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Poverty and Environmental Degradation: Searching for Theoretical Linkages

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Abstract

Existing literature about poverty and environmental degradation suggests that poverty is the victim of environmental degradation, but could not conclude whether poverty is also the cause of environmental problems. However, most of those studies are empirical i.e. analyze case studies in certain locations and very specific to certain types of environmental problem, not theoretical or analytical studies which are based on behavioral economic model. Some relevant analytical economic models which are based on standard assumption of optimizing economic agents are surveyed. Those models confirm, among others, the significant role of property right and the way population growth may interact in the nexus. In addition to that, they may introduce some additional insights such as how environmental degradation could be seen as rational decision of the poor to disinvest in base-resource and the way that institutional failure may also be endogenously caused by poverty. The discussion of some limitation of both empirical and theoretical literature suggest that more economically-relevant definition of environmental degradation, and more emphasis on proper valuation of natural resources are necessary.

1. Introduction

> *"Greenery is for the poor too, particularly on their own doorstep"*
> From the Economist, 4 July, 2002

One out of five people on earth still live with $1 a day, and many coordinated effort and commitment have been targeted to reduce the number of poor people including the so-called Millennium Development Goals: halving extreme poverty by the year 2015 (World Bank, DFID, EC, UNDP, 2002). Unlike poverty issue, which has been in the mind of the world leaders for generations, environmental problems started to gain global widespread attention in 1970s, especially after the Stockholm Conference on the Human Environment in 1972 (World Bank, 2000). However, the accelerating severity of this problem, such as degrading agricultural lands, shrinking forest cover, global warming, and bio-diversity losses,

has put the problem into top priority as well and start to become the topic of day-to-day conversation, not only in the northern hemisphere, but also in developing countries[1].

Environmental issues were used to be considered only the problem of the riches[2]. It was rich countries who first deforested their land, and accumulated CO_2 in the atmosphere for decades, in the name of industrialization. Environmental commodities are also considered luxury goods. It is hard to imagine that poor people strive down the street in a demonstration for the issues of saving giant panda or blue whales. However, this paradigm has started to change. We can see that many environmental problems are associated with poverty especially the fact that, environmental degradation in many cases, and many ways, affects the livelihood of the poor. The poor are vulnerable to environmental degradation because they depend heavily on natural resources, have less alternative resource, and most often exposed to environmental hazards, and are least capable of coping to environmental risks (Dasgupta and Mäler, 1994, World Bank, DFID, EC, UNDP, 2002).

The issue of poverty and environmental degradation, then, started to become interesting source of academic inquiry, and attract thousands of researches and studies including in the field of economics. Most studies in the existing literature, not only economics, on the poverty-environment relationship are empirical. They analyze case studies in certain location and very specific to certain types of environmental problem[3]. Some of them involve not only economics but also other disciplines such as ecology, biology, or political sciences[4]. This existing literature, generally, suggests that poverty may be one of the causes of environmental degradation, and that environmental degradation could also

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[1] See for example remarks by the World Bank's president, James D. Wolfensohn, to the United Nations General Assembly Special Session on the Environment, New York, June 25, 1997.
[2] Many still think the same today.
[3] Some recent studies include Cavendish (2000) for Zimbabwe, Dasgupta et al (2002) in Laos, Swinton and Quiroz (2003) in Altiplano, Peru. Comprehensive review by Duraiappah (1998) and Ekbon and Bojö (1999) also relies heavily on case-studies.
[4] See for example Fuhr (1999), who shows how different conclusion on the issue on poverty and environment can be drawn from different discipline. Political science, for instance, stress for the importance of 'good governance', while ecological approaches stress on 'biological linkage'.

adversely affect the poor, or even create more poverty. However, only a few of those studies are theoretical or analytical which are based on behavioral economic model[5]. This paper, then, is an attempt to identify how economics, with their standard analytical approaches, may contribute to the existing paradigm on the poverty-environmental nexus. A formal general theory, for example, may help explain some regularities found in empirical case studies[6], and in turn this will help provide better understanding for policy formulation. Poverty–environment inter-linkage has also been a global agenda, such that poverty reduction strategy need to incorporate environmental issues as well. World Bank, for example, has started to incorporate environmental issues into their country-assistance strategy[7]. Formal economic theories will provide guidelines in addition to the conclusion drawn from empirical studies. Furthermore, understanding of existing formal theories, will always be useful for future research that may generate better theories.

The research question that would like to be addressed in this paper is how poverty and environmental degradation are interlinked. In particular, the question of whether and how poverty cause environmental degradation and whether and how environmental degradation affect poverty would be addressed by, first, reviewing and summarizing the existing empirical literature, and using this as a background, to secondly, identify, and analyze relevant analytical economic models and discuss and criticize their contribution to those existing literature.

The paper will be divided into four sections. Section 1 gives introduction. Section 2 will discuss the conclusion that has been and has not been drawn by the existing empirical literatures, as a stepping-stone into section 3, in which some relevant analytical literature will

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[5] One of the few is Dasgupta (1999) which formally analyze the relationship between poverty, population, and environment that will be discussed in detail in later section.

[6] The existence of such regularities would be discussed in section 2.

[7] Bucknall, et al (2001, p. 4).

be critically surveyed, and linked to empirical works, and finally, section 4 concludes and discusses some implication for future researches

2. Lessons from Empirical Studies

To begin with, Duraiappah (1998), as illustrated in figure 1, put forward some postulates of causality relationship which may exist between poverty and environment.
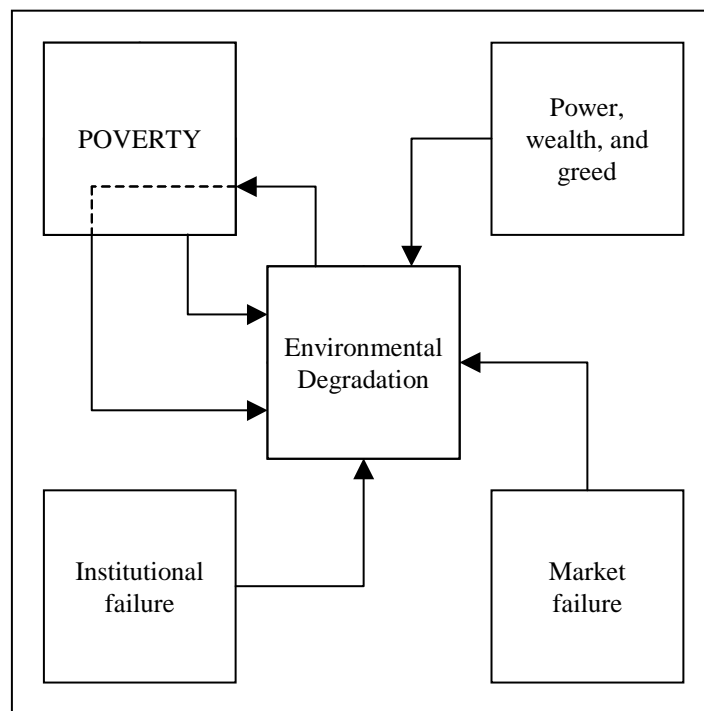

Figure 1.
Duraiappah's (1998) postulates of poverty-environment nexus
Note: Arrow indicates direction of causation

Figure 1 shows that the possible causes of environmental degradation are market failure, institutional failure, power, wealth, and greed, and also poverty. Environmental degradation and poverty, however, may have mutual causality.[8] Because environmental problem has been seen as the effect of the failure of market to take into account the full value (price) of the services from the environment, market failure has been generally accepted as

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[8] Duraiappah (1998) also make a distinction between endogenous poverty (poverty caused by environmental degradation) and exogenous poverty (poverty caused by other factors). Dashed line in figure 1 indicates endogenous relationship between poverty and environmental degradation.

the main cause of environmental degradation[9]. Institutional failure in form of inappropriate government policy, or ill-defined property right as a cause of environmental degradation has also been widely accepted as the cause of environmental degradation (Dasgupta and Mäler, 1994, Pearce and Warford, 1993). Government subsidy to wrong sectors (e.g. for polluting industries), or to wrong products (e.g. gasoline) is examples of inappropriate government policies, whereas, bad governance (such as rent-seeking activities in the logging industry), or land-tenure insecurity are examples of other institutional failures.

Duraiappah (1998) also used Boyce's (1994) political-economy argument about inequality in power, which is correlated with wealth, are also among the causes of environmental degradation. As Boyce (1994) argues, the gainer of environmental degradation (such as industrialist and large logging companies) are usually the more powerful and wealthier, whereas the loser (e.g. pollutee and small farmers) are usually less powerful. Therefore, the more unequal distribution of power and wealth, the more likely environmental degradation will be prevalent.

Duraiappah (1998) then continued by analyzing the existing empirical literature to find out which of those postulated relationship has been supported and concluded that: (a) It is activities by the rich and powerful (not the poor) were the primary contributing factors to environmental problems. Profit motives of commercial logging, for example, are the biggest cause of deforestation compared to subsistence motives of small holdings (e.g. for the need of fuel woods); (b) Institutional and market failures play a prominent role in environmental degradation; (c) Poverty may increase environmental degradation but as a reaction to adverse effect of the environmental degradation triggered by other factors mentioned before[10]. In this

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[9] Even nowadays, environmental economics has been mentioned synonymously with the theory of externalities. Baumol and Oates' (1975) seminal book on the theory of environmental policy has been standard reference in environmental economics and cover mostly about the theory of externalities.

[10] This implies that if institutional failure or activities of the rich does not affect (through environmental degradataion which adversely affect the livelihood of the poor), the poor would not do activities which could put environmental resource in danger.

situation, the poor are left with no option but adopting unsustainable activities, and (d) the poor are unambiguously the most affected, or the victim of, environmental degradation. In short, Duraiappah (1998) concludes that his literature review does not present evidence that the poor do initially or directly degrade the environment, but it is obvious that the poor is the victim of environmental degradation[11]. Thus, to emphasize, the direction of causation is from environmental degradation to poverty, not the other way around.

Some comments on Duraiappah's (1998) approach, however, are worth pointing out. Firstly, although it is inevitable, that analyzing poverty-environment nexus, require us to identify what are standard causes of environmental degradation, and whether poverty is one of them, Duraiappah (1998) analysis seems to be too focus on those non-poverty factors, and this may explain why the direct relationship from poverty to environmental degradation has not been elaborated in great detail. There are many things working in between in the linkage from poverty to environmental degradation. Some of important ones include (as will be discussed in the later sections) the role of discount rate and population growth.

The other important issue, that may be missing, is that certain environmental degradation may be desirable from economic point of view. Market failure argument suggest that current state of the environment is not optimal because economic agents do not take into account the effect of their decision to others (externalities problem). However, even if we internalize that externalities, society will opt for some optimal level of environmental degradation. Zero environmental degradation of course is not desirable. This line of argument seems to be missing in Duraiappah's (1998) postulates, and other empirical works that will be discussed later.

Survey of empirical literature by Ekbon and Bojö (1999), more or less, result in similar conclusion to Duraiappah (1998), with more explicit discussion on how population

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[11] However, we have to be aware as well, that the rich are also affected by environmental degradation. Global warming is one of the examples. However, the poor has much less, even none of, financial resource, to avoid, or adapt to the adverse effect of environmental problems. In short, they are much more vulnerable.

growth and discount rate. Ekbon and Bojö (1999) conclude that empirical works confirm the poor people as the main victims of a bad environment. The poor are simply more vulnerable to environmental degradation such as loss in biological resources in rural area, or air and water quality deterioration in urban areas. Extreme environmental stress can also force the poor to migrate, creating more poverty. All of those constitute the 'victim' hypothesis, and the studies that were surveyed by Ekbon and Bojö (1999) confirm this hypothesis.

However, Ekbon and Bojö (1999) stressed the mixed empirical evidences of hypothesis that poor people are agents of environmental degradation, but suggest some possible mechanism from the former to the latter i.e. through the role of population growth, and the role of discount rate. Poor parents, for instance, produce more children to secure income at old age, and provide additional labor to collect essentials goods such as water and fuel wood. Discount rate plays important role, because poor people have limited ability to await distant, uncertain benefit, compared to short run need for essential day-to-day life.

To complete our discussion on the empirical part, some more recent empirical studies that have not been covered by Duraiappah (1999) and Ekbon and Bojö will be summarized to see how their conclusion would fit into the two previous surveys. One of those recent studies are a study by Swinton and Quiroz (2003), who used regression analysis of 1999 farm survey data in Peru to analyze whether poverty is to blame for soil, pasture, and forest degradation. They conclude that natural resource sustainability is not correlated with poverty. Fallowing, a standard practice of poorer farmer there, in fact, may reduce soil erosion and fertility loss. Somewhat similar conclusion are also made by Cavendish (2000) who used panel data from Zimbabwe. He concluded that while poorer households depend heavily on environmental resources, which contribute 40% to their income, it is richer households who use greater quantities of environmental resources in total. Another recent study by Dasgupta et al (2002) using spatial and survey data in Laos provide mixed conclusion, implying more deep analysis

required to come up with clear explanation. Finally, a survey of 70 empirical studies by Templeton and Scherr (1999) conclude that local population growth and its microeconomic manifestation, which may include poverty, in hills and mountains of developing countries do not necessarily threaten forest production, agriculture, livestock production or watershed stability. In short, more recent empirical studies seem not to contradict the conclusion of surveys by Duraiappah (1998) and Ekbon Bojö (1999) as previously discussed.

In summary, the existing empirical literature concludes that environmental degradation adversely affect poverty, because the poor are the most vulnerable to environmental degradation, due to their heavy dependence on natural-resource base, and limited resource to cope with adverse environmental effect. However, the thesis that the poor are also the agent of environmental degradation seems not to be supported. Being poor per se is not the cause of environmental degradation. There are many others factor involved, such as institutional failure or population pressure. In short, the linkage is not so simple that we can also blame the poor for environmental degradation.

As mentioned earlier, however, the poor as a sub-group of a society, may find themselves better-off, by harvesting natural resource and will always have incentives to do so. As long as, externalities of the poor's decision has been taken into account, economist will find the resulting environmental degradation as optimum or desirable. Some may prefer to call the use of natural resource by the poor as environmental degradation, but some may not. Environmental degradation may also be more precisely defined as non-sustainable use (e.g. logging in excess of its natural growth), or may also be limited (especially by welfare economist) to be non-optimal use of natural resources (over-use or even under-use). Hence, it seems that empirical literature need a more proper or acurate definition about what constitute environmental degradation that can incorporate this standard economic framework.

In term of a broader framework of society at large, it is fairly possible that even more environmental degradation that may reduce poverty is even considered optimal when equity may enter social welfare function. If one way that equity could be improved is by extracting more natural resources, then the poor causing environmental degradation is even a desirable thing.

3. Searching for Theoretical Linkages

Unlike the empirical literature, there are only relatively a few of analytical economic paper that are explicitly related to the linkage between poverty and environmental degradation. The existence of generally accepted theory, sometimes are questioned, even by an economist like Parta Dasgupta, who is considered one with the most authority in this field (Dasgupta, 2000: p. 623[12]). However, this rarity of relevant analytical works should not avoid us from trying to get insight from theoretical point of view over this issue. One strategy that could be followed, is to broaden the literature into those that may not explicitly discuss poverty per se, but may be relevant if different interpretation of those models is inserted. In the section that follows, I will discuss Dasgupta's model, which setup a simple analytical model that put poverty and environmental degradation explicitly, and I will also discuss some theoretical work from the field of environmental/resource economics which will be relevant. Those analytical work will be differently interpreted and put into the context of this paper, and hopefully become an important contribution of this paper, since theoretical insight are lacking in the literature on the linkage between poverty and environment.

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[12] Dasgupa (2000, p. 623) admits that those works may not amounts to a theory, but it is more like a new perspective.

3.1. Dasgupta's Hypothesis of Poverty-Population-Environment Nexus

In explaining the linkage between poverty and environmental degradation, Dasgupta's (2000) model is a combination of how the poor in rural economy, population, and environment are related to each other within the context of common property resources. In his deterministic and static model, a common-property-resource-based rural economy consist of N identical households, each has n household members maximizing the quadratic production function (or net income, which we could regard as level of well-being, the lower of which could be considered poverty).

$$\max_{n} y(n) = -\alpha + \beta n - \gamma n^2 \tag{1}$$

where $\alpha, \beta, \gamma > 0$ and $\beta^2 > 4\alpha\gamma$. Each household maximize equation (1) taking α, β, and γ [13] as given. Household optimum decision will result in $n* = \beta/2\gamma$ and $y* = -\alpha + \beta^2/4\gamma$.

This model implies that environmental degradation (e.g. represented by increase in α or γ, or decrease in β) can reduce $y*$, hence poverty[14]. However, it does not yet tell anything that the reverse (poverty cause environmental degradation) may occur. Dasgupta (2000) then follows that the state of the local natural-resource base is a function of the total village population, M, or $\alpha = \alpha(M), \beta = \beta(M), \gamma = \gamma(M)$. The higher the total village population, the lower the state of the resource. However, the total population M is not in the consideration of optimizing behavior of each household. It is an externality problem, which Dasgupta (2000), calls as 'reproductive externality'. In a symmetrical equilibrium, $M* = Nn*$.

Does the model, now, imply that poverty can cause environmental degradation? As figure 2 illustrates, a downward shift in the production function (for example due to

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[13] α, β, and γ are simply parameters of the quadratic function that is tried to represent the state of the resources. A change in those parameters such that it shift down the quadratic function then make productivity of household will be lower for each labor input. Given only labor and resources are input in the prodution function, then those change represent the lower state of the resources.

[14] In this simple, model, as households are assumed to be identical, lowering income level of a household imply more poverty in the whole village.

exogenous resource degradation) from $y_1(n)$ to $y_2(n)$, will make household find itself poorer (lower y) and n_1 is no longer its optimum household size. This household, then, starts to demand more children, and n_2 now, becomes its optimum household size. Increase in optimum household size, in turn, translate into higher village population M^* and, consequently, lower the state of the environment, through changing α, β, and γ, as now they endogenously depend on M^*. Dasgupta's (2000) simple analytical model, now, illustrates the linkage that poverty may cause environmental degradation. As Dasgupta (2000, p. 635) emphasizes:*" … what would happen along this pathway is that poverty, household size, and environmental degradation would reinforce one another in an escalating spiral.*" In short, Dasgupta emphasizes that the model create a linkage among those three variables, each of which is viewed as being endogenous.
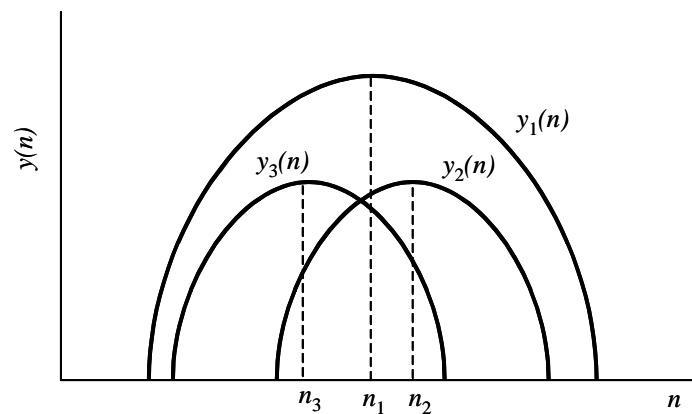

Figure 2. Household income per head as function of household size

Whether or not this model has given significant contribution to our understanding of poverty-environment linkage is conditioned by the following critical notes. First, Dasgupta's model does not say that poverty directly cause environmental degradation, it is channeled through other variable namely population growth or increasing household size. Therefore, population is importantly indispensable, could not be excluded, in poverty-environment nexus. Being poor in itself, is not the cause of environmental degradation. If a household, for instance, decides not to increase its family size, as a response to being poorer, then we could

not simply accuse the poor as agents of environmental degradation. Figure 2, again illustrate this point, where production function could shift to $y_3(n)$ resulting in lower optimum household size n_3, and thus do not create negative externality[15]. Therefore, the poor degrading the environment, as a response to being poorer, is not a general result of this model. This model could not be used as a theoretical backup to say that poverty is the cause of environmental degradation, especially while overlooking population growth factor.

Secondly, the fact that poverty and environmental degradation are both endogenous does not enable us to unambiguously states what cause what. This is empirically relevant, as case or site-studies usually shows far more complex relationship, mediated through various macro and micro-level factors that include policy measures, markets and prices, local institutional arrangement, gender relations, property rights, entitlement to natural resources, and so on (Word Bank, 2001, p. 11).

Finally, Dasgupta (2000) does not stress the role of property right even though if we look at the model setup we may see that it is not poverty but ill-defined property right that is the biggest cause of environmental degradation. It is in the model setup that the resources on which the rural poor depend is assumed to be common-property, and that is why the externality effect occur. The setup that the property right is common is very critical to the model, and it is the one which drives Dasgupta's (2000) conclusion that poverty may have adverse effect on the environment. If the assumption is relaxed e.g. resource is either private property, or better-managed common property, such that optimum population size is internalized, then such feedback from being poorer to more environmental degradation, or "the escalating spiral" would disappear[16].

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[15] Dasgupta (2000) discuss the possibility of such shifting in $y(n)$ but not discuss the implication to our relevant issues of whether respons to being poorer are increasing household size, thus increasing environmental degradation.

[16] More formally speaking, if the resource is now private property, the household decision to increase its size (after exogenous production function shift, for example) would not change α, β, and γ. In this situation, the lower quality of the resources is not caused by household repons.

In addition to some critical constraints of this model in explaining poverty environment linkage as discussed previously, there are many other limitations of this model. Firstly, Dasgupta's model is too simple to be able to capture the big picture of poverty-environment nexus, because it may only apply to very specific places, hence as a theory it may not hold in general. Serious environmental degradation such as large-scale deforestation, for example, occur in places where interaction between villagers and outside world are frequent, not in a closed rural economy. This interaction may be very important determinants in the nexus, because such factor as market infiltration, profit, or even government involvement may enter the picture. A very closed rural economy may only apply in places where indigenous people lives and mostly they are people who are more attached to nature, their habitat. Their size of population are mostly negligible compared to the sizable scale of their neighboring resources, hence they are not danger to the environment.

In addition to its lack of generality, some other issues which is standard to analytical economic model is not present. Utility function, which could be more relevant, among others is not specified and maximization of net production (not utility) is also easily questioned. Finally, the model does not capture the dynamics which may imply that it disregard the issue of dynamic efficiency. Most problem in natural resource or environment are dynamic in nature because today's decision of economic agents have long run implication. A static model may suffer from over-simplification of this reality.

However, despite those limitation, the analytical model of Dasgupta (2000) may have a close link to some conclusion drawn from the empirical literature. Firstly, the model stress the role of population, similar to what is concluded in Ekbom and Bojö (1999, p. 10–11) that population pressure exacerbates both poverty and environmental degradation.

3.2. Clark Dynamic model of Renewable Resources: The Role of Discount Rate

Clark model, is a standard general dynamic model of optimum extraction of renewable resources, building upon that found in the fisheries literature (Swanson, 1994). The model generally can be used to explain what may cause renewable resources non-sustainably depleted or even extinct. The purpose of this model exposition is to see whether and to what extent we could infer some relevant connection between poverty and how the resources are degraded.

In this standard model, an economy has the following societal (centralized) objectives[17].

$$\max_{y} \int_0^{\infty} [p(y)y - c(x)y]e^{-rt} dt \tag{2}$$

$$\text{s.t. } \dot{x} = H(x) - y$$

Where $p(y)$ is the inverse demand curve (a function of the aggregate harvest, y), $c(x)$ is the average cost of harvest (a function of stock level, x), $H(x)$ is the growth of the resource, and r is discount rate.

Lower level of stock of the resource could represent environmental degradation relevant to the question of this paper. The optimal stock (x^*) of the resources will follow the following first order condition.

$$x^* : \frac{\dot{\lambda}}{\lambda} - \frac{c'(x)y}{\lambda} + H'(x) = r \tag{3}$$

Where λ is the 'shadow price' of a unit of resource stock which equates with resource 'rent' in equilibrium. The LHS of arbitrage condition in equation (3) is the rate of return from the resources (e.g. fisheries, or biological assets, or could be bio-diversity). Hence, environmental resources compete with other assets in term of its return and must be equalized

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[17] I follow the exposition of Clark model based on Swanson (1994).

if arbitrage condition must hold. As the return on *x* is decreasing in *x,* it implies that the higher the discount rate, the lower the stock of resources (*x*).

The model does not have explicit story about poverty. However, as it is considered a plausible argument that poverty is associated with higher discount rate (for example, Pearce and Warford, 1993; Pearce, forthcoming, Ekbon Bojö, 1999), this model may imply that poverty may cause the stock of resource to be optimally lower. Discount rate, or the rate of time preference refers to the willingness to trade current benefits for future gain. For the poor, the short run-benefit is day-to-day survival, and hence creating an urgent need for immediate gain. This situation is, in some places, supported by the fact that in poor rural area, interest rate from informal credit market is usually high (Ekbom and Bojö, 1999, p. 9). Empirical evidences also strongly support this hypothesis[18]. Hence, this standard analytical model, could relevantly be brought into the context of poverty and environment nexus. It bring relevant possible theoretical story on the mechanics of how poverty may lead to environmental degradation.

If open-access situation is added into the model, another interesting relevant insight would also worth discussing. If the resources is uncontrolled (resulting open-access situation), then individual harvester do not consider the effect of his action on the stock of resources. The decentralized optimization problem will become,

$$\max_{y_i} \int_0^\infty [p(y)y_i - c(x)y_i]e^{-rt}dt \tag{4}$$

$$\text{s.t. } \dot{x} = H(x) - y$$

where y_i is individual harvest, in contrast with aggregate harvest *y*. The following relevant first order condition must hold.

$$y^*: \lambda = p - c \tag{5}$$

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[18] See for example the recent article by Holden et al (1998).

$$\text{for } \dot{\lambda} = 0 \text{ , } \lambda = \frac{c'(x)y}{(r - H'(x))N} \tag{6}$$

As number of harvesters (*N*) become very large, equation (6) suggest that shadow price of resource (or resource rent) will be eventually close to zero. Equation (5), then will imply that the price received from the flow of reserves is equal to cost of production. In a fisheries literature, this is called 'rent dissipating effect', and could be a theoretical explanation of why poverty is very common in open access resources[19] such as fisheries[20]. Incomplete property rights reinforce the vicious poverty-environment circle.

The dynamic setup of this model is one of the advantages over the static one such as Dasgupta's model discussed previously. In term of economic point of view, the model ensures that the economy is efficient in a static and dynamic sense. Objective is maximized over the long run. However, again in our context, the model has the following caveats. Although, it may be true that poverty, through lower discount rate, may result in lower stock of resource, does this lowering stock constitute an environmental degradation, given the fact that it is optimum for the society to have that lower stock of resource? Again, a more precise definition of environmental degradation is necessary. This applies too to Dasgupta's model discussed earlier.

One problem that may arise is if the resulting "optimum" lower stock is also caused by misappropriation of the resources. Some environmental resources may have value as a stock, for example the value of forest is not only as a source of timber to be harvested, but also as a source of biodiversity. Some species may have value if it exist, and when it vanishes it may create disutility to society. This appropriation failure are prevalent because those values may not be tangible (or ignored) to economic agents that have command over the

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[19] Although the causality between environment and poverty is less clear here, but it is a good of why story of why institutional failure in the form of open access situation will be correlated more poverty.

[20] In Indonesia, for example, It was estimated that 80 percent of the fishers and their families lives in the national poverty line. Fisheries in Indonesia involve not only the 4 million people employed but also other 3 or 4 member of their families which constitute more then 15 million people alone (http://www.fao.org)

resources. The value of forest for as a stock of carbon (to reduce the global warming), could only be seen by global community but not by the locals. This model does not take this into account. Technically speaking, it does not include the possibility that the stock x in itself generate return to society, or somebody else (externality). It only include the profit generated by harvesting the stock. This imply that the setup of this model i.e. having profit instead of welfare or utility as its objective function is one of the greatest weakness of this model. Using utility as the objectives function may improve the model because we can setup utility also a function of the stock of the resources. Lower discount rate, combined with this 'appropriation failure' may in fact make this excessively lower stock into more serious problem.

The appropriation failure discussed above, however, is not a story that may support the hypothesis that poverty is the cause of environmental degradation. It is more relevant to be considered as one of the market failure argument i.e. the failure of market to properly value the scarce environmental resource. However, in such an imperfect world, still, it is fairly relevant to say that that poverty may worsen the situation.

3.3. Clark-Swanson Model: Beyond Discount Rate

Swanson (1994) extend the standard Clark model, by adding another control variable i.e. resource base (R) i.e. another type of resource as complement to the environmental resource in question (e.g. ocean for fishery, land for elephant, forest for biodiversity, etc.). He argues that increasing base resource (e.g. increasing land area for elephant to live) will shift up the growth function of resource. However, providing additional land has opportunity cost, i.e. the use of land for other purpose ($r\rho_R R$, where ρ_R is the price of land). Therefore, in Swanson (1994) model society has the following problem.

$$\max_{y,R} \int_0^\infty [p(y)y - c(x)y - r\rho_R R]e^{-rt}dt \tag{7}$$

$$\text{s.t. } \dot{x} = H(x;R) - y$$

In addition to standard first order conditions, another additional condition must also hold.

$$R*: \frac{\lambda H_R}{\rho_R} = r \qquad (8)$$

This implies that a particular environmental resource, x, will receive allocation of base resource, R (e.g. elephant will receive sufficient land allocation) only when it is able to generate a competitive return from this use.

This model imposes another constraint to environmental resource i.e. besides it must be able to earn a competitive return on its own stock – result from the standard Clark model – it must also be able to earn a competitive return on the base resources that it requires for its sustenance (Swanson, 1994, p.813). In other words, when the value of alternative use of land is higher, less base-resource will be allocated, and hence reducing the stock of the particular environmental resource. In short, environmental degradation may also be caused by unwillingness of human to invest in the required ancillary resources.

As it is plausible argument that investing in base resource (conservation) is less possible to be among the available choices of the poor, we can put this model into our context of poverty-environment nexus. For the poor, conservation in base-resources may be a luxury and they simply cannot afford it. The argument that poverty limits people's choices and induces them to deplete resource faster, then aggravate the process of environmental degradation is not new. However, Swanson (1994), from different angle, emphasizes that some type of environmental resources in fact competing with us for the use of certain base-resources. Elephant and human are actually competing each other for the place to live in poor African countries. Swanson's (1994) extension of the Clark model gives a formal theoretical linkage explaining why certain types of environmental degradation, such as species extinctions, bio-diversity loss, are prevalent in poor countries.

Swanson (1994) continue by adding another variable i.e. management service as a control variable, and extend the societal problem into,

$$\max_{y,R,M} \int_0^\infty [S(y,R,M) - c(x)y - r\rho_R R - r\rho_M M]e^{-rt}dt \qquad (8)$$

and add one more condition as a result,

$$M*: \frac{S_M}{\rho_M} = r \qquad (9)$$

which simply says that the amount of resource invested into management of environmental resource (*M*) has to yield a competitive return as well. Although this extension is trivial, but the relevance to poverty-environment nexus seems to be very important. Without explicitly, emphasizing this point, Swanson (1994) has endogenized property-right regime into the model. Management service can take a form of investing in security to national park, the lack of which, for example, can turn a state property into an open access resources. Thus, open-access situation is simply caused by lack of resource, poorer country will not be able to afford guarding a vast area of forest, for instance, and consequently, the forest become an open access property.

In the poverty-environmental nexus, which also involve institutional failure, Swanson (1994) extension turns to be a potential new feedback linkage. It provides a new mechanics of how poverty may create ill-defined property right and in turn create environmental degradation.

Swanson's (1994) extension to standard Clark model, however, still do not incorporate the possibility that the amount of stock of resource in itself may have value to the society. Moreover, the idea of base resource may only be relevant to certain type of environmental problem, such as species extinction, as this model intends to be focus on at the first place. In addition to that, in general, it is not always clear which resources are base (ancillary) to which resources. Base resource, in it self, such as land, may be degraded (erosion). However, despites its lack of generality, Swanson's model, if put into the proper

context, has generated new insight and understanding that may be relevant in the context of linkage between poverty and environmental degradation.

3.4. Environmental Kuznet Curve (EKC) Hypothesis

EKC hypothesis simply says that environmental degradation are positively associated with level of development, but until certain point, the relationship is reversed i.e. higher income is associated with better environmental quality. It was based on empirical ground that there is a relationship between income per capita and concentration of industrial pollution (Dasgupta and Mäler, 1994, p. 5). Environmental degradation is increasing functions of income when income is low, and is decreasing function of income, when income is high (inverted-U shape).

The EKC hypothesis may be relevant in our context because although this hypothesis is based mainly on empirical basis[21], the relationship between income level and environmental degradation is of course, in the interest of the issue of poverty-environment nexus, because poverty is simply synonymous to certain low-income level. Moreover, as our interest is in the left part of the curve, it implies that lowering income level (more poverty) will improve the environment, and increasing income is the cause of environmental degradation. In short, we have a trade-off between level of well-being and environmental quality. EKC hypothesis may also support the fact that environmental degradation to some extent may be desirable. If the benefit of moving from lower income to higher income, is lower than the cost of having more environmental degradation, then society is better-off. This has also been discussed earlier in the context of optimum environmental degradation.

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[21] Theoretical argument of EKC hypothesis may also be found in Lopez (1994) and Selden and Song (1995) which mainly use the framework of neoclassical growth model that show how the relationship between income and pollution level can have U-shaped.

Another relevant interpretation of the EKC hypothesis is it may be seen as a support that development in general (in the form of increasing income) is one of the cause of environmental degradation. Exploiting natural resources for the shake of development is unavoidable, especially when it is optimum to do so. Dasgupta (1999, Dasgupta and Maler, 1994, Dasgupta, 1994), however strongly criticizes the relevance of EKC hypothesis in the poverty-environment nexus. Not only because of its strong implication i.e. the only way to lower environmental degradation is to have more poverty, but also the irrelevance of type of environmental problem in the EKC hypothesis i.e. air quality which more of a problem of developed countries. The environmental problems in poor countries are totally different. As Dasgupta and Mäler (1994, p. 8) pointed out: "… *as regards local environmental resources (e.g. local forest products, grazing lands, water sources), the link between poverty and the environment is different from that suggested in the Environmental Kuznet Curve*."

With regard to our context, simply disregarding EKC hypothesis will not be wise at all, because, as hypothesized in the preceding empirical literature, one of the main cause of environmental degradation is power, wealth, and greed (Duraiappah, 1998), and in some studies it is evident, that the riches are the agents of environmental degradation. With careful distinction of relevant environmental problem, EKC hypothesis could be a good theoretical support of those hypothesis.

3.5. Theory and Empirics: Consensus, Missing Links, and Caveats

Figure 3 illustrates the summary of how the survey on the theoretical literature based on analytical economic model extend the poverty-environment nexus based on existing empirical literature. Bold line in the figure indicate the extension of theoretical literature to the conclusion of empirical studies. Either it complement the empirical conclusion by adding theoretical supports or provide new potential linkages.

As figure 3 indicates, firstly, the result of the preceding theoretical surveys adds and emphasize the role of population growth, that elaborate the mechanism of how poverty may affect environment degradation (Dasgupta's hypothesis). Secondly, Clark's model of optimal renewable resource extraction provide, in-between explanation, of how poverty may affect environmental degradation through the role of lower discount rate. Thirdly, lower investment of base resource, as the possibility in Clark-Swanson's model adds more possible theoretical explanation in the way poverty may affects the environment. In addition to that, Clark-Swanson model also introduce the link from poverty to institutional failure. And finally, EKC hypothesis may be used as a support that it is, development in general may cause environmental degradation.

The strongest consensus that arises between empirical and theoretical approach is the importance of property right. Analytical models discussed in this paper support the finding in empirical literature that ill-defined property right is one of the primary root of most environmental problems. This has a very strong policy implication. As environmental degradation, unambiguously, lead to more poverty, then attacking its root i.e. ill-defined property right will be a poverty-reduction policy that is also environmentally-friendly. Improvement in the tenure system or better management of common property resources will be among the preferable type of approaches. In addition to that, making sure that population growth does not lead to excessive extraction of resources, will be a good policy to be recommended. This has both empirical and theoretical basis.
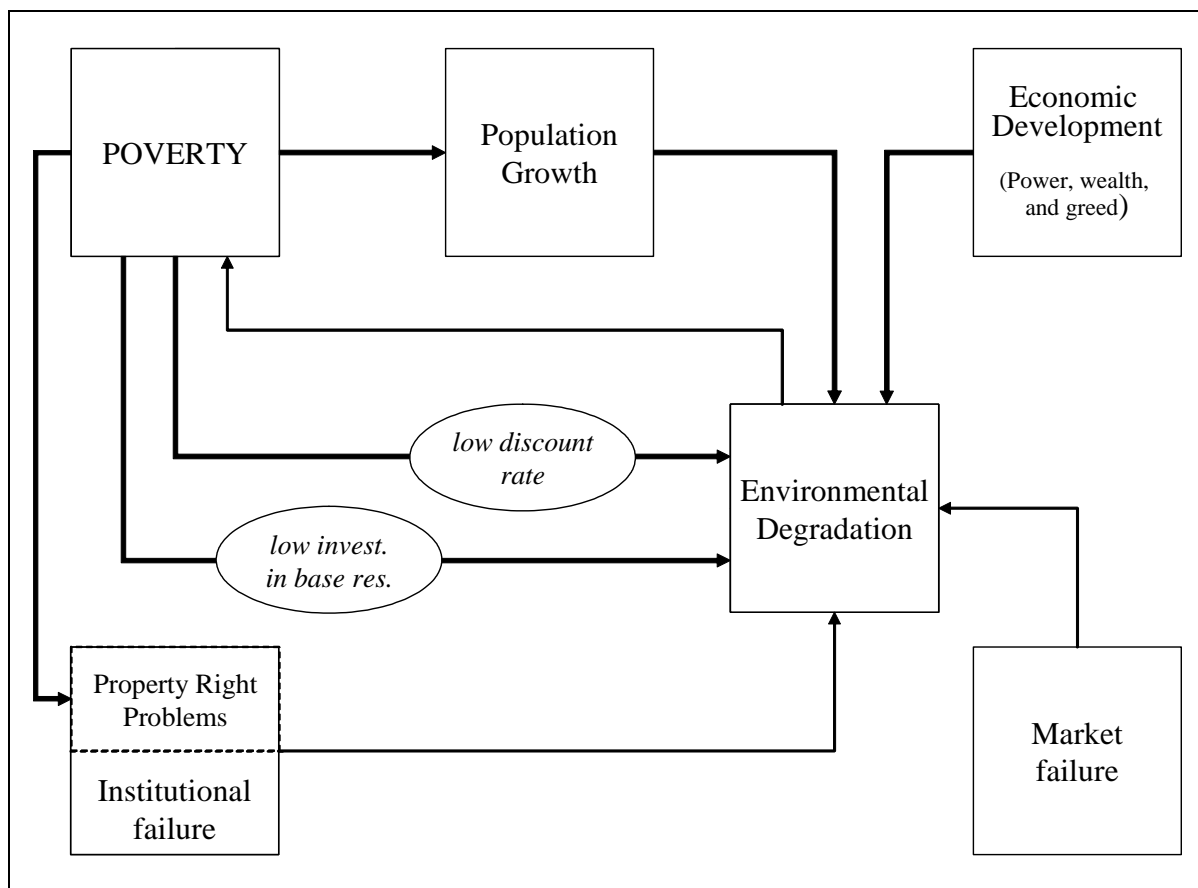
Figure 3. Poverty-environment 'extended' nexus
Note: bold-line indicate the contribution from theoretical literature

Both empirical and theoretical literature discussed here, however, seems to be less precise in defining environmental degradation. From the 'economics' view point, environmental degradation, to some extent, may be optimal to the society. Simply, a decrease in a stock of resources could not be classified as environmental degradation. Non-sustainable use and non-optimal use of natural resources may be a more relevant term. This redefinition environmental degradation may possibly give different insight into the problem, but currently this seems to be one of the caveats of current literature.

When we discuss about optimal use of natural resource, however, one big caution, has to be pointed out. The proper optimum only observable when we live in "the first best" world, i.e. such as no-externalities in any sort. One of the example that is missing in the

analytical literature discussed previously is the possibility that environmental resources as a stock could also generate utility to society. In more general form we may call this as appropriation failure. This is also in the class of market failure. Furthermore, not only the market that may be fail to appropriately value the resource, so may the poor. Putting into the context of Swanson's model, for example, the decision of the poor not to invest in base resources may be caused by lack of their knowledge of the real value of the resources. There is also other cases where they may know the proper value, but they can not capture them, because the resource only valuable to other people very distant to them. Species extinction, biodiversity loss, and global warming are among them. This important issue seems to be lacking in both empirical and theoretical work.

In the previous discussion of theoretical literature, the link on poverty to standard model of optimal renewable resource depletion is through the lower discount rate. There are two important issue that is still need to be explored further, and it is actually in the current debate in the literature. First, the need of the theoretical linkage between poverty and the rate of time preference. More formal argument about this linkage is currently needed (Pearce and Warford, 1993), because this argument is mainly backed by some empirical works, and a few of them actually suggest no correlation between the two (Ekbon and Bojö, 1999). This possible weak link may question the relevance of Clark's model in our context. Secondly, recent development in the relevant literature (see for example Groom et al, 2003, and Gonzalo, 2003) may suggest that standard practice of treating discount rate in benefit cost calculation or even in dynamic optimization as exogenous and constant may no longer relevant. The new finding of this current development will be of significant relevance to our context as well.

As any economic analytical model, the models surveyed above, may always be criticized through their plausibility of their assumptions. They, among others, rely on the

setup that the poor are also optimizing rational agent, which may not be true in practice. On the one hand, the fact that Dasgupta's model only capture static picture of the problem may also be questioned. Clark's model and its extension by Swanson (1994), on the other hand, despites its dynamic setup, may be more suitable for only certain type of environmental degradation[22] and also rely on competitive market assumption, which may not always hold in the places where the poor live. However, despites all these drawbacks, those models provide us with more understanding of how the mechanics works in the poverty-environment nexus, especially using the language of economics.

5. Concluding Remarks and the Way Forward

To conclude, the consensus that arises from existing empirical literature suggest that environmental degradation adversely affect poverty, due to their heavy dependence on natural-resource base, and limited resource to cope with adverse environmental effect. However, the thesis that the poor are also agent of environmental degradation seems to be a too strong argument. Being poor per se is not the cause of environmental degradation. There are many others factors involved, but the main important ones are institutional failure in the form of ill-defined property right and population growth. This more or less is confirmed by the theoretical literature surveyed in this paper. However, analytical literature extend the empirically-based poverty-environment nexus, either by adding theoretical supports or provide new potential linkages, such as how environmental degradation could be seen as rational decision of the poor to disinvest in base-resource and the way that institutional failure may also be endogenously caused by poverty. Some drawback of current empirical and theoretical literature and potential unexplained picture of the nexus are also discussed in preceding sections.

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[22] For example, Swanson's (1994) extension is more suitable to explain species extinction and biodiversity losses.

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