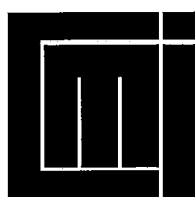


Economic Analysis of Land Degradation in Indonesian Upland

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Summary:

The objective of this research is to determine factors affecting land degradation in the upland in Indonesia, and to suggest appropriate policies regarding land-use. The regression results indicate that about half of the variance in land degradation in the regional data set is explained by the variation in cropping intensity, population pressure, income per capita, transmigration, and conditioning variables. Sensitivity analysis shows that the variables for population pressure and income per capita in both data sets, and transmigration in the provincial data set are robust in explaining variation in land degradation. The results of this study could be taken as a signal to reevaluate the rice self-sufficiency policy. Efforts to increase the productivity of rice should not always be interpreted as an expansion of rice area, especially for some marginal land outside Java. Several policy recommendations are suggested by the analysis: (a) reduce intensive land-use practices, (b) reduce population pressure, and (c) promote a strategy to raise income.

Indexing terms:

Land degradation
Soil erosion
Agriculture
Indonesia

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1. Introduction¹

The role of Indonesian agriculture in the national development strategy has meant increased pressure for upland cultivation with intensive food crop practices. One part of government's economic policy has been an expansion of the agricultural area through transmigration and other extensification policies with the goal of maintaining self-sufficiency in rice and other food crops. Yet, area expansion has created pressure on marginal land and steeper slopes, thus the government has initiated several soil conservation projects throughout the country. The goals of the projects are to increase farm production and incomes, while reducing soil erosion. The projects are implemented through input and capital subsidies for terracing and related conservation measures. Persuading farmers to adopt terracing, alley cropping, agro-forestry and other conservation practices through capital and input subsidies is believed to be a panacea to minimize land degradation.

However, these agronomic policies alone cannot steer the process of land degradation unless complemented by economic and price policy. The most recent evidence regarding the sustainability of such conservation projects in Indonesia indicates that the effects of the operating subsidies are not sustainable (Huszar *et al.*, 1994). The altered management practices are neglected once the projects and the subsidies are terminated. High dependence on input subsidies is cited as the main cause of the failure of the conservation projects. The effects of the capital subsidies may persist longer for capital effect fixed in place of the land. But these effects are probably not sustainable either. If farmers lack the financial means to sustain the use of improved inputs, they may also lack the means and motivation to maintain the terraces. Evidence from other developing countries indicates that a case-by-case approach to environmental projects without the support of economy-wide changes is not successful (Schramm and Warford, 1989).

In a more specific context, the underlying cause of upland land degradation in relation to economic changes is not very well understood. Part of the problem is that the quantification of land degradation is extremely difficult. Many studies lack any historical perspectives and are often trapped in "single spot" analysis. For example, until the late 1980s or early 1990s, some economists have applied natural resources accounting approach to value the economic depreciation caused by land degradation (Magrath and Arens, 1989; Repetto *et al.*, 1989). Despite their

¹This is a short version of my Ph.D. dissertation at the University of Wisconsin-Madison, USA. Sincerest appreciations, are due to the committee members: Professors Richard Barrows, Ian Coxhead, William Thiesenhusen, Russell Middleton and Calvin DeWitt for their helpful suggestions. Thanks also go to Arild Angelsen, Ussif Rashid Sumaila and participants of a seminar at the Chr. Michelsen Institute for their comments and interesting discussions. Arild Angelsen also gave detailed comments to a draft version of the paper. The responsibility for any remaining errors and omissions is, of course, mine.

contribution to the growing literature of sustainable economic development, such studies have several limitations. The study by Magrath and Arens (1989) extrapolate a specific region's estimate into the entire nation, which is clearly not very useful, and may even be directly misleading. Moreover, the economic explanation of the process of land degradation and the cause – effect relationship are not clearly specified. Consequently, such studies do not offer insight into land degradation incentives and how to reduce the erosion rate to approach the rate posed by natural process. Therefore, it is important to document and examine the nature of land degradation, both as a cause and consequence of economic change. The case of upland agriculture in Indonesia provides an exemplary opportunity to study the economic causes and consequences of land degradation under conditions typical of many developing countries. In this research, empirical estimates of the determinants of land degradation using data for all of Indonesia over time will show that intensive land use practices, population pressure, income per capita and transmigration programmes are important determinants.

The objective of this research is to determine factors affecting land degradation in the upland and to suggest appropriate policies regarding upland land-use in Indonesia or elsewhere in developing world. The study will contribute to the improvement in the analytical frameworks of land degradation literature. It will emphasize provincial and regional analyses given physical and economic disparities between Java (and Bali) and the other islands. Soil erosion estimates in this study will be derived for each province based on the information on physical resources and land use from recent and highly detailed, satellite imagery data (RePPPProT, 1990). The conclusion of this study will address economic policy reforms and land degradation issues in developing countries. In the next section, we review economic theory on the causes of land degradation. In section III, we present the extreme bound analysis (EBA) as an analytical framework to identify factors affecting land degradation. In sections IV, we present and discuss the empirical results of data analysis, the implications for economic policy on land degradation issues in Indonesia and other developing countries. Finally, we conclude the paper with recommendations for future research on land degradation.

2. Economic Theories of Land Degradation

The beginning of an economic theory of land degradation can be traced to the "classical" debate over the Malthusian model of population, resources and economic growth. The current form of the debate is captured in the work of followers of Malthus and Boserup – known as Neo-Malthusian and Neo-Boserupian models, respectively. This debate has contributed to the literature of agricultural development and natural resources management. In the classical Malthusian model, land is viewed as a fixed input and land degradation is a result of population pressure. The limiting force of population growth is food supply and the survival wage. Land degradation can occur under high levels of population

pressure. The concern of the Neo-Malthusian model is the race between population growth and agricultural technological change. The most important feature of the Neo-Malthusian model is that the technology is held exogenous, unrelated to population growth.

The Boserupian model argues that technological change is endogenous, preconditioned by population pressure, though it alone does not insure that new techniques will be invented or adopted. The Neo-Boserupian model focuses on the effects of population growth. Population pressure can induce technological innovation, causing the society to search for new technology or adapt the existing technology to the new environment.

According to the Neo-Malthusian models, land degradation and other kinds of environmental deterioration occur as population pressure lead to an expansion of the cropping area, forcing the cultivator to move from the best lands available to more environmentally-fragile marginal land. As population increases, new land will be opened to cultivation. The most fertile land is cultivated and settled first, but the effect of this expansion is to allow for higher rates of population growth, such as has been the case of Java. Given a fixed amount of land and a fixed agricultural technology, the cultivable area per person will decline as population increases. In order to support the subsistence level of income, families are forced to expand the area cultivated by moving to marginal land, such as sloping upland. As population pressures continue to increase, the cultivation of ever-more marginal land leads to increased land degradation. The scenario becomes more complex when farmers adopt new agricultural technology, including a decision to cultivate the land more intensively and more frequently, which has some parallels to the Boserupian theory.

Neo-Boserupian models argue that the adoption of intensive land-use practices can result in the "mining" of soil. In fragile areas, agricultural production may destroy soil structures and thin the topsoils so that the capacity to reduce erosion and moisture is decreased. Land use-practices on marginal land may involve changing vegetation with deeper rooting systems to a food crop with a more shallow rooting, which is more susceptible to erosion. More importantly, the availability of essential nutrients for plant growth declines as the soil is degraded. The natural process of soil formation is far too slow in relation to the rate of "mining", especially given the rapid growth of population. In Africa and probably in most of the outer islands of Indonesia, soil "mining" is occurring on a large scale, causing much more irreversible damage than would be the case with soils in temperate climates which tend to have a "better" structure. In this case, the role of government policy in encouraging the intensive practices, but not the soil conservation, is important in explaining land degradation in the upland. The existing scenario is actually about the same as that postulated by Neo-Malthusian model, which argues that population pressure forces the cultivation into more marginal area which again leads to land degradation.

The present study uses the extent of soil erosion as a proxy for land degradation in the upland. Factors contributing to soil erosion have been well-identified by soil scientists and agronomists as: (1) the erosivity of eroding agent, (2) the erodibility of the soil, (3) the slope of the land, and (4) the nature and management of plant cover (Mitchell and Bubenzer, 1980; El-Swaify, 1982; Morgan, 1986). The multiplicative relationship among these components is known as the Universal Soil Loss Equation (USLE), the widely-accepted method to estimate the rate of soil erosion (Wischmeier and Smith, 1978). For more detailed discussion about the modification of USLE for tropical countries, including Indonesia, see Arifin (1995).

Economic studies of land degradation, including the present study, focus on factors determining land use and management, assuming the first three factors are relatively constant. In addition to the classical works of Neo-Malthusians and Neo-Boserupians, those of Levi (1976) in Sierra Leone, Redclift (1989) in Latin America, Potter (1987) and Barbier (1989) in Indonesia, Lele and Stone (1991) in Central Africa and Southgate *et al.* (1990) in Ecuador are examples of studies concerned with land degradation. From these studies, the factors contributing to land degradation can be summarized as: (1) intensive land use practices, (2) population pressure, (3) income per capita, and (4) poverty, insecure property rights and lack of land ownership. The influence of each factor is elaborated below.

First, intensive land use practices refer to change in cropping practices from slash and burn to long and short fallow system and eventually to more permanent cropping (*autonomous process*) and to the increased role of the state in enhancing productivity through encouragement of intensification practices (*policy-led process*). In upland agriculture, adverse environmental effects of autonomous intensive land use would arise when the positive effects of population pressure are superseded by the detrimental effects of continuous cropping. This is especially serious for fragile soils which are very dependent on vegetative cover for moisture and stability. Such soils are commonly found in most African countries and in the outer islands of Indonesia. Cropping practices on the soils which are converted from tropical rain forest will suffer from high acidity because plant residue requires a significant amount of liming. If the trees are completely removed from the area, the crops will experience lack of water and nutrients because the water holding capacity of such soils are low.

Second, one possible objection to the role population pressure in the theory is that most models employ a static notion of the concept of population density. Most Neo-Boserupian authors, including Boserup herself, tend to equate the *density* of population with the *pressure* of population. This might be true in the case of *land-surplus economy*, such as early century African countries and the outer islands of Indonesia or even Java where there is a reasonable degree of freedom of population movement. An alternative explanation to reflect the concept of

population pressure is applied by Levi (1976). Assuming the pressure on resources is due only to the food demand of the population, rather than the demand generated by commercial production, such pressure can be referred as population pressure. In other words, the shift in food demand is explained by the size of population, holding preferences and income constant. Therefore, population pressure will vary with the ratio of total population to total labour force (the dependency ratio plus one).² The greater the dependency ratio, the harder a given stock of labour will work to support the dependents and the less leisure it will have. Even if the land becomes more scarce or in a *land-scarce economy*, the ratio of population to labour force in a particular region reflects the population pressure on land resources. This concept of the dependency ratio could relax the assumption of homogenous land quality imposed by the concept of population density, but would have problems since the labour stock is directly related to its flow.

Third, income per capita is often cited in explanations of land degradation, particularly the influence of income level on land use activity and land degradation. The theory suggests that the lower the income per capita, the higher the possibility that the upland agricultural land will be degraded (WCED, 1987). Some evidence suggests the relationship of income per capita and land degradation to follow an inverse U-shaped curve (Antle and Heidebrink, 1995). Sometimes the term poverty is used interchangeably with the income per capita concept, but these are two different concepts which should be discussed separately. A region with high income per capita might have a high percentage of poverty, and vice versa. Examples include some provinces in Kalimantan and Java, where income per capita is high but the percentage of people living below poverty line is also high. Income per capita deals with the average returns to economic activity, while the poverty is also related to the distributional pattern of the income.

Fourth, in Indonesia, and perhaps most other parts of the developing world, land degradation nearly originates with and most directly affects the poorest members of society (Potter, 1987). Poor farmers who are dependent on small-holdings and low-return crops may be aware of soil erosion but may not be able to afford conservation measures. The opportunity cost of conservation investment may be extremely high. In this case, poverty may prevent households from making necessary investments, including tree crop growing activities. For many households

²In demography, dependency ratio is the ratio of dependents to the labor force or the population under age 14 and over 65 to the population of 15-64 years of age.

$$\text{Dependency Ratio (DR)} = \frac{P_{<14} + P_{>65}}{P_{15-64}}$$

$$\text{Thus, population to labor ratio} = \frac{P_{<14} + P_{>65}}{P_{15-64}} + \frac{P_{15-64}}{P_{15-64}} = \text{DR} + 1$$

alternatives to agricultural production hardly exist. Richer farmers with profitable crops that are highly erosive may not consider soil conservation if their returns do not seem to be affected by soil erosion losses, which might well be the case in the short-run (Barbier, 1990). Even though there is no clear direction of causality, it is clear that many environmental problems are positively correlated with poverty. Higher rates of land degradation might increase the poverty level as farming expands onto marginal lands and poorly suited and fragile environments.

Some argue further that the movement of agricultural labour onto marginal land is related to highly inequitable farm-size holding and land tenure patterns. For Indonesia, an additional cause could be the transmigration programme, a government policy that encourages permanent cropping practices and increases population pressure on the outer islands, often in marginal areas.

The hypothesis to be tested in this study is the following: *The variation of upland land degradation in Indonesia can be explained by the degree of intensive land use practices, population pressure, income per capita, and transmigration programme.* Formal econometric and statistical techniques based on the data available will be used to test this hypothesis.

3. Extreme Bound Analysis

Regression analysis is normally used to test such a hypothesis as the above one. However, a simple regression analysis is not adequate to analyze further the performance of each explanatory variable (see Levine and Renelt, 1992). An analytical framework known as extreme bound analysis (EBA) is employed in this paper to identify the magnitude of the factors affecting land degradation. The EBA is actually an empirical technique of analysis and a variant of specification searches, initially developed by Edward Leamer. In his subsequent works, Leamer (1983, 1985, 1990) suggests that data analysis should combine estimation with sensitivity analysis, which uses one alternative assumption at the time. Sensitivity analysis could demonstrate either that all alternative assumptions lead to essentially the same inferences, or that minor changes in the assumptions make major changes in the inferences. For example, a "doubtful" variable can simply be included in the equation or two different equations can be estimated, one with and one without the "doubtful" variable. Under the EBA one could determine inferences that are clearly supported by the data and are sturdy enough to withstand minor changes in the assumptions (Leamer, 1990).

The EBA techniques can be criticized because these techniques do not deal with serial correlations or non-normality (McAleer *et al.*, 1985). However, the authors' proposed method of combining backward and forward step-wise regression to handle the problems of choice of variables also suffers from the issues of inconsistency, particularly in the order of the steps and in the significant levels

(see the discussion in Leamer, 1985; Leamer and Leonard, 1985). Empirical applications of the EBA technique can be found in Cooley and LeRoy (1981), Levine and Renelt (1992), and others. Based on these empirical works, the present study uses extreme bound analysis (EBA) as part of the methodological framework. Consider the following regression:

$$Y_t = \alpha + \sum_{i=1}^n \beta_i X_{it} + \sum_{i=1}^k \gamma_i Z_{it} + u_t \quad (1)$$

where Y_t is the dependent variable, X_{it} is a vector of focus variables with coefficient β_i , Z_{it} is a vector of doubtful variables with coefficient γ_i , α is the intercept and u_t is the disturbance term.

Suppose that the primary interest is in estimating β_i - the coefficient of focus variable X_i . In this case, specification uncertainty is reflected by the inclusion of k doubtful variables Z_i . This is legitimate if there is no prior information or theoretical justification to include or to exclude those as conditioning variables. For k uncertain variables, there are 2^k regressions which could be defined by inclusion/exclusion some or all of the doubtful variables (Cooley and LeRoy, 1981). The regression equation for the present study can be written as follows:

$$E = \alpha + \sum_{i=1}^4 \beta_i X_i + \sum_{i=1}^4 \gamma_i Z_i + u \quad (2)$$

where E is the average annual rate of land degradation in the upland, X_i is a set of focus variables and Z_i is a subset of variables chosen from a pool of variables which are based on available theory as a potentially important explanatory variables of land degradation. The dependent variable E is calculated using a modified USLE, and available both for six regions (Sumatra, Java-Bali, Kalimantan, Sulawesi, Maluku-Nusa Tenggara and Irian Jaya), and for all 27 provinces in Indonesia. A much more detailed information about the average annual rate of land degradation can be found in Arifin (1995).

The focus variables are: intensive land use practices, represented by proxy cropping intensity (CI-POTEN), population pressure (PRESSURE), non-oil income per capita (GDP/CAP), and cumulative transmigration up to 1990 (TRANS-90). The pool of variables Z_i , which could affect the rate of land degradation include the 1961 population density (DENS-61), annual population density in the current year (POP-DENS), government expenditure on transmigration (TRANSEX), percentage of population living below poverty line in 1987 (POVER-87), and a set of dummy variables. In the regional data set, two dummies will be used: Java-Bali (D_JAVA+) and non-Java (D_NOJAVA). In the provincial data set, seven dummies will be used: Sumatra (D_SUMTRA), Java and Bali (D_JAVA+), Maluku-Nusa Tenggara (D_MLK-NT), Kalimantan (D_KALMTN), Sulawesi (D_SULWSI), and all regions of outside Java combined as non-Java dummy

(D_NOJAVA). For the definition and data sources of these variables, see Table 6.

The extreme bound analysis (EBA) will involve varying the subset of Z variables included in the regression. The ultimate objective is to find the widest range of coefficient estimates on each of the focus variables, or variable of interest, that are not rejected in a standard hypothesis test. In this study, the choice of combining sets of Z variables is limited to only three. First, the priority is given to the first three of the four continuous quantitative variables; second priority is the set of qualitative (regional dummy) variables. Including too many "doubtful" variables in the regression would eventually cause the variable of interest to lose its significance. Therefore, the total number of explanatory variables included in each regression is between four and seven.

Levine and Renelt (1992) have noticed that the EBA may cause multicollinearity, inflate the coefficient standard errors, and exaggerate the range on the coefficient of interest. However, since the multicollinearity really reflects a weak-data problem (Leamer, 1990; Kennedy, 1992), one should not simply think that the regression is bad and decide to drop a particular variable that might be important. Levine and Renelt (1992) further suggest that multicollinearity is not a procedural problem but rather represents the inability to identify a statistical relationship that is insensitive to the conditioning set of variables (page 944).

4 Empirical Results and Discussion

4.1 Base regressions

As explained previously, two data sets are used in the study: regional and provincial. The regional data set is an aggregate of six different regions or big islands of Indonesia: Sumatra, Java-Bali, Kalimantan, Sulawesi, Maluku-Nusa Tenggara, and Irian Jaya. Provincial data set is a detailed provincial characteristics of all provinces (except the special territory of Capital Jakarta and the youngest province East Timor). Regression results of the "base" variables in the regional and provincial data sets are respectively presented in equation (3) and (4) as follows (t-statistics in parentheses):

$$\begin{aligned}
 E-UPL = & 55.9 + 0.342 \text{ CI-POTEN} + 10.77 \text{ PRESSURE} \\
 & (2.42) \quad (2.78) \quad (2.23) \\
 & - 0.110 \text{ GDP/CAP} + 0.0002 \text{ TRANS90} \\
 & (-4.56) \quad (0.03) \\
 R^2 = & 0.45, \text{ SEE} = 23.13, \text{ F} = 12.26 \quad (3)
 \end{aligned}$$

$$\begin{aligned}
 E-UPL = & - 45.3 + 0.259 \text{ CI-POTEN} + 30.68 \text{ PRESSURE} \\
 & (-2.11) \quad (3.37) \quad (6.81) \\
 & - 0.083 \text{ GDP/CAP} + 0.118 \text{ TRANS90} \\
 & (-3.68) \quad (3.14) \\
 R^2 = & 0.21, \text{ SSE} = 57.20, \text{ F} = 16.20 \quad (4)
 \end{aligned}$$

The variables have the signs predicted by a wide class of models. All variables but TRANS90 in equation (3) are significant at the 0.05 significance level. In the regional data set, the base variables explain about half of the variance in upland land degradation in the pooled cross section-time series data from the 1980-1991 period. In the provincial data set (equation 4), the base variables explain about 21 percent of the variance in land degradation in the upland. Standard errors of regression in both data sets are small so that the F-ratio of the regressions is significant at the 0.01 level. This implies that the model performs well in explaining variation in land degradation in the upland (E-UPL) using all independent variables in the base regression. Durbin-Watson tests show no autocorrelation among the residuals in both data sets, implying no problems from using pooled data of time series and cross sections to estimate the land degradation models.

The addition of conditioning sets of "doubtful" Z-variables to the base models results in a wide range of changes in regression coefficients (β), coefficients of determination (R^2), and F and t statistics. The sources of these changes can be the relative sensitivity of the focus variables, and the relationship between the focus and conditioning variables. Tables 1 and 2 present correlations among variables for the regional and provincial data sets, respectively. From the tables, it is clear that some variables may be a source of multicollinearity. However, because the present study is interested in the nature of and the effects of doubtful variables on base variables, no statistical transformation has been performed to estimate or adjust for the multicollinearity. Also, explanation will be advanced by using more economic theory in the form of additional restrictions since multicollinearity is not a source of bias in regression coefficient estimation (see Kennedy, 1992). A quite high correlation coefficient (r is either negative or positive 0.9 or more at 95 percent significant level) is found among the variables of cropping intensity (CI-POTEN), population density (POP-DENS), initial population density: (DENS-61), dummy variables of outside Java (D_NOJAVA) and of Java and Bali (D_JAVA+). This observation supports the Boserup hypothesis that society responds to population density, the higher the population density, the higher the cropping intensity.

Tables 3 and 4 present the extreme bound analysis (EBA) for each of focus variables in the regional and provincial data sets, respectively. In both data sets, the sensitivity analysis shows that variables of population pressure and income per capita are robust and significantly different from zero. The robust and positive relationship between population pressure and land degradation is consistent with a wide assortment of economic theories of land degradation. Also, income per capita is inversely related to land degradation, shown by a robust negative coefficient of GDP/CAP variable.

A robust and positive regression coefficient is also found in the relationship between upland land degradation and the transmigration up to 1990 (TRANS90)

in the provincial data set. However, in the regional data set the coefficient is not statistically significant, perhaps because the amount of transmigration varies within region. Both extreme lower and upper bounds and the base regression yield a regression coefficient not different from zero. In addition, the regression coefficient for cropping intensity is positive but fragile in both data sets. By adding some combinations of the doubtful Z-variables, the extreme lower bound of the regression coefficient differ significantly from the base regression. A more detailed discussion of the robustness/fragility of each focus variable is given below.

4.2 *Intensive Land-Use Practices*

For the base regression, the effects of the intensive land-use practices variable on land degradation in the upland is consistent in both regional and provincial data sets. Recall that the proxy for intensive land-use practices is the ratio of harvested area of upland food crops to the potential arable upland, or simply termed the cropping intensity of potential upland. The working hypothesis is that the higher the cropping intensity in previous years, *ceteris paribus*, the higher the chance for the upland to experience degradation. Java has had the highest cropping intensity for many years. Harvested area of all food crops in Java is higher than that in other regions, where Javanese farmers can harvest their crops up to three times a year.

Although Java has experienced higher cropping intensity, it is important to note that the dependent variable is an *estimate* of land degradation based on USLE, rather than *actual* degradation. The *actual* degradation can only be measured in the field. One difficulty is that conservation practices are more extensive in Java than in the other regions (see Barbier, 1989), and conservation practices are not included in the modified USLE. However, much degradation in Java occurred prior to the implementation of government programmes and subsidies for conservation measures, which started in the 1970s or early 1980s. Research indicates that in many watersheds in Java the subsidy approach has *not* led to sustainable conservation practices in the long run (Huszar *et al.* 1994).

The extreme bound analysis (EBA) shows that the relationship between the cropping intensity variable and land degradation is fragile. Including some conditioning sets of doubtful or Z-variable changes the significance level of the cropping intensity variable. The fragility of the cropping intensity variable (CI-POTEN) in explaining the variance of land degradation can be traced to the relationship between cropping intensity and the set of Z-variables. Cropping intensity is extremely high in Java-Bali, but so is also land degradation. Since the combining sets of Z-variables have a pattern of variation similar to that of the cropping intensity variable, inclusion of the combining set decreases the significance level of cropping intensity variable. In other words, the fragility is

mostly caused by the presence of variables that are in nature highly correlated with the CI-POTEN such as TRANSEX and DENS-61 and POP-DENS.

4.3 Population Pressure

For the base regression, the variable for population pressure (dependency ratio plus one) is significant at 0.05 level in determining the rate of land degradation in the upland in both regional and provincial data sets. In other words, the null hypothesis that there is no relationship between population pressure and upland degradation can be rejected. In addition, the EBA shows a robust positive relationship in the regression coefficient for population pressure variable (at 0.05 level for the base and the higher bound and 0.1 level for the lower bound), after inclusion of combining sets of Z-variables.

As in the case of cropping intensity, population pressure is also higher in Java, with a high initial population density. The robustness of population pressure variable can be seen from the Tables 3 and 4. After inclusion of "doubtful" variables, even with those having high correlation with the focus variables (such as DENS-61, TRANSEX and some dummy variables), the changes in the coefficient are still within the limit of $\beta_i +$ two standard deviations. One concern with this population pressure variable is the difference in the regression coefficient between regional and provincial data set. For the base and upper bound extreme, the coefficient in provincial data is about twice as high as that in regional data set; but for the lower bound, the coefficients in the two data sets are about the same. This difference could have a significant impact on the elasticity of the variable, hence its policy implications, which could be caused by the nature of the variation in the dependent variable, rather than the nature of the population pressure variable.

4.4 Income Per Capita

The non-oil income per capita variable shows a negative sign in both data sets, as hypothesized. The lower the income, the higher the upland land degradation. For most farm households, lower income means lower opportunity to earn extra cash within the non-oil sectors. This translates into a higher dependency on agriculture. The EBA also shows a robust and negative relationship between the variable GDP/CAP and land degradation in both data sets, all at the 0.05 significance level. Inclusion of conditioning sets of Z-variables does not alter the sign of the regression coefficient. The result is consistent with contemporary theories, suggesting that poverty is an important contributor to land degradation (WCED, 1987).

Interestingly, the income per capita variable (GDP/CAP) does not show a strong negative correlation with the poverty variable (POVER-87), cf. Table 2. One

explanation is that any per capita or average income variable cannot incorporate the distribution of income among individuals. Even though it is clear that income distribution may explain some upland land degradation, a detailed discussion is beyond the scope of this study. The poverty level in 1987 does not represent poverty throughout the 1980-1991 observation period, which was one reason for excluding POVER-87 as one of the focus variables. Moreover, econometric analysis cannot explain the underlying process by which landlessness and small farm-size cause the land degradation.

4.5 Transmigration Programme

Cumulative transmigration up to 1990 has a statistically significant impact on land degradation in the provincial data set (at 0.05 level), but not in the regional data set. Aggregating the information of transmigration by region obscures important variations between provinces within the region. Some provinces in Sumatra (Lampung, South Sumatra, and Riau), Kalimantan (West and Central Kalimantan) and Sulawesi (Central and Southeast Sulawesi) have been chosen by the government as priority areas for transmigration.

This may explain why the EBA for the transmigration variable shows a fragile, positive, but not statistically significant relationship for the regional data set. Both in the base regression and in the regression with the Z-variables included, the coefficient for the transmigration variable is not significantly different from zero, sometimes even negative using the regional data. Transmigration increases both cropping intensity and population pressure, both of which could contribute to land degradation.

4.6 Z-Variables and Regional Characteristics

Inclusion of the "doubtful" Z-variables in the regression analysis produces some interesting results. The Z-variables might influence land degradation in the upland, but the data structure, weak theoretical justification, and potential multicollinearity problems prevent these variables from being chosen as focus variables. For example, the initial population density (DENS-61) has a high correlation with the present population density (POP-DENS) and the focus variable of cropping intensity (CI-POTEN). Also, the proxy variable of government expenditure on transmigration (TRANSEX) has a high correlation with transmigration variable (TRANS-90) and with initial population density (DENS-61). Regional characteristics which can only be classified as dummy variables have helped to fine-tune the regression analysis. Almost all dummy variables in the models are statistically significant in both data sets, and a rather constant pattern is observed. In the regional data set, only dummy for non-Java (D_NOJAVA) and for Java-Bali (D_JAVA) are used in order to avoid perfect collinearity. Dummy variables for

Sumatra and for Kalimantan consistently have negative signs, while other dummies have positive signs in the equations.

The main interpretation of these results is that the pattern of land degradation in Indonesia exhibits great regional variations. The regional dummy variables capture the effects of variables that are not included in the analysis, but that have important region-specific impacts on land degradation. For example, the soil erodibility factor (K) in the USLE model does not fully incorporate information on the depth of top soil – an important characteristic that varies geographically across the nation. Economic data on land use differences among regions cannot be captured in the regression models. Extensive shifting cultivation practices in Kalimantan may explain the low rate of upland degradation. However, because the land-use data of Central Bureau of Statistics (CBS) do not distinguish between permanent cropping and shifting cultivation, this important regional difference is omitted from the focus variables but it is captured by the regional dummy variables.

5. Policy Implications

The regression results can be used to analyze the likely land degradation response to policy-driven change in the independent variables. The concept of elasticity, the change in land degradation per one percent change in the independent variables, is a unit-free measure, where values are computed at the means of each independent variable (Table 5). It should be noted, however, that elasticities are not constant but change when measured at different points along the regression surface. As seen from Table 5, the elasticities of regression of the focus variables are less than one and about the same in both regional and provincial data sets, except for the population pressure variable in the provincial data sets which is 1.74. Interpretation for policy formulations will rely on the corresponding data set. Although the effects of the focus variables on land degradation are generally small, since elasticity is built on a *ceteris paribus* assumption for values of all other variables, an effect of a simultaneous change in several of these variables would be more profound.

For the cropping intensity variable, the elasticity is 0.11 in both data sets. Computed at means, a one-percent increase in the ratio of harvested area to potential arable land would increase land degradation 0.11 percent, holding other variables constant. Given only a slight fragility in the EBA results for this variable, policies that encourage more intensive practices on upland should be reassessed. Application of modern technologies in crop production in the upland should not always be complemented with more "soil mining" activities. As already explained, the Indonesian government encourages more intensive practices throughout the nation as part of a set of policies to increase food production, particularly outside Java and Bali. The transmigration policy is a significant

