

Growth in national income and forest transition in Bangladesh

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ABSTRACT

Growth in national income is seemed to be interlinked with environmental ups and down. Where economy develops by taking resources from environment, after a level an economy must have to help the environment to keep up both of their sustainability. Environmental Kuznets Curve (EKC) hypothesis explains the interrelationships between the development paths of a nation with its total environmental quality. Deforestation in Bangladesh is the critical environmental concern to the ecologists and environmentalists. The dictation of the national economic growth to the deforestation can be found through the study of EKC. To understand the EKC phenomena for deforestation, the study was undertaken through reviewing the literatures. With the understanding of the different EKC trajectories for deforestation in the different developing countries, the economic development of Bangladesh was attempted to implicate with the EKC. The proven EKC trajectories for deforestation in some regions/countries show a higher income per capita requirement for the turning point. The study suggests to tunneling in the EKC trajectories for Bangladesh. The type of economic and forest policy that Bangladesh should follow to retard the deforestation is also revealed. Clean Development Mechanism (CDM) and Reduced Emissions from Deforestation and Degradation (REDD) have been suggested for tunneling the EKC in Bangladesh. The study is expected to be useful in forestry development in Bangladesh.

Keywords: Climate change, Deforestation, Economic growth

1. Introduction

Tropical deforestation is one of the serious environmental concerns because of its increasing biodiversity loss, soil degradation and significant contribution to the global climate change, etc. (Ehrhardt-Martinez et al. 2002). The economic activities of a nation including the livelihood and cultural integrity are also affected by the degradation (Culas 2007). The quick deforestation in the tropical zone has been come out a limelight as a major source of global greenhouse gases (GHG). Fearnside and Laurance (2004) reports that the tropical deforestation contributes from 0.8 Gt¹ to 2.4 Gt to the total annual GHG emissions in the globe². Forests in the tropical zone, especially Asia including Bangladesh, has reached at the most threatened line on the earth and also have been a significant source of GHGs (Laurance 2007). Increased amount of GHG is considered as the main cause for global warming, causing climate change. The most important GHGs are CO₂, SO_x, NO_x, CH₄ and F-gases (gases that contain Fluorine).

Growth in Gross Domestic Product (GDP) or income per capita in a nation is seemed to be interlinked with environmental ups and downs. Where economy develops by taking resources from environment, after a level an economy must have to help the environment to keep up both of their sustainability. The abatement activity starts after a substantial amount of capital stock is achieved (Selden and Song 1995). An Environmental Kuznets Curve (EKC) is a hypothesized relationship between economic growth (income per capita) and environmental quality. This curve indicates that, economic growth initially takes part to degrade the environmental quality, but with further growth it implies to reverse the relationship and environmental degradation starts to reduce. This relationship provides an inverted U-shape curve, where environmental degradation first rises and then falls with increasing income per

¹ Stands for Gigatons; 1 Gt = 1 X 10⁹ metric tons = 10¹⁵ grams

² Due to the uncertainty of the estimates and debates by different studies, the GHG emissions from the tropical deforestation varies

capita. The idea of EKC came under limelight in 1991 with the study of NAFTA³ (Grossman and Krueger 1991), though the idea of Kuznets curve (relationship of economic growth and income inequality) exists from 1955 (Kuznets 1955). However, the Environmental Kuznets curve (EKC) hypothesis became very important after 1991 for its potentiality and promise of finding a final solution of environmental degradation. As forest ecosystem is an integral part of the total environment of a geographic zone, there should have some impacts of economic growth on the forests. Koop and Tole (2001) analyzed the economic distributional profile of a developing country on the forest loss. They found that the economy with more inequality had more effects on deforestation than that of the egalitarian economy. Rather, the egalitarian economy could ameliorate the negative impact of the economic growth on the forest. Mather (2007) also studied on the forest transition in some Asian countries, which proved the effect of economic growth on the forests.

Bangladesh, a South Asian least developed country, has been experiencing severe deforestation since the last 3 to 4 decades. Still, Bangladesh has not found any effective way to halt the deforestation. It is hypothesized that Bangladesh is following a full inverted U-shape curve for deforestation. Like other developing countries of the world, Bangladesh is hypothesized to be at the initial up facing stage of EKC at this moment. Many studies were found to judge the EKC for deforestation in different developing countries (for example, Koop and Tole 1999 for 76 developing countries; Bhattarai and Hammig 2001 for Latin America, Africa and Asia). While studying the economic impacts on the deforestation at a global level, Scriciu (2007) concluded that case-specific factors might influence the deforestation in different countries and socio-geographic zone. So, he emphasized the research on this, on more disaggregate, local level. But, there is no validly published study of EKC on deforestation in Bangladesh. How EKC behaves for developing economy, is still a

³ North American Free Trade Agreement

matter of argument too. The study aimed at relating the results of EKC for other developing countries with Bangladesh. What will be the fate of the deforestation of Bangladesh with ongoing economic development? Will Bangladesh follow the inverted U-shape EKC curve in that? If yes, what should be the economic and environmental policy? To answer these research questions, this paper is expected to contribute significantly in this environmental issue. The findings of the study would be of immense importance for the forestry development in Bangladesh.

2. Methods

2.1. The background of the EKC hypothesis

In 1955, Simon Smith Kuznets, a Russian American economist proposed a hypothesis relating economic growth and income inequality or Gini Coefficient (Stern 2004; Torras and Boyce 1998). He states that, income inequality may rise at first with increasing economic growth, but in long run, it will tend to diminish after a point in economic growth. This relation can be shown in an inverted U-shaped Kuznets curve, which is named after Simon Kuznets.

But the idea of making a relationship of environment and Kuznets curve emerged in 1991, with Grossman and Krueger's study of NAFTA (Grossman and Krueger 1991; Stern 2004; Bhattarai and Hammig 2001). Then, for the first time Kuznets curve was aggregated with environment. A curve is produced with an inverted U-shape relationship between income per capita and environmental degradation. It was named as Environmental Kuznets Curve (EKC) in 1994 (Selden and Song 1994).

This curve implies that, environmental degradation first increases with increasing income per capita. But after a certain point in increasing income per capita, environmental

degradation tends to diminish (Figure 1). Though environmental degradation rises quickly with a steep slope in the curve, its reduction gives a moderate slope. But yet it gives a hill shaped curve by taking income per capita in X-axis and environmental degradation in Y-axis. But when there is no turning point in income per capita for any pollutant, a straight line is also found (Figure 1).

<< Figure 1. General environmental Kuznets Curve, (a) A full trajectory of inverted U-shape EKC; (b) Straight line of EKC, where no turning point is found>>

In some cases, an N-shaped EKC has been found too, i.e. Bhattarai and Hammig (2001) for Deforestation, Torras and Boyce (1998) for SO_x, etc. It happens when environmental degradation shows positive, negative and positive relationship, respectively with income per capita. It means environmental degradation first increases with income per capita, but decreases after a certain level. That's how, we get a peak. But along with further increase in income per capita, degradation tends to rise again which provides a trough in EKC (Figure 2).

<< Figure 2. Peaks and troughs of EKC>>

Gangadharan and Valenzuela (2001) described that, in EKC relationship, environment is like a luxury good. At the early stage of development, environment is not really taken care of. But when income reaches a certain level, people want to act smart for environment. But this relationship is not as automated as it seems. Grossman and Krueger (1995) said that it is 'an induced policy response' and it has some variables working on it.

The EKC is generally measured with two models, i.e. Fixed Effect (FE) and Random Effect (RE) model. The first model is deployed where all other variables remain constant and only the changes in emission are measured with the changing income per capita. And the second model is deployed where other additional variables are calculated as a changing factor. It is sure that different will be the result, if different is the model. For example, RE model has given higher value for turning point than FE model in NO_x study (Selden and Song 1994). Again, Grossman and Krueger (1991) have found that FE model has shown higher value for turning point. Not only has the turning point differed with model, but also the presence of hill shaped EKC depends on them too. Just like, Koop and Tole (1999) has found a turning point for deforestation using FE model, but no statistically significant turning point is found using RE model.

2.2.Data sources and reviewing methods

To explore the EKC trajectories for deforestation in relevance to Bangladesh, the study was conducted from August 2008 to August 2009. The data on global warming, causes, consequences; EKC, behavior of deforestation in the EKC trajectory; the socio-economic status of Bangladesh, were collected mostly from the authoritative sources available in the internet. Some facts were cross-checked directly in the offices of Bangladesh, mostly located at Dhaka and Chittagong. For searching the most recent facts, Scirus⁴, Scopus⁵ and ISI web of knowledge⁶ were used for reviewing the most relevant scientific articles. For that, some common keywords like economic growth, environmental degradation, deforestation, EKC, Kuznets curve were used to search out the specific articles. After selecting all the required articles, those were downloaded from the online sources. Then all the downloaded articles

⁴ <http://www.scirus.com/>

⁵ <http://www.scopus.com/>

⁶ <http://apps.isiknowledge.com>

were printed out for the study. To make a concrete understanding on the EKC regarding deforestation, many cross-references were also used.

As deforestation is the important factor for global warming and causes for the major biodiversity loss in Bangladesh; it had been considered for understanding on the EKC behavior. Most important findings on those parameters were synthesized, their specific research paradigms were compared and deviations among the results were discussed. The calculation GDP and/or income per capita were considered for US\$ at the specific period. The synthesis of the original scientific articles on EKC and different environmental degradations was used to implicate those for Bangladesh considering the national income and other drivers of EKC in Bangladesh.

3. Bangladesh Forestry sector: General overview

Bangladesh is a South Asian least developed country located between 20°34' to 26°38' N latitude and 88°01' to 92°42' E longitude with a geographical coverage of 14.76 m ha with three broad categories of land-hills, uplifted land blocks and alluvial plains. The country is characterized by low per capita gross national product; low natural resource base; high population density, and high incidence of natural disasters. The climate is subtropical, characterized by high temperature, heavy rainfall, often excessive humidity, and fairly marked seasonal variations. Though more than half of the area is located in the north of the tropics, the effect of the Himalayan mountain chain makes the climate more or less tropical throughout the year (MoEF 2005). The country has an almost uniformly humid, warm, tropical climate. There are three main seasons: (1) a hot summer season, with high temperatures (5–10 days of more than 40°C maximum in the west), highest rate of evaporation, and erratic but heavy rainfall from March to June; (2) a hot and humid monsoon

season (temperatures ranging from 20 to 36°C), with heavy rainfall from June to October (about two-thirds of the mean annual rainfall); and (3) a relatively cooler and drier winter from November to March (temperatures ranging from 8 to 15°C), when minimum temperature can fall below 5 °C in the north, though frost is extremely rare (MoEF 2005). The mean annual rainfall varies widely within the country, according to geographical location, ranging from 1200 mm in the extreme west to 5800 mm in the east and northeast (MoEF 2005).

Forestry is an important sector in Bangladesh's economy. It contributed about 1.84% of the country's GDP and 10.2% of the agriculture income in 2003/2004. The annual GDP of this sector in 2003/2004 was 4.48% (GOB 2004). Iftekhar (2006) reports that 'if environmental services and contribution in people's livelihood could have been properly accounted for, then the share of the forestry sector would have been much more'. Forestlands make up almost 18%, agricultural lands 64% and urban areas 8% of the total lands in Bangladesh (FAO 1998). Other land uses account for the remainder. Total forestland area is 2.56 m ha, including officially classified and unclassified state lands, village forests and tea/rubber gardens. Most of the state forestland is degraded. Classified and unclassified forestland signifies an administrative or legal category, not necessarily areas with forest cover. The natural forest accounts for about 31% and forest plantations 13% of total forest areas. Shifting cultivation, illegal occupation and unproductive areas account for the remaining forestland (FAO 1998). Presently, protected areas represent just over 5% of forestland. Bangladesh Forest Department is responsible for administering 65% of state forestland. The other government forestlands are administered by local District Commissioners (DC). The better quality natural forests and plantations in the government forestlands, excluding parks and sanctuaries (medium to good density), makes up around 0.8

m ha, which is 5.8% of Bangladesh's total area. The area included in the present protected area network is 0.12 m ha, equal to 5.2% of state forestland or less than 1% of Bangladesh's total area (FAO 1998). The hilly areas of Chittagong, the Chittagong Hill Tracts, Cox's Bazar and the Sylhet Forest divisions consist of hill forests, which are subject to severe degradation due to overpopulation, shifting cultivation and extension of agriculture (Salam et al. 1999). In the hilly areas, two main types of forests are found, i.e. evergreen and deciduous. These forests may be subdivided into several subtypes based on altitude, soil, rainfall, and other factors. The evergreen forest is made up of tropical wet evergreen and tropical mixed evergreen. The deciduous forest consists of tropical moist deciduous and tropical open deciduous. Tropical mixed evergreen forest is the most important type, with the dominant tree species *Dipterocarpus spp.*, which is highly valued due to its high priced timber. In the forests of the hilly areas, more than 100 evergreen and deciduous tree species have been identified as growing naturally (Salam et al. 1999).

During the period 2000-2005, the annual rate of deforestation in Bangladesh is 0.3% (2000 ha) as stated by FAO (2007). Due to the deforestation, many plants and animals have been extinct or endangered in Bangladesh (Chowdhury et al. 2009). A total of 40 inland mammals, 41 birds, 58 reptiles and 8 amphibians and 106 vascular plant species have reached at risk in different magnitude (IUCN 2000; Khan et al. 2001). Salam *et al.* (1999) indicate that deforestation and degradation in the forests in Bangladesh are influenced by infra-structural problems related to the country's underlying socioeconomic features. Salam *et al.* (1999) divided the underlying factors into four sets of actors: (1) the indigenous forest dwellers, having their own problems (e.g., high population growth); (2) migrants, who move to the forests; (3) the timber industries cutting down too many trees; and (4) the government through its Forest Department which is not able or willing to implement suitable policies to

regulate the cutting of trees and to prevent illegal cutting. Mitigating the first and second factors is a time consuming task. The country is facing the high rate of population as a severe problem in the country (Niroula and Thapa 2005; Lush et al. 2000). The constantly increasing population and its growing consumption expect further loss of forest cover due to these first and second factors. In contrast, the third and fourth actors can be seen as a relative indulgence. The nature of the causes of forest loss in Bangladesh is such that any attempt to revert these trends will be ineffective without changes in the attitudes and practices of Forest Department officials and politicians with forest interests. The Forest Department has been losing its management capacity for many reasons, mostly related to the third and fourth actors.

4. Climate change, causes and consequences

Climate change, caused by anthropogenic global warming, is the most discussed and feared environmental concern in the world today. It indicates to the increase in the average temperature of the earth's near-surface air and oceans. According to Intergovernmental Panel on Climate change (IPCC)'s third assessment report, the temperature of the atmosphere has increased 0.6°C, during the twentieth century (IPCC 2007). Measurements and estimates of sea level show increases of 6–8 inches (15–20 cm) in the last century. Climate model projections summarized in the latest IPCC report indicate that the global surface temperature will probably rise a further 1.1 to 6.4 °C (2.0 to 11.5 °F) during the 21st century (IPCC 2007). Along with that, sea level rise projection is done. This is of course a severe threat to the survival of human race. That's what made the experts to initiate necessary programs to abate it. In 1992, the United Nations Framework Convention on Climate Change (UNFCCC) provided a general framework for reducing the emission of greenhouse gases, which is the main cause of global warming. At the third conferences of the parties (COP-3),

Kyoto protocol was adopted, where the responsible countries were given specific targets for reducing GHGs. But the Kyoto protocol came into force on February, 2005.

4.1. Causes

IPCC concludes that increasing GHG and aerosols concentrations is the main cause of global warming in the last century. Rather than natural, this increase is resulting from various anthropogenic activities. It is observed that, fossil fuel burning and deforestation are responsible for most of the measured temperature increase since the middle of the 20th century. It shows that, GHG emission has increased 70% from 1970 to 2004. These gases are carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and F-gases. Among those gases, CO₂ is the most important anthropogenic gas. Its annual emission has increased about 80% from 1970 to 2004 (IPCC 2007). Global increases in CO₂ concentrations are primarily due to fossil fuel burning, 56.6% of the total emission. Deforestation, decay of biomass, etc. produces CO₂ and contributes 17.3% in total emission (IPCC 2007). Some other sources also exert CO₂ for 2.8%.

4.2. Consequences upon Bangladesh Forestry Sector

During the last century, IPCC have observed the consequences of climate change through the rise in sea level, along with the rise in global average surface temperature. They also interlinked the changes in the snow cover in northern hemisphere. It is projected that, without any strong climate policy, the GHG concentration will increase regardless and bring ultimate destruction by different phenomena of climate change.

The Sundarbans, one of the largest mangrove forests of the world (Wahid et al. 2007; Islam 2003; Iftekhara and Islam 2004) located in the south-western coast of Bangladesh, will also be flooded by the sea level rise. Using high resolution elevation data, Loucks et al.

(2010) estimates that with a 28 cm rise above 2000 sea levels, the present stock of the Royal Bengal Tiger (*Panthera tigris*) will be declined by 96%, and the breeding stock will reduce by around 20%. Wahid et al. (2007) find that the annual maximum tidal range has been increased by 0.75m in the eastern and central parts of the Sundarbans during the last two decades. Higher salinity condition (>20 ppt) also have been reported for at least 1.5 months in a year. Sea level rise will cause rise in the salinity concentration in the water and soil in the Sundarbans and destroy its unique biodiversity. Increased salinity will change the habitat pattern of the forest and may increase disease pressure for many species. Aquatic organisms might migrate inwards because of increased salinity (Khan 2009). A large number of people are dependent on Sundarbans for their livelihood. It will also deteriorate the defense of coastal people from cyclones as the mangrove swamps serve as natural barriers against strong winds and tidal surges. Recently, we have seen the necessity of Sundarbans at the time of SIDR, a cyclonic storm in 2007 (Mallick and Vogt 2009).

5. Review findings and Discussion

5.1.General review for the effectiveness of the EKC

Many papers have been published on the EKC since 1991, after Grossman and Krueger's study on NAFTA, which shook the economic view of the world. From then, the basic argument of each paper was, was there any turning point for environmental degradation or not. In this section, some basic reviews have been done for the effectiveness of EKC.

It is so obvious that, when income per capita crosses certain point, then the nation attempts to invest in mitigation measures for the betterment of environment (if society is fully aware of environment and the new technology). In general, the idea of EKC assumes that environmental degradation has no effect on economic growth (Stern 2004). However, most of

the primary pollutants like SO₂, SPM, NO_x and CO show an inverted-U shape EKC, where secondary pollutants give a monotonous straight line (Cole et al. 1997). Koop and Tole (2001) and Mather (2007) confirm the national economic growth on tropical deforestation. Scriciu (2007) and Barbier & Burgess (2001) conclude that national income effect on the deforestation varies from region to region and also does not always prove the EKC.

The fate of developing and poor countries through the viewpoint of EKC is often argued by several experts. As EKC tells that, economic growth is the only possible way to retard deforestation; so, when will they achieve enough income per capita for turning point? However, Munasinghe (1995; 1999) has hypothesized a tunnel through the EKC which will help the developing countries to attain lower turning point by adopting measures from the developed ones (Figure 3)

<< Figure 3. Tunneling through the Environmental Kuznets Curve >>

That's how the developing ones can avoid higher amount of income per capita for turning point and reduce environmental degradation in their development path. He proposed for an alternate development path by proposing tunnel, in one word (Figure 4). He has shown three possible path of economic development aligned with the environmental damages. The optimal path is the one path; an economy should look for, to avoid the severe or moderate distortions of environment.

<< Figure 4. Alternate path of development to reduce environmental damage >>

5.2.EKC for deforestation

People use forest products at the early stage of development. But after a certain rise in income per capita, forest products are replaced with some other alternative products that do not exert any harm to the forest. That is the main principle of EKC in deforestation. The idea depends on several factors. Fuel wood use is assumed to be reduced with increasing income per capita, by replacing it with modern energies, e.g., gas, electricity or else. Amount of timber used in furniture, house building or other chores will be reduced. Furthermore, with increasing income per capita, education and awareness about the environment will also increase that will help to reduce the rate of deforestation. And another fact is, several afforestation program can be induced both by the government and private sectors if GDP/income per capita is above a certain level.

Shafik and Bandyopaddhay (1992) first did an empirical study on deforestation, in 1992. But, before that, in 1976, Samuelson hypothesized an EKC relationship with respect to forestry and conservation in a seminal paper on the economics of deforestation (Bhattarai and Hammig 2001). Shafik and Bandyopaddhay (1992) however got no statistically significant evidence for EKC, which means there was a positive relationship between income per capita and deforestation. Table 1 shows the different EKC studies for deforestation mostly cited by Winslow (2005). They studied data of 66 countries using a log linear model. Their study considered data of between 1962 and 1986. Shafik (1994) got same result as Shafik and Bandyopaddhay (1992) for deforestation using Quadratic, FE model. Bhattarai and Hammig (2001) did a vast study of EKC for deforestation in 66 tropical countries. A quadratic RE model to estimate those aggregated data provided no statistically significant support for an inverted U-shape EKC. When they studied data (using cubic, FE and RE model) of 31 countries from Africa, he found a turning point from which deforestation was on the way to

decrease. This peak was at an income per capita of \$1300. But there was another turning point from which deforestation was increasing again. This trough point was at an income per capita of \$5000. The result was different in case of 12 countries of Asia. Same model provided a U-shape (not inverted U-shape) curve. The trough and peak were at \$2200 and \$5500, respectively. But one experiment was quite a light for EKC in deforestation. A cubic FE and RE model for the data of 20 countries in Latin America has shown a turning point in deforestation at \$6600. Koop and Tole (1999) studied the facts in Latin America in a Quadratic, FE model and found a turning point at an income per capita of \$8660. But his RE model has shown no evidence of EKC for deforestation.

<< Table 1: EKC studies for deforestation >>

Barbier and Burgess (2001) have done a study with a vast area that covered the tropical deforestation of Africa, Asia and Latin America (Table 2). He studied deforestation by tropical agricultural land expansion. His study covered data from 1961 to 1994. Turning points were estimated in Purchase Power Parity (PPP). He studied both one way and two ways FE and RE model first; and then, he added three additional institutional variables- corruption index, property rights index, political stability index. They concluded that national income did not always show the EKC for deforestation. But country wise, local case studies may sometimes prove these trajectories.

<< Table 2: EKC studies for deforestation by Barbier and Burgess (2001) >>

It is observed that Cubic models have given optimistic results for EKC in some cases, while most Quadratic models have not. In many observations, deforestation has not shown

any supporting evidence for the full trajectory of the EKC (Shafik and Bandyopadhyay 1992; Shafik 1994; Koop and Tole 1999). There may be a reason that, they are at the first stage of EKC, when degradation increases with increasing income per capita. According to Koop and Tole (1999), empirical results indicate that a significant EKC exists in the simple regression, but it is gradually lost when the conditions are freed up. Tests also strongly designate that the less restrictive specifications are favored by the data. But Bhattarai and Hammig (2001) has observed another pessimistic study in Africa. They found a peak at income per capita of \$5000, where deforestation increases again. The situation in Asia is a bit different, but deforestation is rising with increasing income here too.

All tropical countries' average PPP for turning point was estimated only at \$858 (Table 2), but yet negative result was found; squared function has also provided negative conclusion (Barbier and Burgess 2001). Table 2 shows that those institutional variables have substantial influence, as the EKC shapes have been changed when these variables are accounted. Only for Africa, the shape hasn't been changed; yet the estimated turning point has been changed and shown some hope to reach that peak in a shorter time.

5.3. EKC implications in Bangladesh

In June 2009, the population of the country was about 156 m having the growth rate 1.3% in the country. Among the total population 77% of the population lives in rural areas (USCB 2009). Bangladesh is a country with developing economy. It is assumed that, Bangladesh is now at the early stage (upward slope) of EKC for environmental degradation. The hypothesis of EKC also gives the assumption that Bangladesh has the rights to degrade now, get developed and abate later on. But the environmentalists are concerned about the results of further degradation in our country and when the turning point of EKC will come

out. Bangladesh is under severe threat of climate change and forest biodiversity loss. According to IPCC and Bangladesh Climate Change Strategy and Action Plan 2008 (IPCC 2007; MoEF 2008), Bangladesh will be among the worst affected countries of climate change. The GDP trend and the drivers of EKC in Bangladesh can show the movement of the environmental degradation through the EKC. The learnt EKC movement discussed in the previous sections can focus how to shorten the first stage of the EKC taking appropriate economic and environmental policy in Bangladesh. The following sections aim at discussing on that sight.

5.3.1. GDP trend in Bangladesh

Bangladesh is one of the thirteen countries that have the potential to grow faster in its economy (ADB 2009). She has achieved more than tripled GDP in real terms, food production has increased three-folds (MoEF 2008). Observing the trend of last twenty years, it is assumed that the country will become a middle income country by 2020. In three out of the last five years, the economy has grown at 6% and over (Figure 5) (CIA 2008). The economic survey of Bangladesh (GOB 2000) states that though decrease in growth rate is observed in some years, yet the growth is on the way nonetheless (Table 3). For a developing country with this GDP growth rate, Bangladesh is defying the impact of the global economic fallout (ADB 2009) and ranked 68th in world ranking by CIA world factbook (CIA 2008). According to the ADB quarterly (ADB 2009), Bangladesh is one of the thirteen countries that has the potential to grow faster. They also reported that, the global centre for economic activity is being already shifted to India, China and other large emerging economies, and Bangladesh must make all efforts to capitalize on its comparative advantages to benefit from this global paradigm shift.

<<Table 3. Growth trend of real Gross Domestic Product (GDP) in Bangladesh during 1975-2000 (at 1984/85 prices) >>

<< Figure 5. GDP real growth rate of Bangladesh from 2000 to 2008 >>

5.3.2. Path of EKC for deforestation in Bangladesh

Considering EKC and the growth trend of the national income of Bangladesh, it is now clear that Bangladesh is going to face a severe threat of environmental degradation in the upcoming years or decades. From the studies of EKC in the developing countries, it is assured that environmental complications will be relentless, until the peak point is achieved. But, economic growth and development is important too. But the prime task will be to get rid of the upcoming environmental threats. The findings of the EKC studies for deforestation show that, Bangladesh, a low-income country, needs to go so far at its required income per capita for the EKC turning point. If we are to wait for that usual turning point, the forest ecosystem in Bangladesh may be degraded irreversibly. It will be best to follow the alternative routes (Figure 3 and Figure 4). Oestreicher et al. (2009) conclude that several surveillance measures with greater funding and proper governance are critical to the slowing deforestation. Santilli et al. (2005) confirm that adequate funding of programs for enforcing environmental legislation, finding alternative livelihoods for the forest dependent people, and alternatives to massive forest clearing and capacity building for dealing with the remote forest regions are critical to the reducing deforestation. In this connection, Clean Development Mechanism (CDM) and Reduced Emissions from Deforestation and Degradation (REDD) can work to forest transition. These two mechanisms can be useful to construct the alternative path in the EKC in Bangladesh. The following sections briefs on these mechanisms.

5.3.2.1. CDM as a flexible mechanism

The Article 12 of the Kyoto Protocol introduces the CDM, originally a part of AIJ (Activities Implemented Jointly). The CDM is an instrument under the authority of the COP and supervised by an Executive Board. CDM projects typically involve Annex I countries as investors and Non-Annex I countries as hosts, essentially joint ventures between developed and developing countries. Emission reductions resulting from these projects, beginning in the year 2000, count towards satisfying an Annex I country's obligations to reduce aggregate emissions during the years 2008 to 2012 (First commitment period). An 'operational entity' accredited by the COP must validate the project before implementation and verify the project's emission reductions before the Executive Board can issue credits for the emission reductions achieved.

Silveira (2005) discusses the role of CDM in respect of sustainable development, formation of carbon markets, and promotion of bioenergy options. His study concludes that bioenergy projects are attractive and CDM provides a complementary bridge for international cooperation towards sustainable development. Ravindranath *et al.* (2006) and Reddy & Balachandra (2006) also conclude that a woodfuel stove project with the improvement of the traditional stoves can well be put on the international 'carbon market' at competitive cost for GHG emission reduction. Forest management and conservation (slowing deforestation) as well as carbon sequestration in agriculture are not allowed in the first commitment period of the CDM. Furthermore, the credit that a party can claim from LULUCF (Land Use, Land-use Change and Forestry) projects under the CDM is 1% of the party's base year (1990) emissions, times five (Rosenbaum *et al.* 2004). The COP agreement means that over the five years, one-fifth of the reduction can come from CDM-LULUCF projects (Rosenbaum *et al.* 2004). The negotiations are being continued how to treat CDM-LULUCF projects after 2012.

However, CDM projects are expected to derive the sustainable development in the Non-Annex I countries. The development must be in the social, environmental and economic arena of a country. The possible carbon sequestration, biomass combustion efficiency and carbon substitution projects are expected to derive lots of impacts on the overall of a host country.

5.3.2.2. REDD to slow down the deforestation

Receiving GHG benefits from the slowing deforestation, the COP 13 in Bali, 2007 discussed a lot on Reduced Emissions from Deforestation and Degradation (REDD). The COP 14 in Poznan, 2008 also went ahead on that. The mechanism has not come into force yet, as still the negotiation is going on. But it is expected that REDD will be the central forestry activities (slowing deforestation) in the tropical developing countries after 2012 (Skutsch and Trines 2008). Before getting REDD as an effective reducing deforestation mechanism, the decisions on nature of carbon buyers and sellers, financing mode, the compensation scheme, type of land use targeted should be made (Oestreicher et al. 2009).

5.3.2.3. Legal issues of reducing deforestation in Bangladesh

Bangladesh, a non-Annex I party, ratified the Kyoto Protocol on 22 October 2001. So, Bangladesh is eligible to be a host country of CDM and the expected REDD projects. Furthermore, Bangladesh has signed the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1973; UNFCCC in 1992; Convention on Biological Diversity (CBD) in 1992. She is a signatory to the Ramsar Convention and the World Heritage Convention. The Bangladesh Wildlife (preservation) Act, 1974, the Forest Act, 1927 (amended in 1989), the Fish Act, 1950, and the Environment Protection Act, 1995 provide legal support for forest and biodiversity conservation in Bangladesh. The national

forest policy, 1994 also supports the mass reforestation activities throughout the country. To mitigate the climate change through the forestry sector in Bangladesh, it is necessary to adjust or pin-point the objectives of the forest policy, national energy policy and national Renewable energy policy which should be compliant with the biodiversity conservation in the forests.

6. Conclusion

Deforestation has not shown the evidence of the full trajectories of EKC at global level. But in the disaggregated local levels, it proves the EKC in most cases, but with the higher per capita income as the turning point. Bangladesh needs to go so far to reach at this turning point when deforestation will be retarded. Though, the economy of Bangladesh is being emerged anyway. To reduce the deforestation in Bangladesh for GHG benefit, biodiversity conservation, we must have to make the tunnel in the EKC. The discussions show that CDM and REDD can be the effective mechanism to make the tunnel. Information accessibility, higher technological support from the developed countries, research based educational facility, law enforcement should be established to shorten the peak of the environmental degradation through the EKC in Bangladesh. The findings of the study would be of immense importance for forestry development in Bangladesh.

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Table 1. EKC studies for deforestation

References	Countries/cities	Time period	Model	EKC Result	Turning point(s)
Shafik and Bandyopaddhay, 1992	66 countries	1962-1986	Log linear	Various	No statistically significant result
Shafik, 1994	47 cities in 31 countries	1972-1988	Quadratic, FE	Various	No statistically significant result
Bhattarai and Hammig, 2001	20 countries from Latin America	1972-1991	Cubic, FE and RE	Inverted U-shape	\$6600
Bhattarai and Hammig, 2001	31 countries from Africa	1972-1991	Cubic, FE and RE	N-shape	Peak at \$1300 and Trough at \$5000
Bhattarai and Hammig, 2001	12 countries from Asia	1972-1991	Cubic, FE and RE	U-shape	Trough at \$2200 and peak at \$5500
Bhattarai and Hammig, 2001	66 tropical countries	1972-1991	Quadratic, Random coefficients model	Various	No statistically significant result
Koop and Tole, 1999	Latin America	1961-1992	Quadratic, FE	Inverted U-shape	\$8660
Koop and Tole, 1999	Latin America	1961-1992	Quadratic, RE	Various	No statistically significant result

Notes: FE and RE means Fixed effect and Random Effect model, respectively

Table 2. EKC studies for deforestation by Barbier and Burgess (2001)

Countries/cities	Models	EKC Result	Estimated Turning point
All tropical countries	One way FE	NO	\$858
Africa	One way RE	NO	\$3706
Latin America	One way FE	NO	\$17359
Asia	One way RE	YES	\$6182
All tropical countries*	Ordinary Least Square with AC [^]	YES	\$5445
Africa*	Ordinary Least Square with AC [^]	NO	\$1211
Latin America*	Ordinary Least Square	YES	\$4946
Asia*	Ordinary Least Square with AC [^]	NO	\$1815

Notes: where EKC result says NO, in those cases, estimated turning points are assumed and not arrived yet. The * sign refers that models in those studies are included three institutional variables- corruption index, property rights index, political stability index. AC[^] refers to Autocorrelation correction by Cochrane-Orcutt procedure, if required. FE and RE means Fixed effect and Random Effect model respectively.

Table 3. Growth trend of real Gross Domestic Product (GDP) in Bangladesh during 1975-2000 (at 1984/85 prices)

Year	Real GDP (millions of taka)	Growth Rate (%)
1975-76	293820	5.7
1976-77	301670	2.7
1977-78	323010	7.1
1978-79	338520	4.8
1979-80	341300	0.8
1980-81	352880	3.4
1981-82	357220	1.2
1982-83	374700	4.9
1983-84	395030	5.4
1984-85	406930	3.0
1985-86	424590	4.3
1986-87	442340	4.2
1987-88	455130	2.9
1988-89	466610	2.5
1989-90	497530	6.6
1990-91	514440	3.4
1991-92	536190	4.2
1992-93	560230	4.5
1993-94	583840	4.2
1994-95	609790	4.4
1995-96	642440	5.3
1996-97	680210	5.9
1997-98	718670	5.7
1998-99	756120	5.2
1999-2000 (provisional)	801710	6.0

(GOB, 2000)

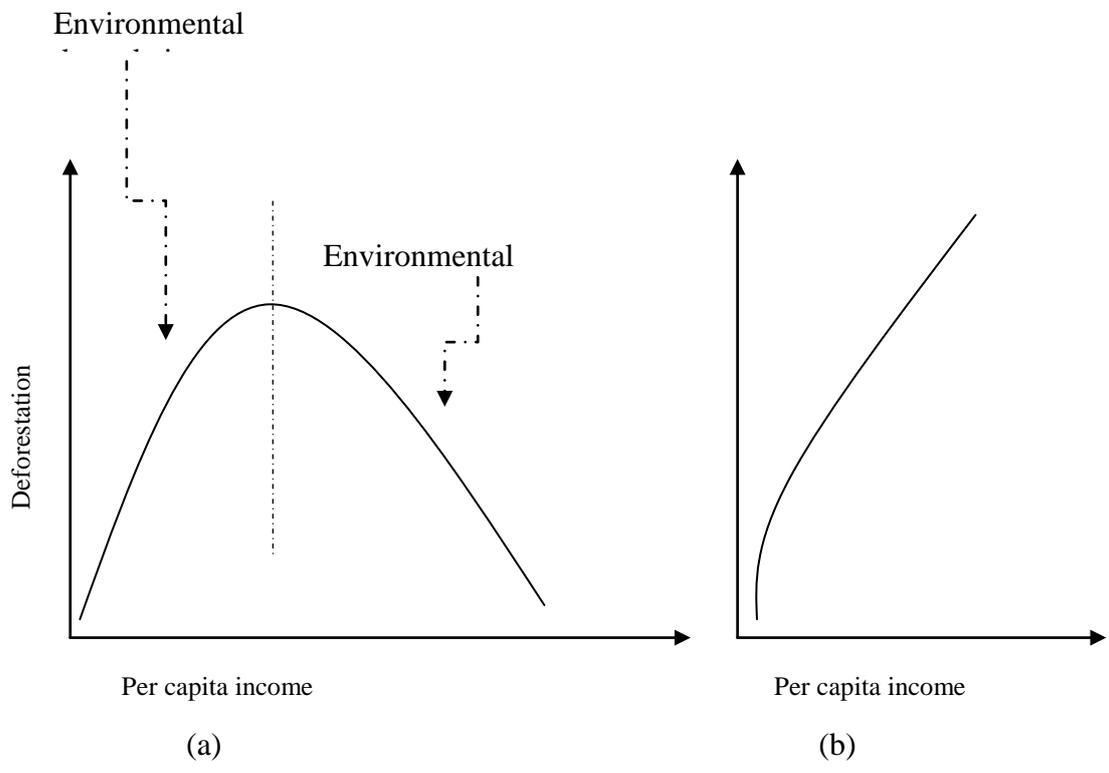


Figure 1. General environmental Kuznets Curve, (a) A full trajectory of inverted U-shape EKC; (b) Straight line of EKC, where no turning point is found

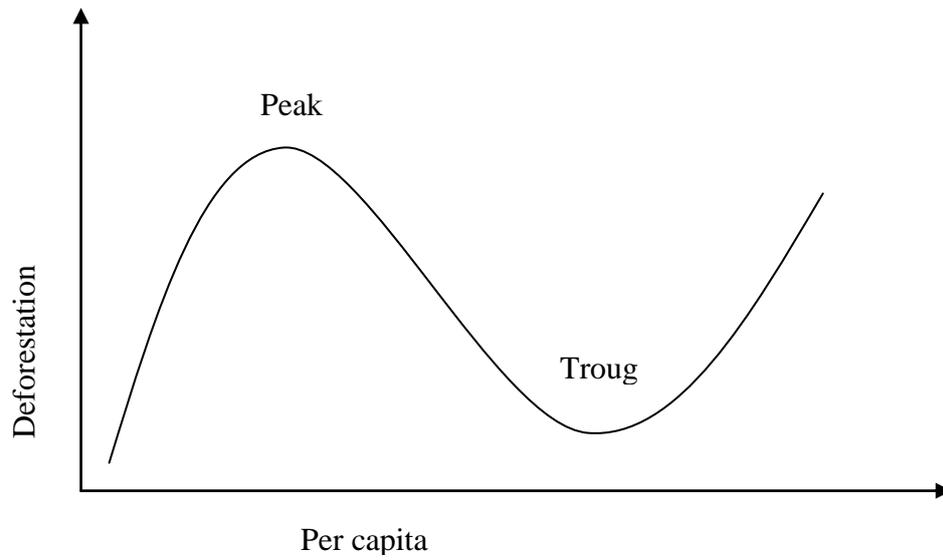


Figure 2. Peaks and troughs of EKC

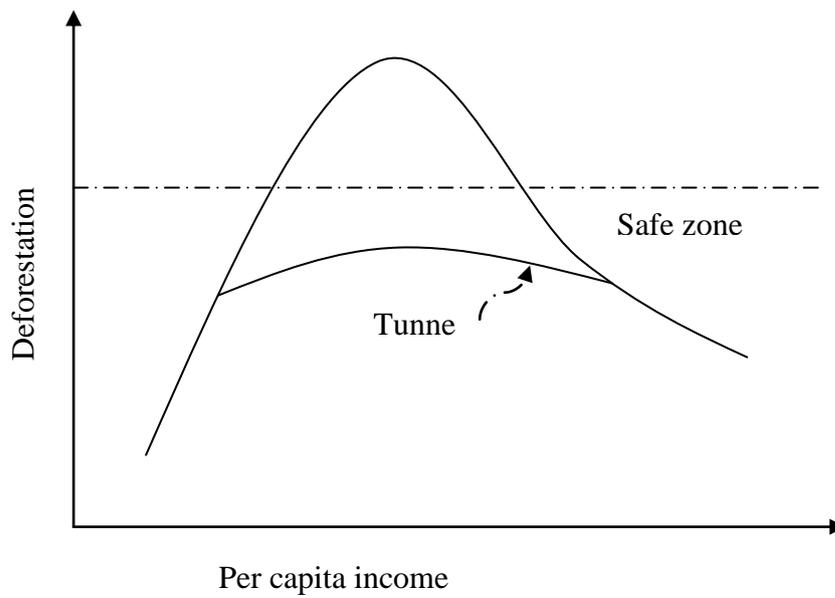


Figure 3. Tunneling through the Environmental Kuznets Curve

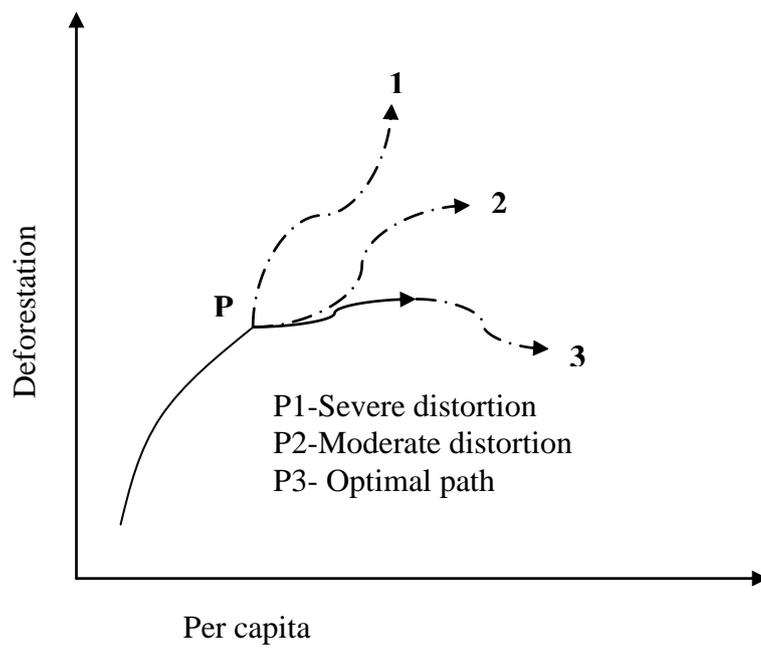


Figure 4. Alternate path of development to reduce environmental damage

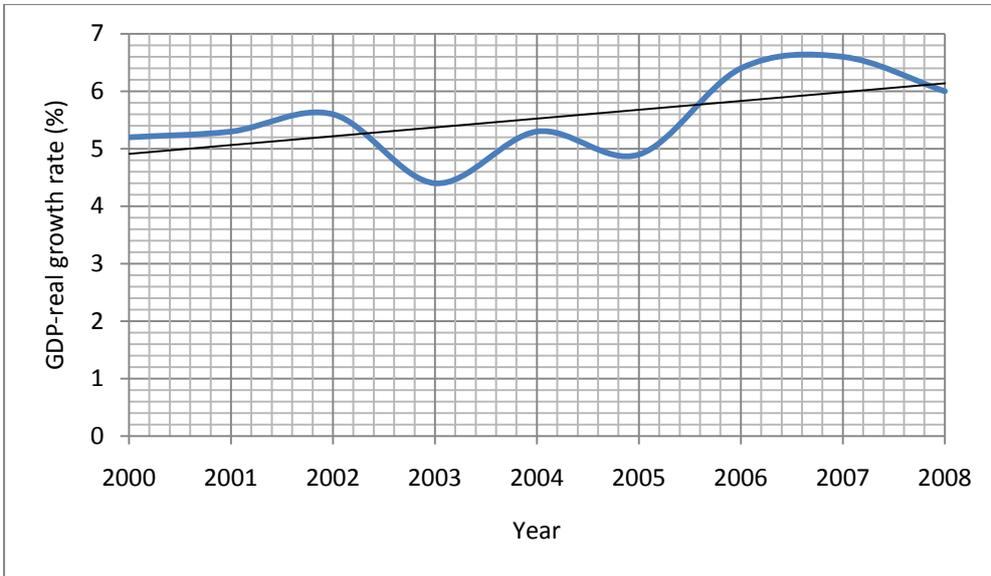


Figure 5. GDP real growth rate of Bangladesh from 2000 to 2008