhammig@clemson.edu

Krishna P. Paudel[2], Assistant Professor
Department of Agricultural Economics and Agribusiness
225 Agricultural Administration Building
Louisiana State University Agricultural Center
Baton Rouge, LA 70803
Phone: (225) 578-7363
Fax: (225) 578-2716
Email: kpaudel@agcenter.lsu.edu

Selected paper prepared for presentation at the American Agricultural Economics Association annual meeting, Denver, Colorado, August 1-4, 2004

[2] Corresponding Author

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Abstract:

This study is an investigation of the process of land conversion from forest to agricultural production, and assessing the factors affecting the process. We also analyze the conditions that would ultimately lead to the EKC type of relationship between deforestation and societal income in an economy.

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This study examines relationship between agricultural productivity growth and forest land cover change in an isolated economy, and then it evaluates factors affecting the emergence of Environmental Kuznets Curve (EKC) relationship for tropical deforestation in the economy. The EKC framework of analysis is a recent development in the literature of environmental economics, which hypothesizes existence of an inverse U-shaped relationship between indicators of environmental deterioration and societal income level, or economic development level. Unlike EKC analyses for air and water pollution, where income and environmental pollutant levels are related, the case of deforestation is different because deforestation is often the result of a specific investment decision and demand for land for the agricultural production and to meet the other basic needs of the society; thereby a normal path of deforestation is also considered as a precursor of development and a natural growth path for society.

The EKC hypothesis posits a relationship that environmental quality will deteriorate during the early stages of economic development, but when societal income reaches a certain level the rate of environmental quality decline will slow. This phenomenon has been empirically verified for several environmental quality indicators including deforestation; but mostly using statistical analysis across countries. The theoretical foundation of the EKC in general, and for EKC for deforestation in particular, is still very weak. In fact, theoretical underpinnings of an EKC relationship for deforestation are not fully explored in the past studies. Recognizing this limitation in the literature, by using a dynamic optimization framework, this paper derives conditions for

optimum land use decisions and an understanding of deforestation EKC, with a focus on the linkage between changes on agricultural and forest uses of land.

For a long time, the relationship between economic growth and its impacts on environmental quality is a controversial public policy issue (see Bhattarai, 2000). In addition, the tropical deforestation process as such is a complex topic influenced by dynamic forces of institutional, structural and policy factors, so the relationship between agricultural development (productivity and/or farm income growth) and tropical development. In an economy, the relationship between agricultural productivity and forestland use change is shaped by long-run development process. Therefore, a dynamic intertemporal equilibrium framework of analysis is adopted in this study to quantify the impacts of policy variables and structural factors on the tropical deforestation and/or tropical forest land use changes.

Whether the process of tropical deforestation can be considered as an economic problem at all is a debatable issue. Likewise, is there an optimal level of deforestation in any economy at any time? The past studies on these issues provide mixed results. Not only forestry contributes on national income, the present forest protection (destruction) is in fact an end result of an overall economic development process in a nation. In other words, the current pace of loss of tropical forest is closely linked to the past development process and the institutional and structural factors in the tropics (Walker, 1993). Therefore, the forest conversion process is an outcome of economic decision making of a rational agent (the frontier small holder farmer, the logging industry, or the state agency as such). Economic incentives (full opportunity costs) faced by farmers (or the state) to a large extent can be explained by simple economic analysis. This paper is an attempt to

explore the economic behavior of society for land use decision for forest protection versus agricultural production.

Most of the available literature on the topic of economics of deforestation, or EKC for deforestation, are empirical analysis using cross-country (or country specific) case study. But, the theoretical process of deforestation and generic factors affecting and process of tropical deforestation applicable to a wider regions are still very limited. Recently, several cross-country scale of studies have reported an evidence of EKC relationship for tropical deforestation process (see, Bhattarai and Hammig, 2001, 2004). Unlike those empirical studies, we explore here the underlying theoretical relationship for emergence of an EKC relationship for deforestation. This is done using the dynamic intertemporal equilibrium model, and extending the model we also evaluate the impact of change on productivity of labor, capital and land on level of deforestation.

More specifically, this paper examines factors affecting land use decisions and derives conditions for optimum allocation of agricultural and forestland in an economy. Then, we evaluate the relationship between agricultural development and forest area changes, and the conditions that would lead to emergence of an Environmental Kuznets Curve (EKC) for deforestation. This is done using a dynamic intertemporal equilibrium framework and an aggregate social welfare maximization approach of analysis.

Hypothesis

We test the following two hypotheses in this study using the concept of intertemporal equilibrium.

Hypothesis 1: The tropical deforestation will be higher during the initial phase of development, but ultimately it starts to decrease over time and when societal income, and in turn, the preference change at a certain level of threshold development level leading to EKC for deforestation in the economy.

Hypothesis 2: Agricultural technology advance will reduce pressure on the forest sector thereby reducing the deforestation level.

Objectives and scope of the study

The major objective of the study is to examine the relationship between agricultural productivity growth and forest land use change in an economy and the factors affecting the process. The specific objectives of this study are:

1) To develop a theoretical framework to analyze deforestation decisions in an economy depicting the intertemporal behavior of the society;
2) To evaluate the impact of key economic and policy factors affecting the optimum forestland use decision;
3) To assess and evaluate the conditions under which an environmental Kuznets curve for deforestation will emerge in an economy;
4) To derive the steady state equilibrium of land conversion from forest to agriculture as agriculture intensification increases over time; and
5) To identify the levels of income and agricultural productivity associated with the turning point of the deforestation EKC and to suggest policy implications.

Significance

By exploring the relationship between tropical deforestation and agricultural development using a consistent framework of economic analysis, this study attempts to fill a gap in the literature of economics of deforestation, specifically related to the EKC for deforestation. The results from this exercise will provide better understanding on the process of tropical deforestation and factors affecting it, in turn improved policy inputs and policy recommendations on tropical deforestation like major controversial global environmental public policy issue. The results also provide answers to questions like: can we halt the deforestation process worldwide by focusing on agricultural development and income growth from farming? If so, what are the required levels of income and agricultural growth, and other policy instruments?

The major implications from EKC studies for environmental policy are restructuring of growth and development policy programs, and to move the economy to a sustainable development path by tunneling it through the potential EKC (see, Panayotou, 1997; and Yandle, et al., 2004). By moving the economy under the ecological threshold limits, by induced policy tunneling effects, or flattening the EKC path in the economic development process, we can avoid any of such potential ecological catastrophic circumstances, but allowing to have sustainable growth and development in the society. Thus, the improved understanding on the reasoning for emergences of EKC, including the theoretical reasoning and factors affecting the process, has huge implications in the development economics, and policy prescriptions forwarded for the global environmental programs.

Literature

The topic of economic growth and environmental quality, or pollution, was much-discussed public policy issues during the early 1970s. However, the issue of the EKC relationship appeared in the literature mostly in the early 1990s during the policy debates on the environmental impacts of the North American Free Trade Agreement (NAFTA). Grossman and Kruger's (1991) study was one of the first empirical studies on the topic, followed by over 100 other published studies on the topic (for a recent review on the past EKC studies, see Yandle, et al. 2004). No doubt, because of the huge public policy implication of the findings, the issue of economic growth and environmental quality is controversial. The issue is further complicated due to huge variation of the type and definition of indicators of environmental quality and variation of measurement criteria adopted across countries.

Considering a vast and growing literature on the topic of EKC, and the limited scope of this study, we only summarize the past studies having theoretical distinctive concept developed, or a unique significance to the EKC for deforestation topic relation to the topic of the paper. For other numerical studies on EKC for deforestation see; Pinayotou, 2000; Bhattarai and Hammig, 2001; and Yanlde, et al., 2004. And for discussions and review on past theoretical EKC studies, see Bhattarai, 2000.

One of the explanations given for the emergence of an EKC is that environmental quality is a luxury good, and therefore, demand for environmental quality increases as societal income rises, or its demand is felt only when societal income reaches a certain critical level (Antle and Heidebrink, 1995; Rutan, 1971). In fact, Lopez (1994) concept of "non-homothetic preferences" at high income levels is also consistent with the

assumption of environmental goods as luxury goods discussed earlier. When the income elasticity of demand for environmental quality is higher than one then preferences are no longer homogenous in the society, which means also that societal preferences would change when income increases to a certain level. In fact, the assumption of homothetic preference is consistent only with unitary income elasticity of demand.

Likewise, Munasinghe (1999) explored the theoretical basis for the EKC relationship based upon simple economic intuition of an agent's profit maximization behavior, i.e., the agent (or firm) maximizes the net benefits from investment. The basic intuition of Munasinghe's (1999) paper is that the slope of curve representing an agent's willingness to pay for environment quality (MB_E), and marginal cost of environmental protection (MC_E) will change when income rises to a certain level. Unlike the other studies, Munasinghe derived the EKC condition from a more commonly adopted methodology of net benefits (after deduction of costs) maximization and budget constraint set up in economics.

Using dynamic optimization techniques, Vogel (1999) explored the conditions for emergence of EKC relationship in an economy and factors affecting it and theoretical implications under alternative scenarios. Like Antle and Heidebrink (1995) and Martinez (1995), he also came to the conclusion that because of hierarchical demand systems society during the early stage of development would give higher priority to more immediate needs such as food, clothing, shelter, and general material well-being. But, as the economy grows, environmental quality becomes scarce due to increased consumption, and therefore relatively more valuable than other material goods. That is, MB_E increasingly becomes greater than MC_E as income rises to a certain level, which leads to

the emergence of an EKC relationship between environmental degradation and income. In summing up, in the past studies on EKC, there is no unique theoretical explanation for that is plausible for explaining the EKC for environmental quality.

EKC for Deforestation and forest land use change

Using the large set of cross-country level data set, Shafik and Bandhopadhyay (1992) first reported that there is a bell shaped relationship between income and annual percentage change in forest and the total deforestation level (changes in forest area between 1961 to 1986). In fact, long before the Shafik and Bandhyopadhya (1992) and Grossman and Kruger (1991) empirical studies on the EKC, Samuelson had asserted the notion of the EKC relationship in forestry in 1976, but in different tone. He stated,

> Once a society achieves certain average levels of well-being and affluence, it is reasonable to suppose that citizens will democratically decide to forgo some calories and marginal private consumption enjoyments in favor of helping to preserve certain forms of life threatened by extinction. It is well known that clear cutting forests is one way of altering the Darwinian environment. … It is part of the political decision-making process to decide at which sustained level … to be permitted to flourish. (Samuelson, 1976, p. 486).

In fact, the conceptual reasoning on presence or absence of a Kuznetian functional relationship between income and forest cover or deforestation trend over time is not clear-cut in the literature. The present empirical evidence is mixed, and it varies depending upon the sets of countries and time period selected for the study. In summing up, in terms of theoretical reasoning, not all contemporary economists have unanimous

viewpoints for the possibility of an EKC relationship for forest cover (see discussions in, Arrow et al., 1995; Stern et al, 1996; Ekins, 1997).

Conclusion

This study hypothesizes that deforestation behaves as a normal good in the lower stages of development. Initially agricultural extensification happens at the cost of deforestation. However, as the economy develops the pressure for deforestation decreases because of the contribution of agricultural intenstification on agricultural productivity. Further, people start realizing the environmental services provided by the forestland thereby stopping the deforestation and instead producing intensively in the already cultivated land. We assume that this societal transformation process is influenced by improvement in the agricultural technology and economic development; and thereby, the deforestation process is endogenously determined in the economy.

The steady state results of this study suggest that the optimum land use decision is affected by the discount rate, land productivity, rate of return on capital, society's preferences over consumption of outputs from farming versus outputs produced from forest land. The results from the comparative statistics analysis reveal that there would be an EKC for deforestation in an economy, as illustrated by past studies of cross-country empirical analyses, when the land productivity and the prefe rence (i.e., income elasticity) of the environmental services from forest land reach a critical level. Our numerical simulation exercises also empirically validate the steady state conditions derived from the intertemporal model. From the simulation exercise, we provide the insight on the conditions under which the EKC for deforestation will emerge in the economy.

Unlike past studies on the EKC for deforestation, this study attempts to test for a Kuznetian type of relationship for deforestation using the basic structures of the economy and adopting the intertemporal dynamic equilibrium framework of analysis. The results from this study suggest that the process of agricultural development and the rate of change in agricultural productivity (and rate of return on capital) are the key factors leading to the deforestation EKC in an economy, and not population pressure and other structural factors as noted in past studies.