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The Poverty/Environment Nexus in Cambodia and Lao People's Democratic Republic

Susmita Dasgupta
Uwe Deichmann
Craig Meisner
David Wheeler

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Abstract

Environmental degradation can inflict serious damage on poor people because their livelihoods often depend on natural resource use and their living conditions may offer little protection from air, water, and soil pollution. At the same time, poverty-constrained options may induce the poor to deplete resources and degrade the environment at rates that are incompatible with long-term sustainability. In such cases, degraded resources may precipitate a downward spiral, by further reducing the income and livelihoods of the poor. This "poverty/environment nexus" has become a major issue in the recent literature on sustainable development. In regions where the nexus is significant, jointly addressing problems of poverty and environmental degradation may be more cost-effective than addressing them separately.

Empirical evidence on the prevalence and importance of the poverty/environment nexus is sparse because the requisite data are often difficult to obtain in developing countries. The authors use newly available spatial and survey data to investigate the spatial dimension of the nexus in Cambodia, and Lao People's Democratic Republic. The data enable the authors to quantify several environmental problems at the district and provincial level. In a parallel exercise, they map the provincial distribution of poor households. Merging the geographic information on poverty and the environment, the authors search for the nexus using geo-referenced indicator maps and statistical analysis. The results suggest that the nexus is country-specific: geographical, historical, and institutional factors may all play important roles in determining the relative importance of poverty and environment links in different contexts. Joint implementation of poverty and environment strategies may be cost-effective for some environmental problems, but independent implementation may be preferable in many cases as well. Since the search has not revealed a common nexus, the authors conclude on a cautionary note. The evidence suggests that the nexus concept can provide a useful catalyst for country-specific work, but not a general formula for program design.

This paper—a product of Infrastructure and Environment, Development Research Group—is part of a larger effort in the group to understand poverty/environment links in different contexts. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Yasmin D'Souza, room MC2-622, telephone 202-473-1449, fax 202-522-3230, email address ydsouza@worldbank.org. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The authors may be contacted at sdasgupta@worldbank.org, udeichmann@worldbank.org, cmeisner@worldbank.org, or dwheeler@worldbank.org. January 2003. (40 pages)

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Susmita Dasgupta
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1. Introduction

Developing countries have serious environmental problems that range from soil erosion to contamination of urban air. Some problems have significance at the global level, such as greenhouse gas emissions and threats to biodiversity. Others, such as erosion and air pollution, cause significant damage at the regional or local levels. Since poverty is widespread, a share of this damage is generally borne by poor households. In some cases, poor households may degrade the environment in ways that are damaging both to themselves and to others. Conceptually, the existence of a "poverty/environment nexus" implies that one problem is a significant determinant of the other. Where this is the case, reducing poverty may be an effective way to reduce environmental damage, or vice-versa. Joint solutions may be highly cost-effective policy options when the two problems are simultaneously determined.

How significant is this nexus in practice? Numerous studies have suggested that environmental damage can have particular significance for the poor. Recent participatory poverty assessments, conducted in 14 developing countries of Asia, Africa, and Latin America, reveal a common perception by the poor that environmental quality is an important determinant of their health, earning capacity, security, energy supplies and housing quality (Brocklesby and Hinshelwood, 2001). Rural studies commonly observe that poor people's economic dependence on natural resources makes them particularly vulnerable to environmental degradation (Ambler, 1999; Cavendish, 1999; Cavendish 2000; Kepe, 1999; Reddy and Chakravarty, 1999). Other studies have assessed the health damage suffered by poor households that are directly exposed to pollution of the air, water and land (Akbar and Lvovsky, 2000; Bosch *et al.*, 2001; Brooks and Sethi, 1997; Mink, 1993; Songsore and McGranahan, 1993; Surjadi, 1993). In addition, environmental disasters and environment-related conflicts may have regressive impacts because the poor are least capable of coping with their effects (Albla-Betrand, 1993; Myers and Kent, 1995).

In some cases, poor households themselves may increase environmental degradation. Poverty-constrained options may induce the poor to deplete resources at rates that are incompatible with long-term sustainability (Holden *et al.*, 1996). In such cases, degraded resources precipitate a "downward spiral," by further reducing the income of the poor (Cleaver and Schreiber, 1994; Dasgupta and Mäler, 1994; Durning, 1989; Ekbom and Bojö, 1999; Mink, 1993; Pearce and Warford, 1993; Prakash 1997; World Bank, 1992; World Commission on Environment and Development, 1987). Rapid population growth, coupled with insufficient means or incentives to intensify production, may induce over-exploitation of fragile lands on steep hillsides, or invasion of areas that governments are attempting to protect for environmental reasons. Again, a downward spiral can ensue (World Bank, 1992).

The existing literature also suggests that the strength of poverty-environment linkages may be affected by factors as diverse as economic policies, resource prices, local institutions, property rights, entitlements to natural resources, and gender relations (Ambler, 1999; Arnold and Bird, 1999; Barbier 2000; Dasgupta and Mäler, 1994; Dutt and Rao, 1996; Ekbom and Bojö, 1999; Eskeland and Kong, 1998; Heath and Binswanger,1996; Leach and Mearns, 1991; Roe 1998). By implication, the relative strength of links between poverty and environment may be very context-specific Chomitz, 1999, Bucknall, Kraus, Pillai, 2001; Ekbom and Bojö, 1999).

What does the empirical evidence suggest about the actual prevalence and importance of the poverty-environment nexus and complementary problems? Here the actual record is sparse, because the requisite data are often difficult to obtain in developing countries. In principle, household-level studies can adequately test whether environmental problems have a disproportionate impact on the poor. In practice, such tests are rare. For example, some studies have established a link between poverty and consumption of wood fuel, and at least one credible study has established the relationship between indoor combustion and health (Ezzati and Kammen, 2001). However, the research also suggests the importance of intervening variables such as cooking practices (indoor vs. outdoor) and fuel choice (e.g., charcoal emits far fewer fine particles than wood). Children die of waterborne disease at higher rates in poor households, but again, research points to the significance of intervening variables such as water source quality and mothers' education (Merick, 1985; Filmer and Pritchett, 1997). Rigorous empirical studies that combine local-area environmental variables (deforestation, outdoor air quality, water quality, soil erosion, etc.) with standard household surveys are almost nonexistent. Similarly, very few local-area studies relate environmental quality to the number and characteristics of poor households.

Empirically, studies of the poverty/environment nexus generally have a spatial dimension because environmental problems are inherently geographical. For example, pollution of air- and watersheds is determined both by the scale of local emissions and the absorptive capacity of the local environment (itself determined by topography, wind speed, rainfall, temperature, altitude, etc.). The size of the relevant region is affected by the dispersal characteristics of the pollutant and medium: Particulate pollution from cement mills may only be dangerous in one urban region, acid rain from sulphur emissions may damage forests hundreds of miles from the source, and eutrophication from fertilizer runoff may affect ocean fisheries a thousand miles downstream from the farms that are the source of the problem.

From a spatial perspective, a potential poverty/environment nexus exists if environmental damage is significant in high-poverty areas. From a policy perspective, a potential nexus becomes interesting if two conditions are met. First, poverty and environment must be linked by at least one-way causation. Under this condition, joint remediation may be preferable to independent strategies for poverty alleviation and environmental improvement. Second, and at least equally important, the characteristics of poor households and environmental damage sources must lend themselves to cost-effective joint remediation. In the best of circumstances, developing-country governments may be stymied by the institutional and logistical challenges of programs to alleviate poverty or improve the environment. Economizing on scarce administrative and technical capacity often implies focusing the available resources on the most heavily-impacted areas. By implication, feasible strategies for addressing the poverty/

environment nexus will exploit administrative scale economies in contiguous areas where both problems are serious.

On the environment side, such scale economies reside in monitoring and enforcement systems. Monitoring is needed to track environmental damage and its sources (pollution, deforestation, etc.). Sustained improvement requires facilities for information collection, storage, retrieval and analysis, as well as staff for regulatory enforcement and technical assistance to agents whose environmental performance must be improved. The need for frequent inspections and consultations, coupled with poor transport infrastructure, suggests that sustained progress will depend on agencies that operate at the provincial or district levels. A similar logic applies to targeted programs for poverty alleviation. From a policy perspective, it seems reasonable to use the same geographic scale to identify poverty/environment nexus issues. In any case, the available data do not permit further spatial dis-aggregation. Accordingly, this paper will analyze the available information for Cambodia and Lao PDR at the district and provincial levels.

2. Mapping the Problems

2.1 Absolute Poverty

For each country, we begin the analysis by mapping poverty at the province and district levels. From a welfare perspective, the size of the poverty population in each area is a better guide for policy than the incidence of poverty.[1] Accordingly, we index provinces and districts by the number of inhabitants who fall below the international norm for absolute poverty. We also incorporate administrative concerns by mapping the settlement density of the poor, since providing services to isolated households is more costly.

2.2 Environmental Problems

We consider five critical environmental problems, two related to natural resource degradation and three to pollution. The "Green" problems are deforestation and soil degradation, while the "Brown" problems are indoor air pollution, contaminated water and sewage, and outdoor air pollution.

Deforestation

The rate of deforestation serves as a proxy for the loss of critical ecosystems and biodiversity, as well as increased risk of soil erosion in steeply-sloped areas. To test for a poverty/environment nexus in this context, we map forested areas and rates of deforestation by province and district. In areas where significant forests remain, we

[1] An extreme example will help clarify the underlying logic: Ten poor households might constitute the entire population of an isolated district, whose poverty incidence would therefore be 100%. On the other hand, one million poor households might represent no more than 40% of the population in a large urban area.

assess the spatial correlation of poverty and deforestation using maps, graphical scatter plots and regressions.

For the regression analysis, our two principal variables are the settlement density of the poor population and overall population density. By incorporating both, we can test the hypothesis that poor households clear forested land at disproportionately-high rates.[2] Rejection of this hypothesis would suggest that poverty alleviation is unlikely to reduce population-induced deforestation. We also test for the impact of commercial logging by controlling for differences in tree species. In our three study countries, some area experts have suggested that deforestation is significantly faster in areas dominated by evergreens, which are the preferred species for commercial loggers. We cannot test the converse proposition (exogenously-generated deforestation reduces the welfare of the poor) until we have better information about the dependence of the poor on forest products. Future research should use local data for a more detailed analysis of this potential link.

Fragile Soils

Steep hillsides under intensive cultivation are particularly vulnerable to erosion and soil degradation, and the economic return to farming steeply-sloped areas is generally lower than the return to cultivating alluvial soils in river valleys. While these observations are straightforward, their implications for the poverty/environment nexus depend on local possibilities for migration. In regions where people are relatively free to migrate to areas with higher expected returns, we would expect steeply-sloped areas to be more sparsely populated than alluvial plains. If population growth raises the labor intensity of alluvial farming, we would expect diminishing returns in the lowlands to induce uphill movement by farmers. This movement would be tempered by erosion and soil depletion in the highlands, with a consequent drop in the overall marginal productivity of agricultural labor. The remaining highland farmers should farm larger plots, on average, to compensate for poorer soils and to maintain parity in expected income with lowland farmers. Damage to highland soils would be a resource conservation problem for society as a whole, but would not have a disproportionate impact on the poorest farmers if they remained free to migrate.

A very different picture would emerge, however, if marginalized ethnic groups were isolated in highland areas by historical patterns of separation and discrimination. In this case, population growth and soil degradation in the highlands might well create a "poverty trap" there. By implication, a potential poverty/environment nexus exists in regions where poor households are highly concentrated in steeply-sloped areas

Indoor Air Pollution

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[2] We recognize that the estimated impact of settlement density may be biased by the exclusion of information on transport costs and other factors that affect settlement location, income and deforestation However, our test remains useful if the degree of bias is similar for poor households and households in general. For further discussion, see Cropper, Griffiths and Mani (1999).

Recent research has suggested that indoor air pollution from wood fuels is a major cause of respiratory disease in developing countries. Many households use wood or charcoal in Cambodia and Lao PDR, so indoor air pollution may be a significant health problem. Although indoor air monitoring data are not yet available, household surveys have recorded the use of wood and charcoal. We use regression analysis to test whether households living in absolute poverty are significantly greater users of charcoal and wood than higher-income households. A positive finding would support the case for a joint environment/poverty strategy: Reducing indoor air pollution would differentially improve the welfare of the poor, and reducing poverty would reduce health damage from indoor air pollution.

We recognize that our results can only be suggestive, since the impact of wood fuel use depends on whether burning is indoors or outdoors. Gauging the true magnitude of the problem will require household-level pollution monitoring and health assessment. This should be an important topic for future research on poverty/ environment links in our focal countries.

Access to Clean Water and Sanitation

Safe water and adequate sanitation are critical determinants of health status, particularly for children. Ingestion of coliform bacteria from contaminated drinking water or food is a prime cause of diarrheal disease, which is in turn a major cause of infant mortality in developing countries. Although data remain limited in Southeast Asia, we use the available information to assess the spatial relationships linking poverty, sanitation and diarrheal disease. At present, many households in the two countries do not have access to safe water or sanitation. A poverty/environment nexus exists if the affected households are disproportionately poor. We use maps, scatter plots and regressions to test for this possibility.

Outdoor Air Pollution

Outdoor air pollution is primarily an urban phenomenon, whose severity depends on the scale of polluting activity, its pollution intensity (or pollution per unit of output), and the characteristics of the urban air shed. Recent research has established that exposure to fine particulates (diameters of 10 microns (PM_{10}) or less) is the main cause of pollution-related respiratory disease. Until recently, little was known about fine-particulate pollution levels in Southeast Asian cities. During the past year, however, the World Health Organization and the World Bank have used a large international database to develop a prediction model for PM_{10} pollution, based on urban population, income, fuel use and local atmospheric characteristics (wind, rainfall, temperature, altitude, etc.).[3] Combining this model with standard "dose-response" functions, we project PM_{10} concentrations and their impacts on health in urban areas of Cambodia and Lao PDR. Aggregation of the results to the provincial level enables us to test for a poverty/environment nexus by assessing the spatial correlation between poverty and health damage from outdoor air pollution.

[3] See Bolt, *et al.* (2002).

We would, of course, prefer to base our estimates on actual monitoring data. However, to our knowledge, previous environmental studies have not even attempted to estimate air pollution for cities in the region. We therefore offer these estimates as a suggestive benchmark for further research.

4. Evidence for Cambodia

4.1 Mapping Absolute Poverty

Figure 4.1 provides the best available map of Cambodia's population at the district level. Like households more generally (Figure 4.2), poor households are concentrated along an axis that runs northwest from the coast to the border with Thailand. Figure 4.3, which displays variations in the density of the poverty population, suggests that provision of services to the poor would have lowest unit cost in the southeastern part of the axis. In this context, we should reiterate that our total-welfare perspective leads us to highlight areas where the most poor people live, not the areas with the highest incidence of poverty. Comparison of Figures 4.1 and 4.4 shows that our choice has a significant implication for policy. Figure 4.4 displays the district-level incidence of poverty, measured by the share of population that falls below the absolute poverty standard. It gives much more prominence to rural areas away from Cambodia's major population axis, and particularly to the northern and northeastern parts of the country. Although this area has a higher incidence of poverty, its population is so much smaller than the country's densely-settled central axis that the total number of poor people in the latter is much larger. Since the axial region is also more densely-settled (lowering service administration costs), it is the logical focus for a strategy that focuses purely on reducing the number of people living in absolute poverty.

4.2 Mapping Environmental Problems

Deforestation

Figures 4.5 and 4.6 provide maps of Cambodia's forest cover and the rate of deforestation for the period 1993 - 1997. In the densely-settled southeastern agricultural areas, forest cover is essentially zero in many districts. Accordingly, the deforestation map registers zero changes for those areas. However, the data displayed in Figure 4.6 also suggest extremely low deforestation rates for some populous northwestern areas where significant forest cover remains. By contrast, deforestation is a major problem at the margin of the central population axis, with immediately-contiguous districts subject to very high deforestation, and areas one district removed also subject to serious deforestation. In Figure 4.6, the other region with rapid deforestation is the sparsely-populated northeast. For the country as a whole, a comparison of Figures 4.1 and 4.6 suggests that poverty alleviation priorities and priorities for prevention of deforestation are weakly related because many of the core poverty areas are already deforested. The scatter diagram in Figure 4.7 confirms this, showing a nearly-random relationship with a rank correlation of 0.14.

We conclude that overlaps between district-level strategies for poverty alleviation and forest protection would be largely coincidental in Cambodia. Some districts rank high on both scales, and some low on both, but nearly equal numbers rank high for poverty, low for deforestation, or conversely. Our regression results (Table 4.1) suggest that overall population pressure is a major determinant of deforestation in Cambodia. However, after controlling for population, the results suggest that forest-clearing by poor people is neither more nor less intensive than forest-clearing by the general population. In the Cambodian regressions, introduction of explicit controls for species yields no higher deforestation rate for evergreens, which are reputed to be more lucrative for loggers.

In summary, our results point to overall demographic pressure rather than poverty as the primary driver of deforestation in Cambodia. By implication, alleviating absolute poverty would be unlikely to reduce population-induced deforestation. However, without further evidence about the dependence of the poor on forest products, we cannot draw any conclusions about whether preventing deforestation would significantly improve the welfare of people living in absolute poverty.

Fragile Soils

Figure 4.8 uses the incidence of steeply-sloped lands to map the potential for erosion and soil depletion in Cambodia. Distinct highland areas are visible in the northeast, southeast, and particularly the southwest regions of the county. The country's central population axis, on the other hand, is effectively defined by the lowlands. Regions with intermediate topography are intermediate in settlement as well. Comparison of Figures 4.1 and 4.8 suggests a strongly negative relationship between settlement by the poor and steeply-sloped land: Poor people are heavily concentrated in lowland areas, and reside at much lower density in highland areas. The map shows little evidence of large poverty populations in steeply-sloped areas, suggesting relatively few cases of inability to migrate because of ethnic segmentation and discrimination. The scatter in Figure 4.9 confirms the negative relationship between poverty and steeply-sloped land (simple correlation coefficient: -0.29), and is consistent with a model of relatively free migration in Cambodia.

We conclude that soil conservation programs in Cambodia's highlands are likely to raise overall incomes by raising the marginal productivity of labor in the highlands and attracting migrants from the lowlands (which will, in turn, raise the marginal productivity of labor there). However, under free migration, such programs are likely to benefit all farmers equally, not just the poorest. Similarly, poverty alleviation programs focused on the masses of poor people along Cambodia's population axis will induce migration of the poor to those areas and, as population falls in outlying areas, higher marginal labor productivity, less intensive farming of the highlands and, in consequence, less deforestation and degradation of soils in steeply-sloped areas. Through the mechanism of migration, conservation programs for highland slopes will raise incomes in the lowlands, and conversely for poverty-alleviation programs in the lowlands. Given the current regional imbalance of Cambodia's poverty population, however (Figure 4.1), direct poverty alleviation seems likely to improve the welfare of the poor much more quickly and effectively than highland soil conservation. While forest protection remains advantageous on ecological grounds, highland soil conservation has no equivalent claim. Beyond forest protection, then, we conclude that focusing incremental resources on direct poverty alleviation (including fertility control) is probably more cost-effective and, paradoxically, better for highland soils in the long run as well.

Indoor Air Pollution

Figure 4.10 displays the scatter plot of district-level poverty population vs. population using fuel wood or charcoal. Obviously, the relationship is very close (the correlation coefficient is 0.84, with much of the remaining variation explained by the plot's obvious separation into two separate sets of points). However, the existence of a true poverty/environment nexus in this context depends on more intensive use of charcoal and wood fuel by poor households. This is strongly suggested by the regression results in Table 4.2. By implication, an environmental strategy focused on reducing indoor air pollution will yield disproportionate benefits for the poor, and a poverty-alleviation strategy will significantly reduce health damage from this pollution. Although our evidence is indirect, we conclude that indoor air pollution is potentially an important poverty/environment nexus issue in Cambodia.

Access to Clean Water and Sanitation

Figures 4.11, 4.12 and 4.13 map total cases of childhood diarrhea, population without access to clean water, and population without access to toilets in Cambodia. Figure 4.12 suggests a close spatial correlation between poverty and lack of access to clean water. Regression analysis (Table 4.3) also indicates that poor households have much less access to safe water than higher-income households in Cambodia. The implications for child mortality are suggested by Figure 4.14, which displays the regional distribution of childhood deaths in Cambodia. Again, the spatial correlation with the poverty population is evident. We conclude that safe water is a poverty/environment nexus issue of great importance in Cambodia.

Again, we should note the difference between the spatial distributions of poverty and mortality *rates*, and the spatial distributions of total poverty and mortality. The latter provide the basis for our welfare analysis, because they reflect the total number of people affected. By this criterion, the central population axis of Cambodia is the high-priority area for addressing both poverty and mortality from lack of clean water and sanitation. Poverty and mortality *rates*, by contrast, are generally higher in the northern and eastern parts of the country. The proportion of households affected by poverty and waterborne disease (Fig. 4.15) is higher in these areas, but the total number of affected households is much lower than in the central population axis.

Outdoor Air Pollution

Using the WHO/World Bank model, we project PM_{10} pollution levels for urban areas in Cambodian cities. Figure 4.16 indicates that estimated pollution levels are generally higher in cities located in Cambodia's population periphery. Using standard "dose-response" models, we estimate the resulting loss of life and average loss of productive life-years for these cities and aggregated the results to the provincial level. The results, displayed in Figures 4.17 and 4.18, suggest minimal correlation (0.14) between poverty population and deaths from air pollution, and a strongly negative correlation (-0.53) between poverty population and loss of productivity-adjusted life years. The latter reflects differences in provincial demographic composition, and suggests that provinces with relatively severe air pollution have populations that are, on average, significantly younger than the others. In these provinces, the loss of a life translates to the loss of a longer working life and, therefore, a greater productivity loss.

We conclude that outdoor air pollution is not a critical poverty/environment nexus issue in Cambodia. By South- and East-Asian standards, Cambodia has a relatively small PM_{10} problem because it is lightly-industrialized and its motor vehicle fleet is relatively small. The WHO/World Bank model estimates total national mortality from air pollution to be around 1,000 per year, with an associated annual cost that is less than 1% of gross national income.

4.3 The Poverty/Environment Nexus in Cambodia

Figure 4.19 summarizes the available evidence for Cambodia's poverty population, deforestation, fragile soils, indoor air pollution, mortality from diarrhea, and mortality from outdoor air pollution. The elements of the matrix are color-coded by severity for ease of comparison. Figure 4.20 further summarizes the evidence by presenting average rankings for the first two ("Green") indices and the last three ("Brown") indices. When provinces are color-coded in four groups, the pattern suggests clear instances of the poverty/environment nexus for indoor air pollution and water contamination. By contrast, there is no evident relationship between the spatial distributions of poverty and deaths from outdoor air pollution. Nor does there appear to be a significant spatial relationship between poverty and either of the Green indices. On the basis of currently-available evidence, we conclude that the poverty/environment nexus in Cambodia is largely confined to household-level problems associated with contaminated air and water.

5. Evidence for Lao PDR

5.1 Mapping Absolute Poverty

As Fig. 5.1 shows, provinces at the northern and southern ends of Lao PDR have the highest percentages of population living below the poverty line. However, the substantial incidence of poverty in more populous areas produces a more even distribution of the total poverty population (Figure 5.2). The northern region remains the poorest, but the affected area expands to include the more populous western districts. As in the Cambodian case, a total welfare perspective implies focusing a poverty-reduction strategy on areas where the poor are both numerous and living in relatively high concentrations. By these criteria, the appropriate focus would be in the northern and south-central regions of the country.

5.2 Mapping Environmental Problems

Deforestation

Figures 5.3 and 5.4 provide evidence on forest cover and the rate of deforestation in Lao PDR during the 1990's. They highlight a critical problem in the north, where the relatively small forested area is being cleared at a rapid rate. By contrast, the southern region of the country has relatively dense forests and relatively low rates of deforestation. Since the poverty and deforestation maps overlap only in the north, it is not clear whether poverty itself has any particular significance for deforestation. As in Cambodia, we test this link with a regression of the rate of deforestation on population per forested area, poverty population per forested area, and controls for tree species (Table 5.1). The species results are similar to those for Cambodia, suggesting that evergreen-dominated areas are not experiencing faster deforestation once we control for population and poverty. Between the latter two variables, population density alone is a sufficient control for demographic pressure. As in the Cambodian case, we conclude that the evidence does not indicate a causal relationship between poverty and deforestation. Basic demographics seem to tell the story. However, the north is clearly a region in which a large poverty population is co-located with a high-priority deforestation problem. Although we see no evidence of causality, then, the northern region of Lao PDR is undeniably high-priority for both poverty reduction and forest conservation.

Fragile Soils

Figures 5.2 and 5.5 provide useful evidence on population clustering on marginal lands in Lao PDR. As we noted in Section 3, clustering of poor people in steeply-sloped areas provides strong suggestive evidence that patterns of ethnic segmentation and discrimination have prevented migration from equalizing expected returns to farming in different locations. Figure 5.5 shows that the northern and southeastern regions of Lao PDR have extensive steeply-sloped areas. Comparison with Figure 5.2 suggests that segmentation is not a problem in the south, since the major poverty areas are not in the highlands. However, the northern region provides a very different picture. Here poor households are heavily settled in steeply-sloped areas. Although more micro-level analysis would be useful, this evidence suggests that population segmentation has created a poverty/environment nexus in the northern highlands. The scatter in Figure 5.6 provides additional supporting evidence, by showing a generally positive relationship between poverty population and erosion potential (measured as the percent of land that is steeply sloped).

Indoor Air Pollution

Table 5.2 summarizes the results of regressions that test the impact of poverty on consumption of wood fuels in Lao PDR. Both linear and log models show that use of wood fuel and charcoal is far more prevalent among poverty households than in the general population. In fact, the results are much stronger than for Cambodia. We conclude that indoor air pollution is likely to be an important poverty/environment nexus issue in Lao PDR.

Access to Clean Water and Sanitation

Figures 5.7 - 5.11 provide evidence on the relationship between poverty, sanitation and mortality. Figure 5.7 overlays the estimated number of people without access to safe water on the poverty map. The impression of a strong relationship is confirmed by the scatter in Figure 5.8, which indicates a rank correlation of 0.85 between poverty and lack of access to safe water. A similarly-positive, but somewhat weaker, relationship exists for access to sanitation (Figure 5.9). The results are clearly visible in Figures 5.10 and 5.11, which depict the strong relationship between infant diarrhea and poverty. We conclude that poverty, safe water, sanitation and infant mortality from diarrhea constitute another important poverty/environment nexus in Lao PDR.

Outdoor Air Pollution

Figure 5.12 shows that northern Laotian cities have generally-higher estimated air pollution than southern cities. We combine projected air pollution with dose-response models to obtain estimates of total mortality. As Figure 5.13 shows, the result is a high spatial correlation (0.68) between the poverty population and estimated deaths from air pollution. As in Cambodia, however, estimated mortality from air pollution is not high by Asian standards because Lao PDR is not heavily industrialized and the motor vehicle fleet is relatively small.

5.3 The Poverty/Environment Nexus in Lao PDR

Figures 5.14 and 5.15 summarize the evidence on poverty/environment links in Lao PDR. Unlike the Cambodian case, the Lao poverty/environment nexus spans all the environmental indices that we consider. Figure 5.14 shows a strong correspondence between poverty rank and environment rank in all five categories -- deforestation, erosion potential, indoor air pollution, contaminated water, outdoor air pollution -- particularly for the lowest- and highest-income provinces. When the environmental rankings are combined into "Green" and "Brown" indices, the correlation is clear across all the provinces. We conclude that the poverty/environment nexus is very strongly defined for Lao PDR, and that the potential synergy between poverty alleviation and environmental policies is very high. The north- and northeastern regions of the country appear to be the main locus for action in this context.

6. Summary and Conclusions

In this paper, we have sought to identify the poverty/environment nexus in Cambodia and Lao PDR. Our analysis has focused on spatial relations between poverty populations and environmental problems at the district and provincial levels. Currently-available data will not support more spatially-disaggregated analysis. In addition, we believe that a regional focus dovetails with administrative requirements for environmental and poverty alleviation programs. However, we recognize that sub-regional analysis could reveal some additional poverty/environment links, as well as providing a better guide for spatial targeting of programs. For this reason, we hope that future research projects will promote more extensive data collection and analysis at the local level.

Our study identifies a poverty/environment nexus for cases where settlement by poor households exhibits strong spatial correlation with each of five principal environmental problems: deforestation, fragile soils, indoor air pollution, unsafe water and sanitation, and outdoor air pollution. Our results suggest that the nexus is quite different in each country. In Cambodia, it seems largely confined to household-level problems associated with indoor air pollution, contaminated water, and lack of access to adequate sanitation. Neither our two Green problems (deforestation, fragile soils) nor outdoor air pollution appear related to the distribution of the poverty population at the district or province levels. We conclude that poor households in Cambodia would benefit most strongly from programs that jointly address poverty and household-level environmental quality. At the same time, all of Cambodia's citizens, including the poor, would benefit from more effective measures to reduce the rate of deforestation.

On the other hand, our results suggest a much broader poverty/environment nexus in Lao PDR, since all five environmental problems exhibit a spatial correlation with poverty. The overlap is particularly strong in the northern and northeastern regions of the country. We conclude that the welfare of the poor in Lao PDR would be significantly enhanced by close integration of poverty-alleviation and environmental strategies in all Green and Brown dimensions. A geographic focus on the north would appear to be most beneficial.

Comparison of results for the two countries suggests a common poverty/environment nexus only for indoor air pollution. It may therefore be appropriate to develop a regional strategy for addressing this problem. We recognize that our analysis is far from exhaustive, and other environmental problems may also warrant close attention. Possible candidates include depleted and polluted fisheries (Ahmed *et al.*, 1998; FACT & EJF, 2002), and the excessive use of pesticides in Cambodia (EJF, 2002; Koma *et al.*, 2000; Koma *et al.*, 2001). Future research should explore these issues more fully.

7. References

Ahmed, M., H. Navy, L. Vuthy, and M. Tiongco, 1998, **Socio-Economic Assessment of Freshwater Capture Fisheries of Cambodia: Report On a Household Survey**, Mekong River Commission: Phnom Penh, Cambodia.

Akbar, S. and K. Lvovsky, 2000, "Indoor Air Pollution: Energy and Health for the Poor," ESMAP Newsletter No. 1, World Bank: Washington, DC.

Albla-Betrand, J. M., 1993, **The Political Economy of Large Natural Disasters**, Clarendon Press: Oxford, UK.

Ambler, J., 1999, "Attacking Poverty While Improving the Environment: Toward Win-Win Policy Options," Background technical paper prepared for the September 1999 Forum of Ministers meeting, under the UNDP-EC Poverty and Environment Initiative; also in **Attacking Poverty While Improving the Environment: Toward Win-Win Policy Options** (2001), Poverty and Environment Initiative, UNDP: New York.

Arnold, J. E. M. and P. Bird, 1999, "Forest and the Poverty-Environment Nexus," Paper presented at the UNDP-EC Expert Workshop on Poverty and the Environment, Brussels, Belgium, January 20-21, 1999; also in **Attacking Poverty While Improving the Environment: Toward Win-Win Policy Options** (2001), Poverty and Environment Initiative, UNDP: New York.

Barbier, E., 2000, "The Economic Linkages between Rural Poverty and Land Degradation: Some Evidence from Africa. *Agriculture, Ecosystems and Environment*, Vol. 82, pp. 355-370.

Bolt, K., U. Deichmann, K. Hamilton, C. Meisner, B. Ostro, K. Pandey, and D. Wheeler, 2002. "The Human Cost of Air Pollution: New Estimates for Developing Countries," World Bank Policy Research Working Paper, World Bank: Washington, DC (forthcoming).

Bosch, C., K. Hommann, G. M. Rubio, C. Sadoff and L. Travers, 2001, **Water, Sanitation and Poverty Chapter, Poverty Reduction Strategy Papers' Source Book**, World Bank: Washington, DC.

Brocklesby, M. A. and E. Hinshelwood, 2001, Poverty and the Environment: What the Poor Say: An Assessment of Poverty-Environment Linkages in Participatory Poverty Assessments, Centre for Development Studies, University of Wales Swansea, UK.

Brooks, N. and R. Sethi, 1997, "The Distribution of Pollution: Community Characteristics and Exposure to Air Toxins," *Journal of Environmental Economics and Management*, 32: 233-250.

Bucknall, J., C. Kraus and P. Pillai, 2000, "Poverty and the Environment, Environment Strategy Background Paper," World Bank: Washington, DC.

Cavendish, W., 2000, "Empirical Regularities in the Poverty-Environment Relationship of African Rural Households. *World Development*, 28 (11): 1979-2003.

Cavendish, W., 1999, "Poverty, Inequality and Environmental Resources: Quantitative Analysis of Rural Households," Working Paper Series 99-9. Centre for the Studies of African Economies. University of Oxford: Oxford, UK.

Chomitz, K., 1999, "Environment-Poverty Connections in Tropical Deforestation," Discussion notes prepared for the WDR Summer Workshop on Poverty and Development, Washington, DC, July 6-8, 1999.

Cleaver, K. M. and G. A. Schreiber, 1994, **Reversing the Spiral: The Population, Agriculture, and Environment Nexus in Sub-Saharan Africa**, World Bank: Washington, DC.

Cropper, M., C. Griffiths, and M. Mani, 1999, "Roads, Population Pressures, and Deforestation in Thailand, 1976 - 1989," *Land Economics*, 75 (1): 58-73.

Dasgupta, P. and K.-G. Mäler, 1994, "Poverty, Institutions and the Environment-Resource Base," World Bank Environment Paper No. 9, World Bank: Washington, DC.

Durning, A. B., 1989, "Poverty and the Environment: Reversing the Downward Spiral," Worldwatch Paper No. 92, Worldwatch Institute: Washington, DC.

Dutt, A. K. and J. M. Rao, 1996, "Growth, Distribution and the Environment: Sustainable Development in India," *World Development*, 24 (2): 287-305.

Environment Justice Foundation (EJF), 2002, **Death in Small Doses: Cambodia's Pesticides Problems and Solutions**, Environment Justice Foundation: London, UK.

Ekbom, A. and J. Bojö, 1999, "Poverty and Environment: Evidence of Links and Integration in the Country Assistance Strategy Process," World Bank Africa Region Discussion Paper No. 4, World Bank: Washington, DC.

Eskeland, G. S. and C. Kong, 1998, "Protecting the Environment and the Poor: A Public Goods Framework and an Application to Indonesia," World Bank Policy Research Working Paper No. 1961, World Bank: Washington, DC.

Ezzati, M. and D. Kammen, 2001, "Indoor Air Pollution from Biomass Combustion as a Risk Factor for Acute Respiratory Infections in Kenya: An Exposure-Response Study," *Lancet*, 358(9281): 619-624.

Filmer, D. and L. Pritchett, 1997, "Child Mortality and Public Spending on Health: How Much Does Money Matter?" World Bank Policy Research Department Working Paper No. 1864, December.

Fisheries Action Coalition Team (FACT) and Environment Justice Foundation (EJF), 2002, **Feast or Famine? Solutions to Cambodia's Fisheries Conflicts**, Environment Justice Foundation: London, UK.

Heath, J. and H. Binswanger, 1996, "Natural Resource Degradation Effects of Poverty and Population Growth are Largely Policy Induced: The Case of Columbia," *Environment and Development Economics*, 1 (1): 65-83.

Holden, S. T., 1996, "Adjustment Policies, Peasant Household Resource Allocation and Deforestation in Northern Zambia: an Overview and some Policy Conclusions," *in* O. Stokke (Ed.) **Forum for Development Studies**, No. 1, 1997, Norwegian Institute of International Affairs: Flekkefjord.

Kepe, T., 1999, "Environmental Entitlements in Mkambati: Livelihoods, Social Institutions and Environmental Change on the Wild Coast of the Eastern Cape," Research Report No. 1, Sussex University, Institute for Development Studies and PLASS (Program for Land and Agrarian Studies): Sussex, UK.

Koma, Y. S., K. Makarady and L. S. Horng, 2001, **The Situation of Pesticide Use in the Tonle Sap Catchment**, Cambodia Center for Study and Development in Agriculture (CEDAC): Phnom Penh, Cambodia.

Koma, Y. S., K. Makarady and L. S. Horng, 2000, **Pesticide Market in Cambodia**, Cambodia Center for Study and Development in Agriculture (CEDAC): Phnom Penh, Cambodia.

Leach, M. and R. Mearns, 1991, "Poverty and Environment in Developing Countries: An Overview Study," Sussex University, Institute of Development Studies: Sussex, UK.

Merick T., 1985, "The Effect of Piped Water on Early Childhood Mortality in Urban Brazil," 1970-1976, *Demography*, Vol. 22: 1-14.

Mink, S., 1993, "Poverty, Population and the Environment," World Bank Discussion Paper No. 189, World Bank: Washington, DC.

Myers, N. and J. Kent, 1995, **Environmental Exodus – An Emergent Crisis in the Global Arena**, Climate Institute: Washington, DC.

Pearce, D. W. and J. J. Warford, 1993, **World Without End – Economics, Environment and Sustainable Development**, Oxford University Press: New York.

Prakash, S., 1997, **Poverty and Environment Linkages in Mountains and Uplands: Reflections on the "Poverty Trap" thesis**, CREED Working paper Series No 12, IIED, London.

Reddy, S. R. C. and S. P. Chakravarty, 1999, "Forest Dependence and Income Distribution in a Subsistence Economy: Evidence from India," *World Development*, 27 (7): 1141-1149.

Roe, E., 1998, **Taking Complexity Seriously: Policy Analysis, Triangulation and Sustainable Development**, Kluwer Academic Publishers: Boston, USA.

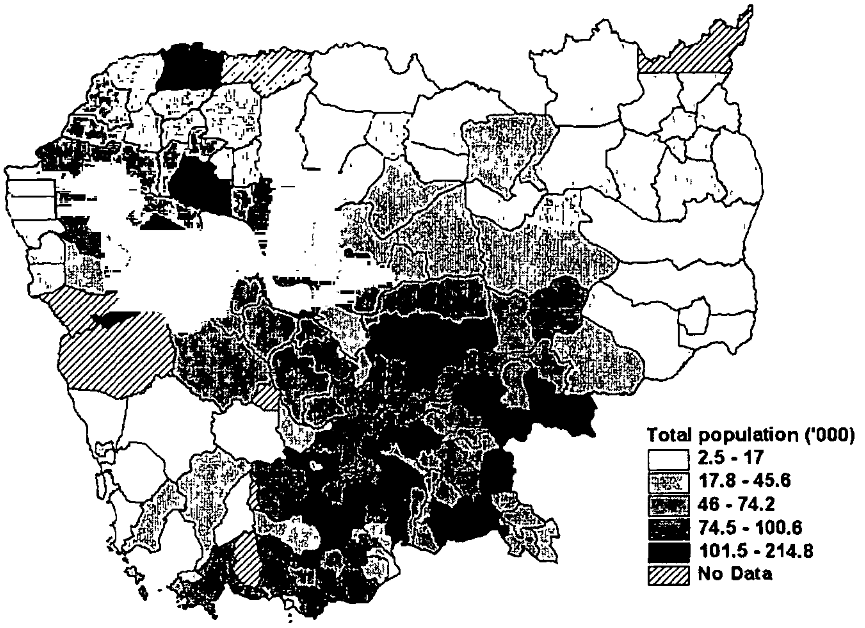
Songsore, J. and G. McGranahan, 1993, "Environment, Wealth and Health: Towards an Analysis of Intra-urban Differentials within the Greater Accra Metropolitan Area, Ghana," *Environment and Urbanization*, 5 (2): 10-34.

Surjadi, C., 1993, "Respiratory Diseases of Mothers and Children and Environmental Factors Among Households in Jakarta," *Environment and Urbanization*, 5 (2): 78-86.

World Bank, 1992, **World Development Report 1992 – Development and the Environment**, Oxford University Press: New York.

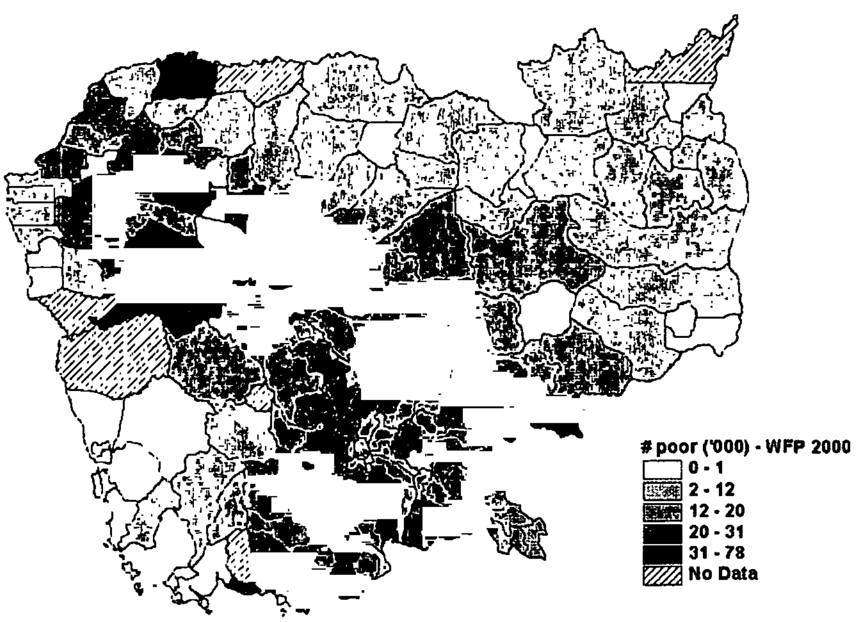
World Commission on Environment and Development, 1987, **Our Common Future, Report of the World Commission on Environment and Development**, Oxford University Press: Oxford, UK.

4.1 Cambodia: Total Population by District, 1998.



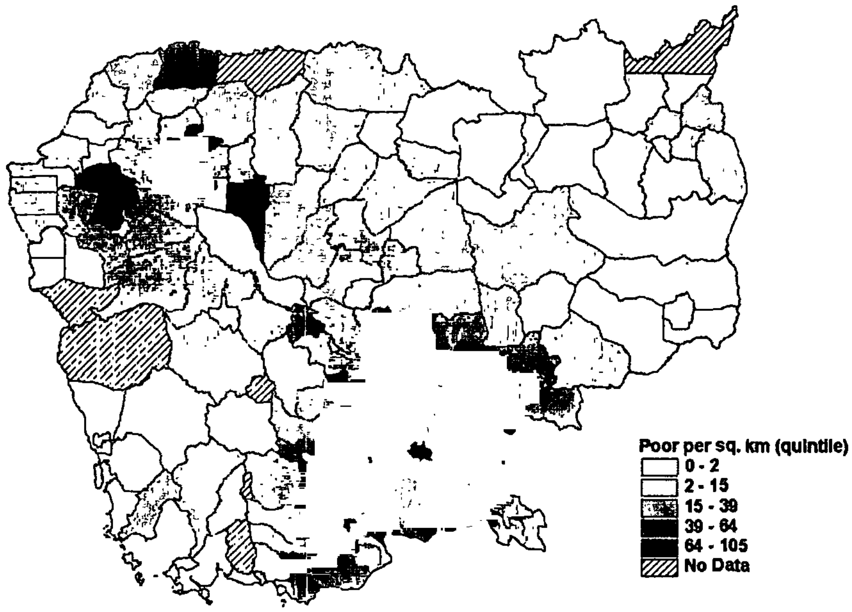
Source: Population Census, 1998.

4.2 Cambodia: Total Poverty Population by District, 2000



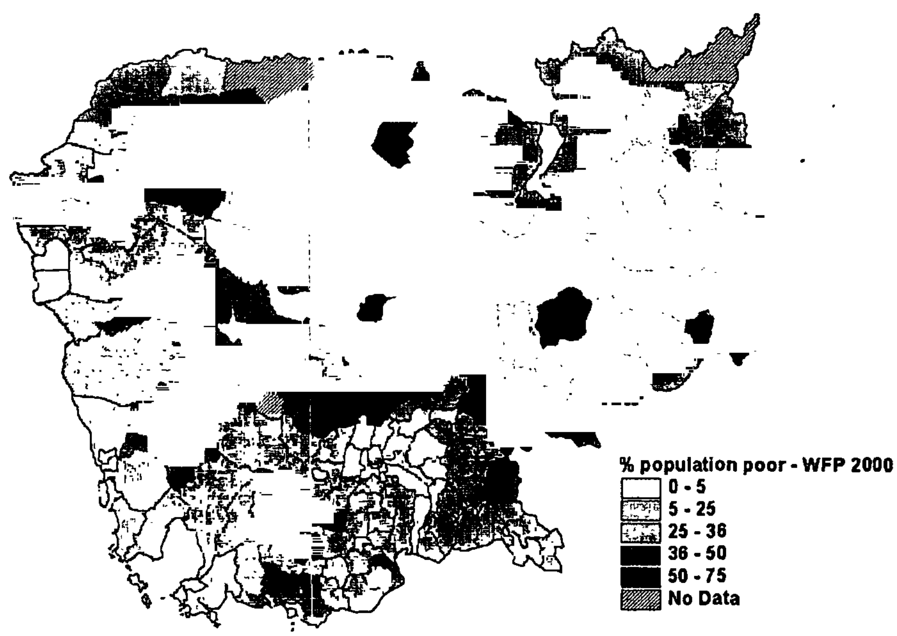
Source: World Food Program, 2001.

4.3 Cambodia: Settlement Density of the Poverty Population



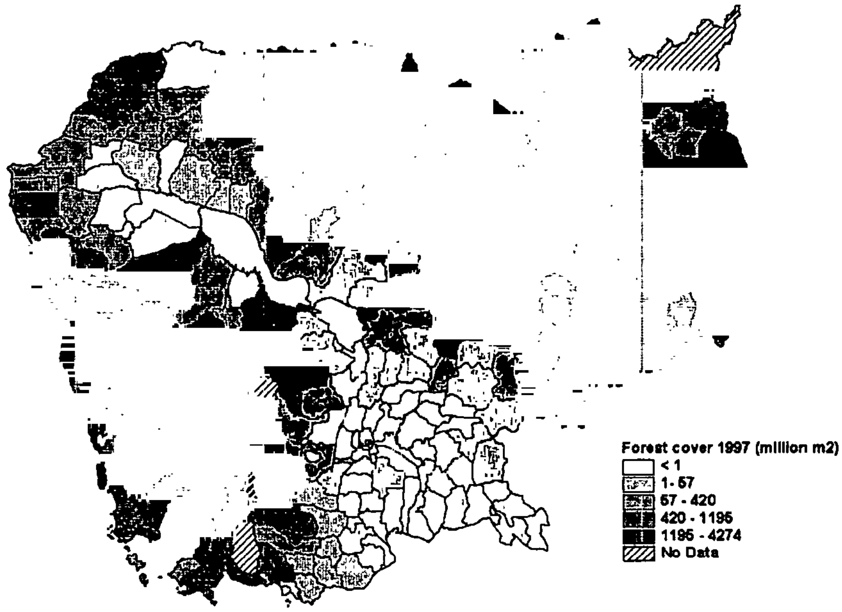
Source: World Food Program, 2001.

4.4 Cambodia: Incidence of Poverty by District



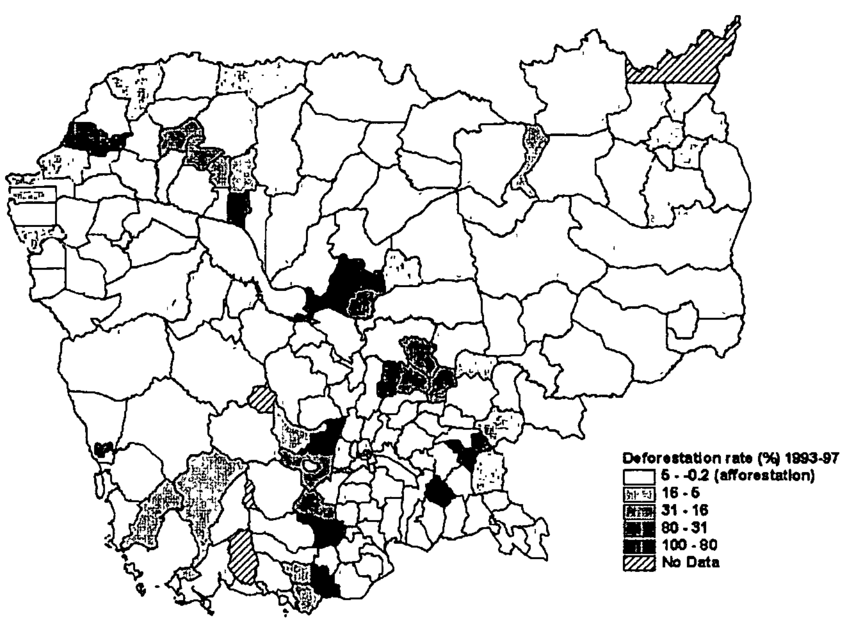
Source: World Food Program, 2001.

4.5 Cambodia: Forested Area, 1997



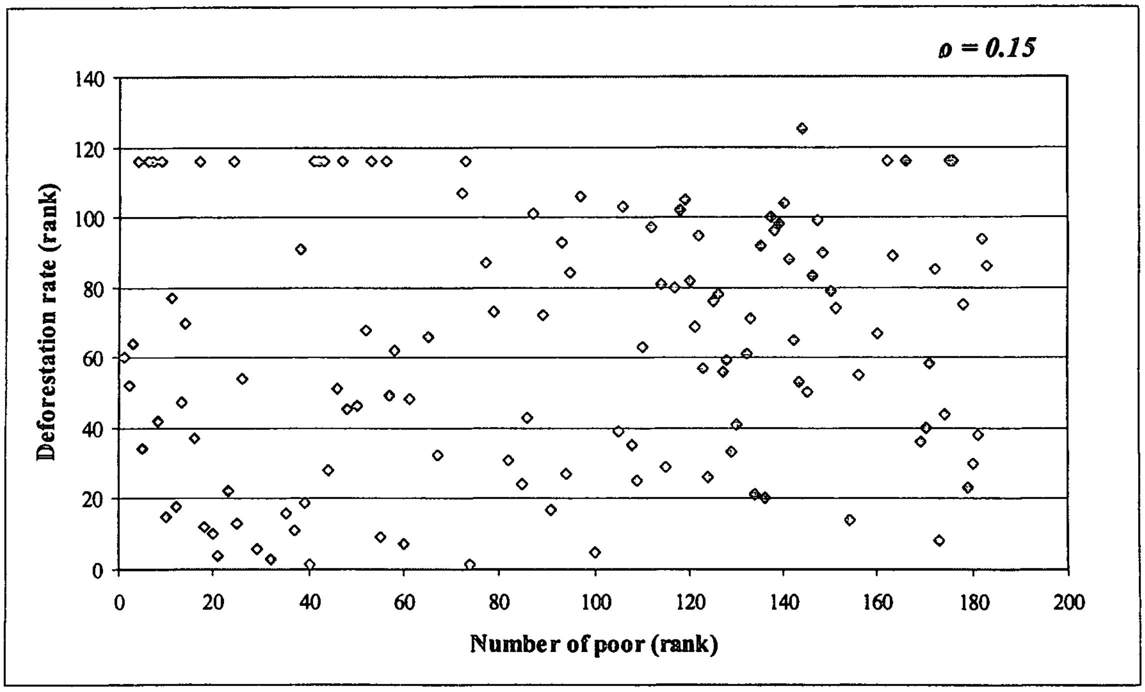
Source: Mekong River Commission (MRC), 2001.

4.6 Cambodia: Deforestation Rate, 1993-97



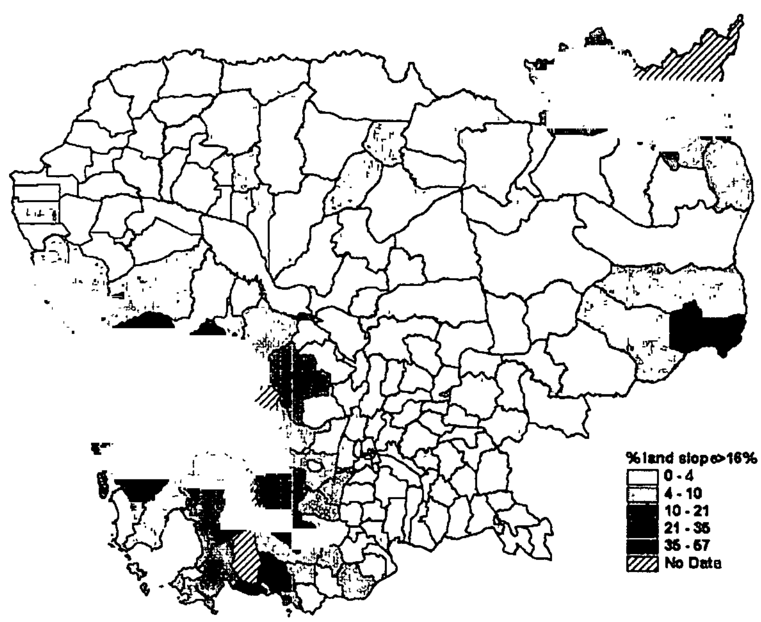
Source: Mekong River Commission (MRC), 2001.

4.7 Cambodia: Rank Scatter: Deforestation Rate vs. Poverty Population



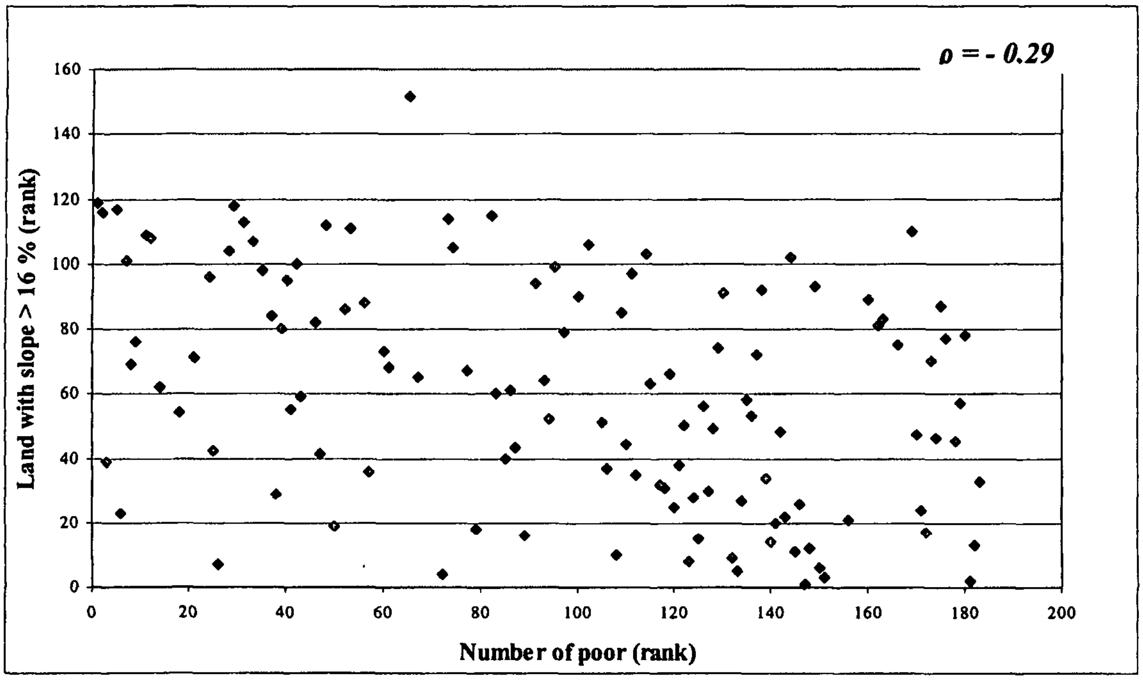
Source: Mekong River Commission (MRC), 2001.

4.8 Cambodia: Percent of Land That is Steeply-Sloped



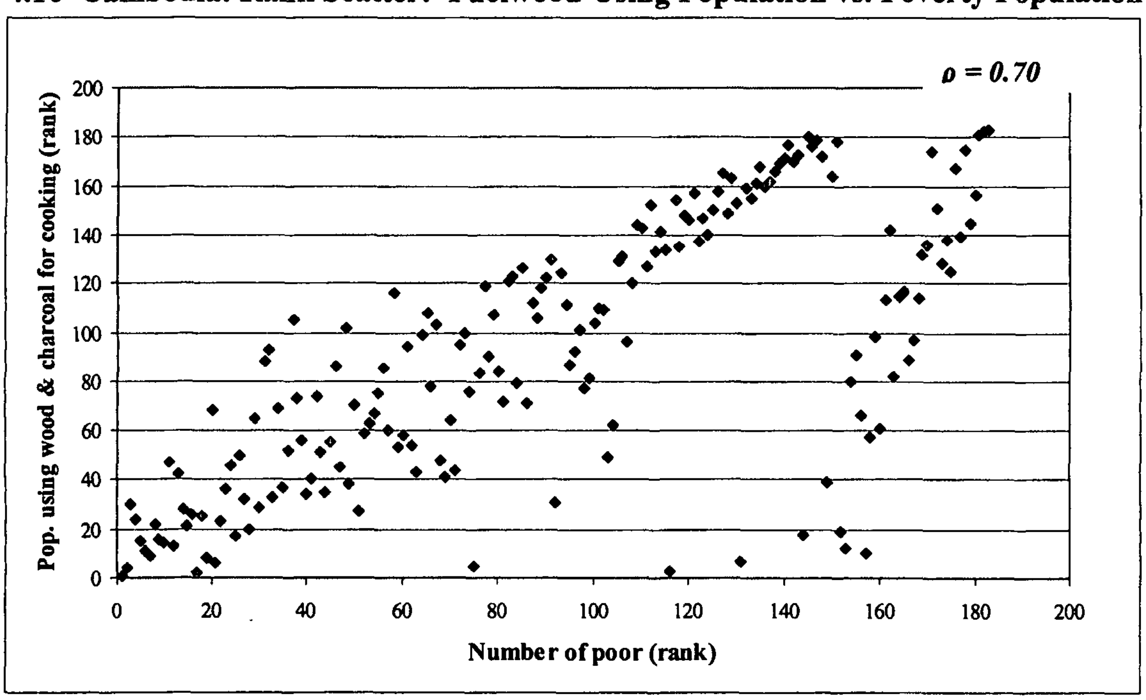
Source: Mekong River Commission (MRC), 2001.

4.9 Cambodia: Rank Scatter: Steeply-Sloped Land vs. Poverty Population



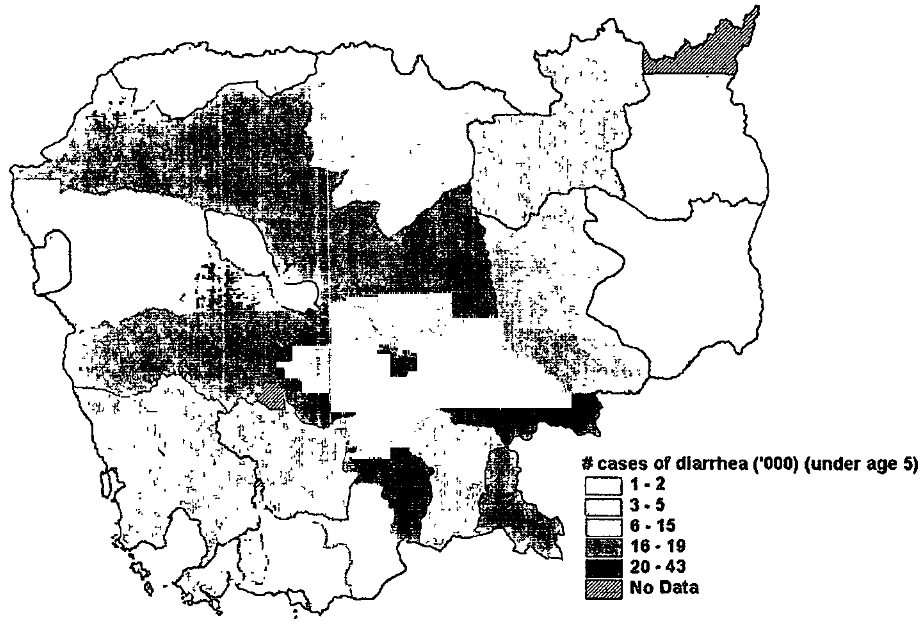
Source: Mekong River Commission (MRC), 2001.

4.10 Cambodia: Rank Scatter: Fuelwood-Using Population vs. Poverty Population



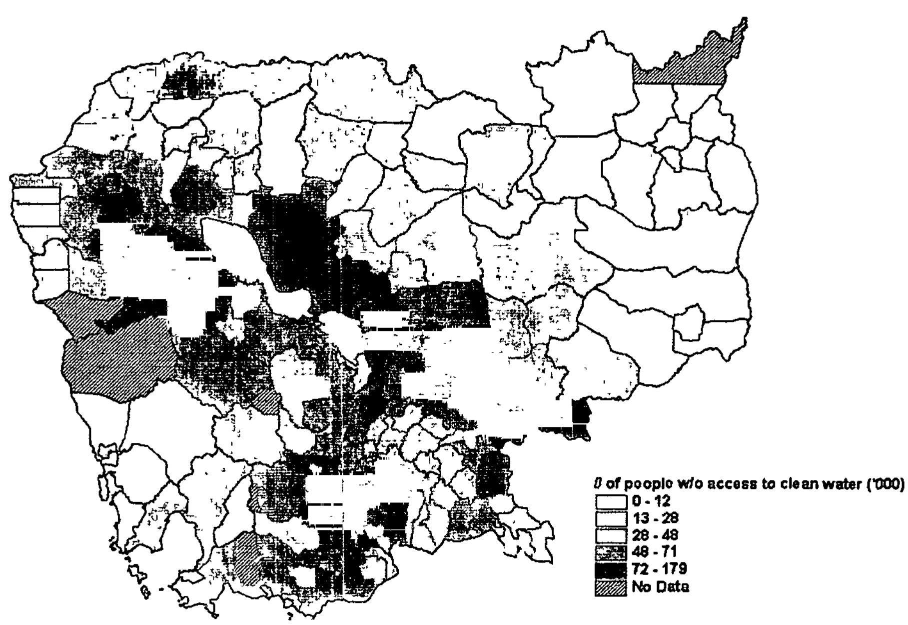
Source: Population Census, 1998.

4.11 Cambodia: Total Diarrhea Cases, 2000



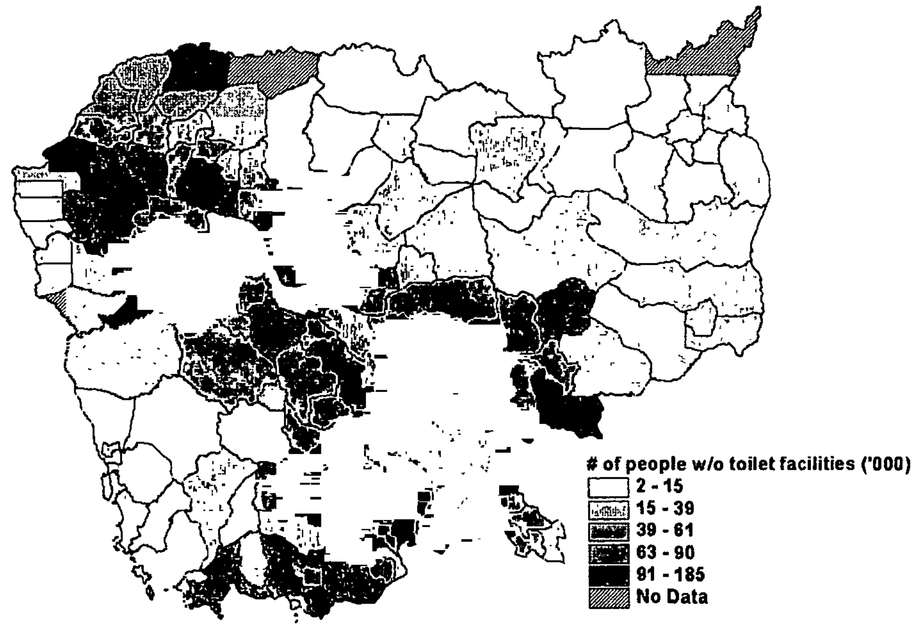
Source: Demographic Health Survey (DHS), 2000.

4.12 Cambodia: Population Without Access to Clean Water, 1998



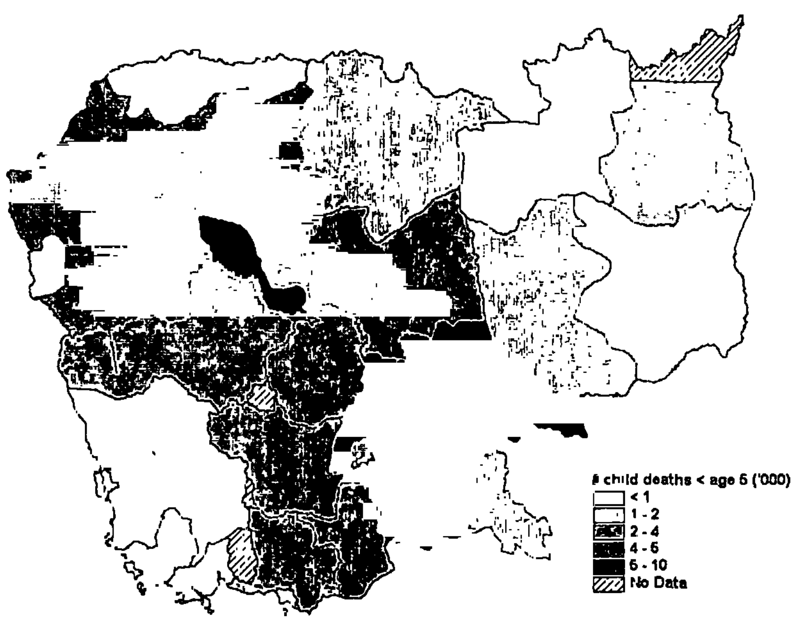
Source: Population Census, 1998.

4.13 Cambodia: Population Without Toilets, 1998



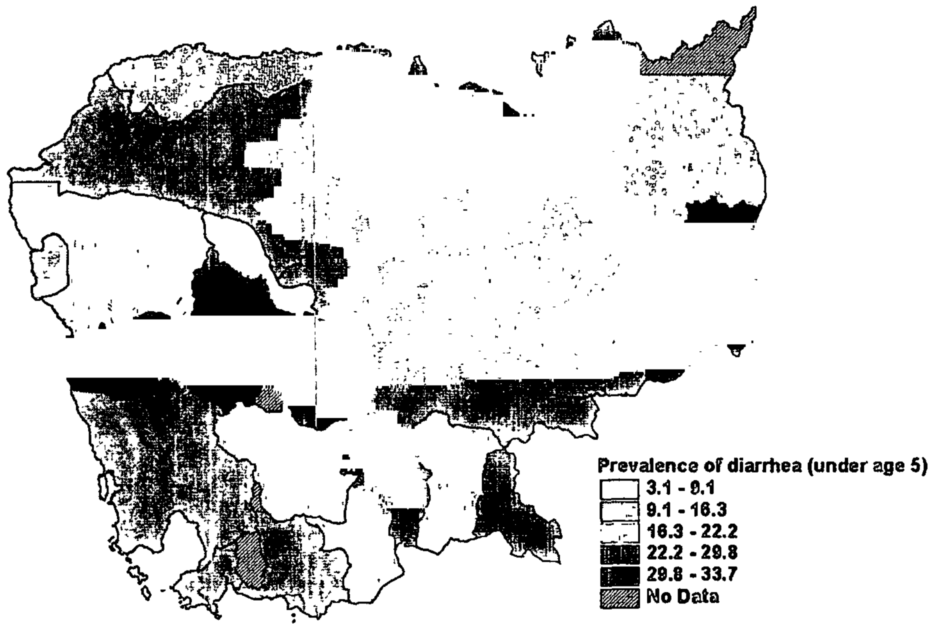
Source: Population Census, 1998.

4.14 Cambodia: Child Deaths, 1998



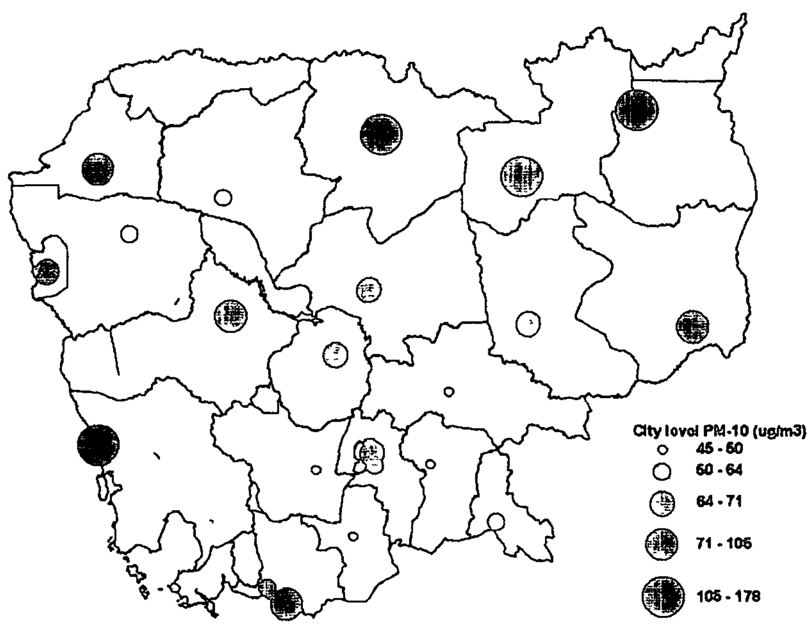
Source: Population Census, 1998.

4.15 Cambodia: Incidence of Diarrhea, 2000



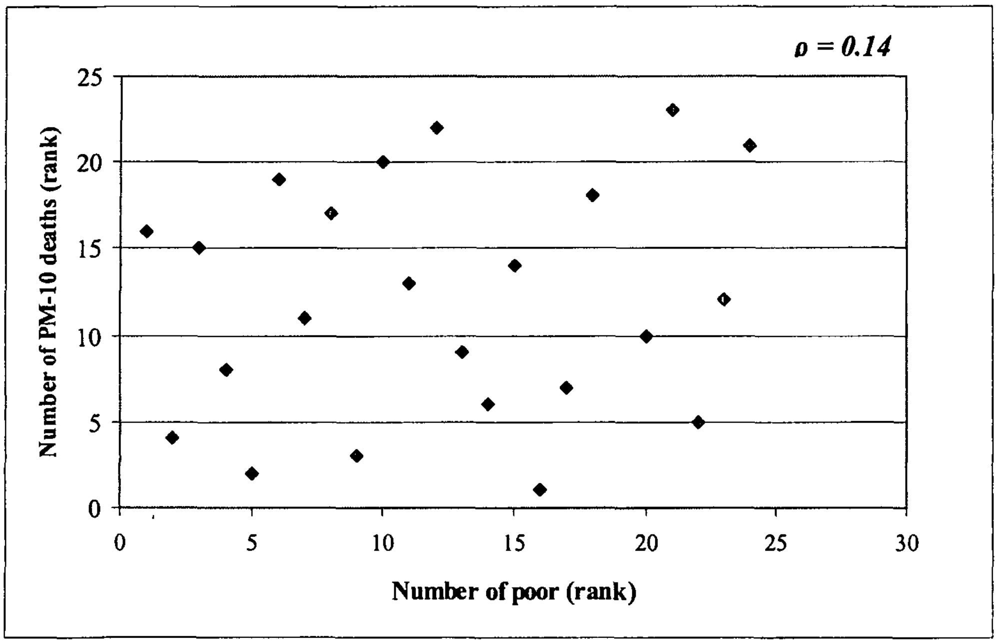
Source: Demographic Health Survey (DHS), 2000.

4.16 Cambodia: Urban PM-10 Air Pollution

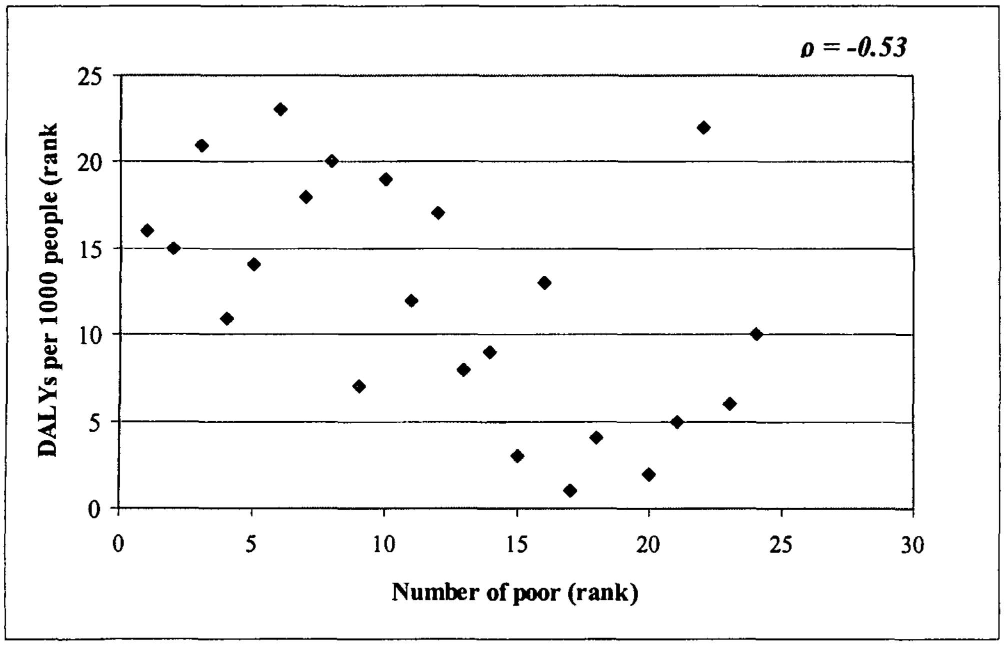


Source: World Bank Estimates, 2001.

4.17 Cambodia: Rank Scatter: PM-10 Air Pollution Deaths vs. Poverty Population



4.18 Cambodia: Rank Scatter: PM-10 Air Pollution DALY's vs. Poverty Population



4.19 Cambodia: Poverty Population and Environmental Problems

Province	Poor	Deforest	Slope	Wood/ Charcoal	Num Diarr	No water	No toilet	Num CMR	Prev Diarr	PM-10 Deaths	DALYs 1000
Kampong Chaam	1	1	3	1	2	1	1	1	2	3	3
Siem Reab	1	2	2	2	2	1	1	1	3	1	3
Prey Veaeng	1	1	4	1	1	2	1	1	4	3	4
Kampong Thum	1	3	4	2	1	1	2	2	3	2	2
Baat Dambang	1	3	2	1	3	1	1	1	4	1	3
Taakaev	1	1	3	1	2	1	1	2	4	4	4
Kandaal	2	4	4	1	2	1	1	1	1	2	3
Kampong Spueu	2	2	1	2	1	2	2	2	4	3	4
Banteay Mean Chey	2	1	3	2	3	2	2	1	3	1	2
Kampot	2	2	1	2	3	2	2	2	2	4	4
Kampong Chhnang	2	3	2	3	4	2	2	2	1	3	2
Svaay Rieng	2	1	4	2	1	3	2	3	1	4	3
Pousaat	3	4	1	3	3	2	3	2	1	2	2
Kracheh	3	4	3	3	3	3	3	3	3	1	2
Preah Vihear	3	3	2	3	2	3	3	3	1	3	1
Phnom Penh	3	4	4	1	4	3	3	3	2	1	3
Kaoh Kong	3	2	1	3	1	4	3	4	3	2	1
Rotanak Kiri	3	2	1	4	3	3	4	3	4	3	1
Otdar Mean Chey	4	1	3	4	4	4	4	4	4	-	-
Stueng Traeng	4	3	2	4	1	4	4	3	2	2	1
Mondol Kiri	4	4	1	4	2	4	4	4	1	4	1
Krong Preah Sihanouk	4	2	3	3	4	3	3	4	3	1	4
Krong Kaeb	4	4	4	4	4	4	4	4	2	2	1
Pailin	4	3	2	4	4	4	4	4	2	4	2

Note: "-" denotes no data for that province.

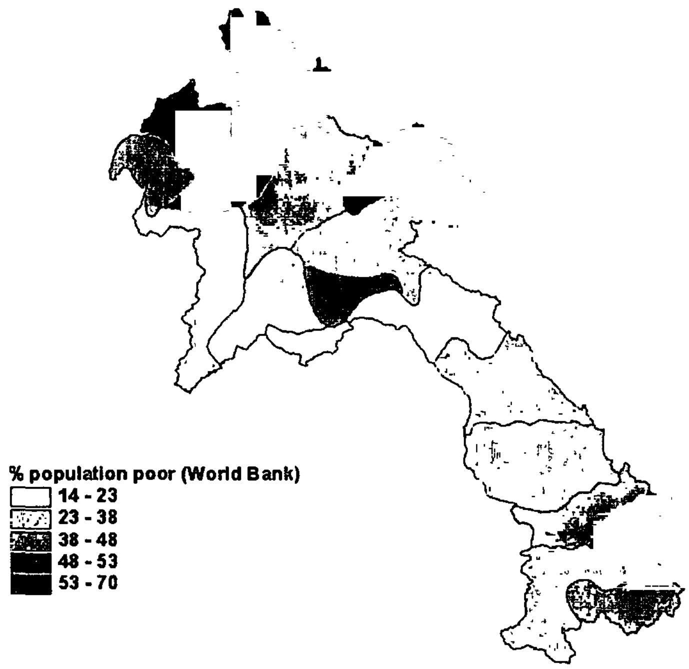
1	**1st quartile**
2	**2nd quartile**
3	**3rd quartile**
4	**4th quartile**

4.20 Cambodia: Poverty Population vs. Green and Brown Environmental Problems

Province	Poor	Green	Brown
Kampong Chaam	1	3	1
Siem Reab	1	2	1
Prey Veaeng	1	2	1
Kampong Thum	1	4	2
Baat Dambang	1	2	1
Taakaev	1	1	2
Kandaal	2	4	1
Kampong Spueu	2	1	2
Banteay Mean Chey	2	2	2
Kampot	2	1	3
Kampong Chhnang	2	3	3
Svaay Rieng	2	3	2
Pousaat	3	3	2
Kracheh	3	4	3
Preah Vihear	3	3	3
Phnom Penh	3	4	2
Kaoh Kong	3	1	3
Rotanak Kiri	3	1	4
Otdar Mean Chey	4	2	4
Stueng Traeng	4	2	4
Mondol Kiri	4	3	4
Krong Preah Sihanouk	4	2	3
Krong Kaeb	4	4	4
Pailin	4	3	4

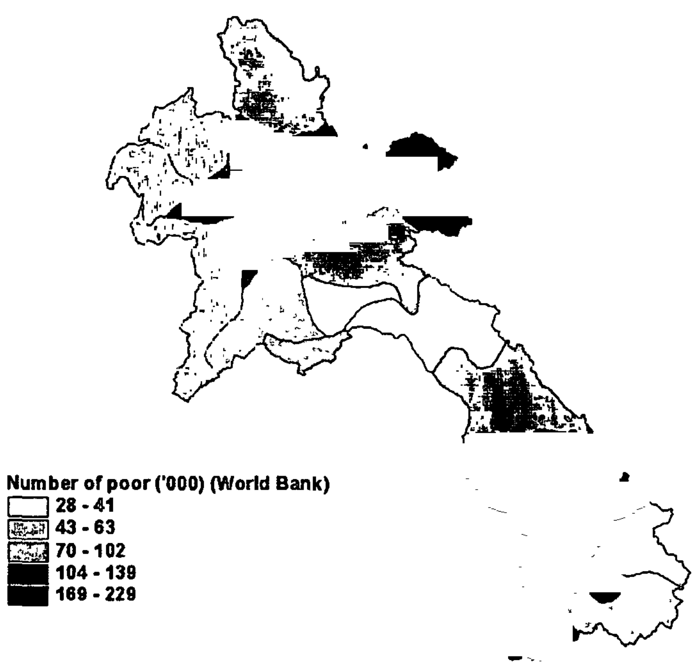
Note: Green indicator index (equal weighting): a) Deforestation rate, b) slope greater than 16%; (each equal weight)
Brown indicator index (equal weighting): a) Number using wood & charcoal, b) number of cases of diarrhea, c) number without access to water and toilets, and d) number of PM-10 air pollution deaths.

5.1 Lao PDR: Incidence of Poverty, 1997/98



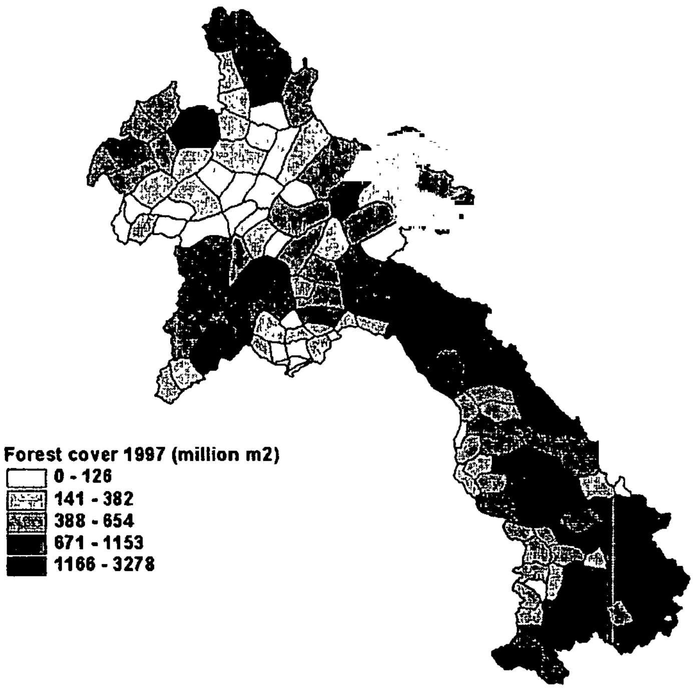
Source: G. Datt & L. Wang (World Bank), 2001.

5.2 Lao PDR: Poverty Population, 1997/98



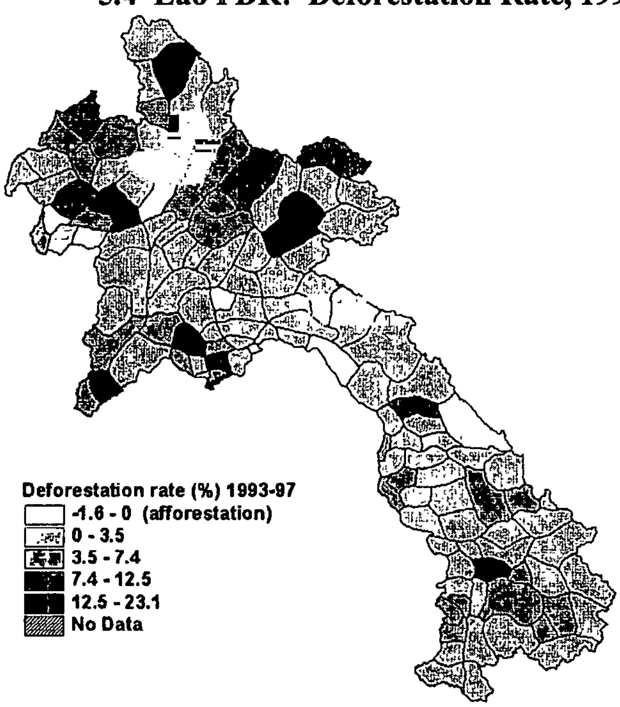
Source: G. Datt & L. Wang (World Bank), 2001.

5.3 Lao PDR: Forested Area, 1997



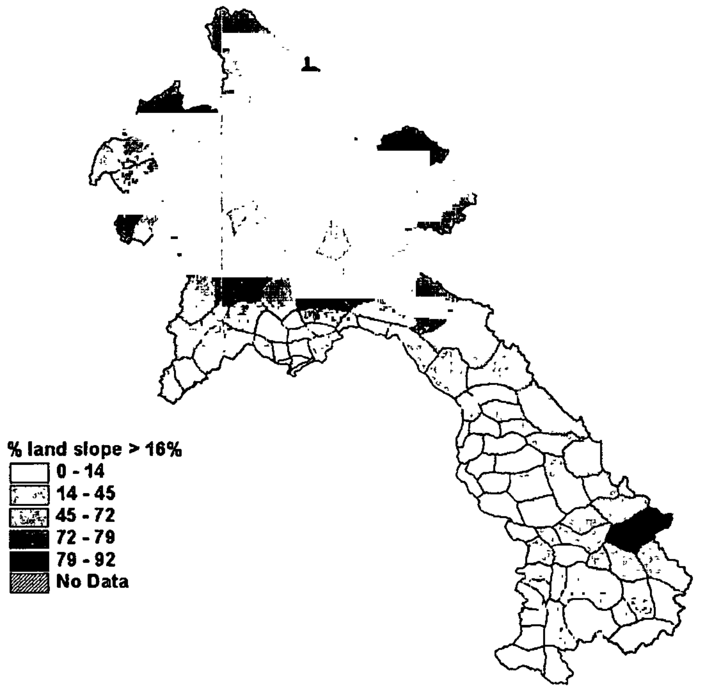
Source: Mekong River Commission (MRC), 2001.

5.4 Lao PDR: Deforestation Rate, 1993-97



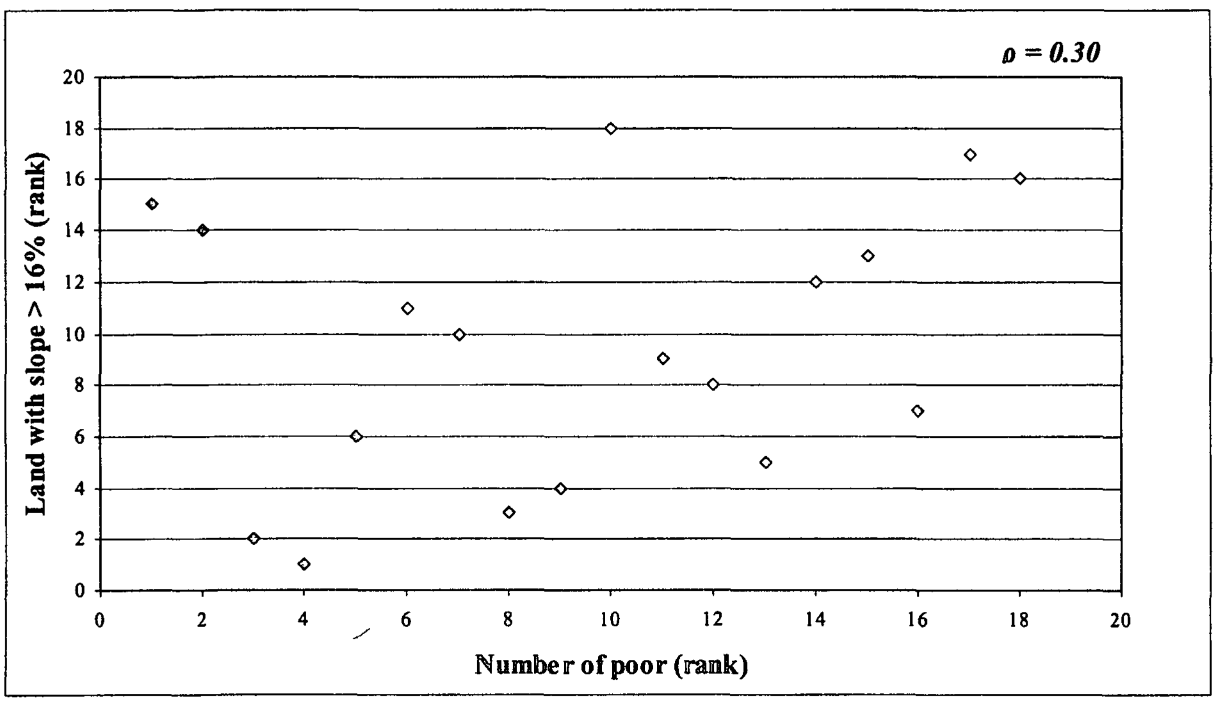
Source: Mekong River Commission (MRC), 2001.

5.5 Lao PDR: Steeply-Sloped Land

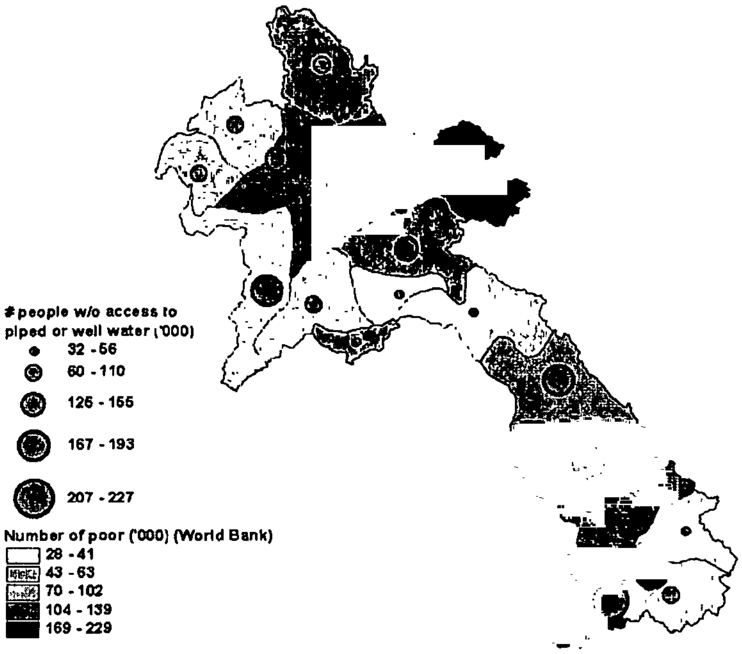


Source: Mekong River Commission (MRC), 2001.

5.6 Lao PDR: Rank Scatter: Steeply-Sloped Land vs. Poverty Population

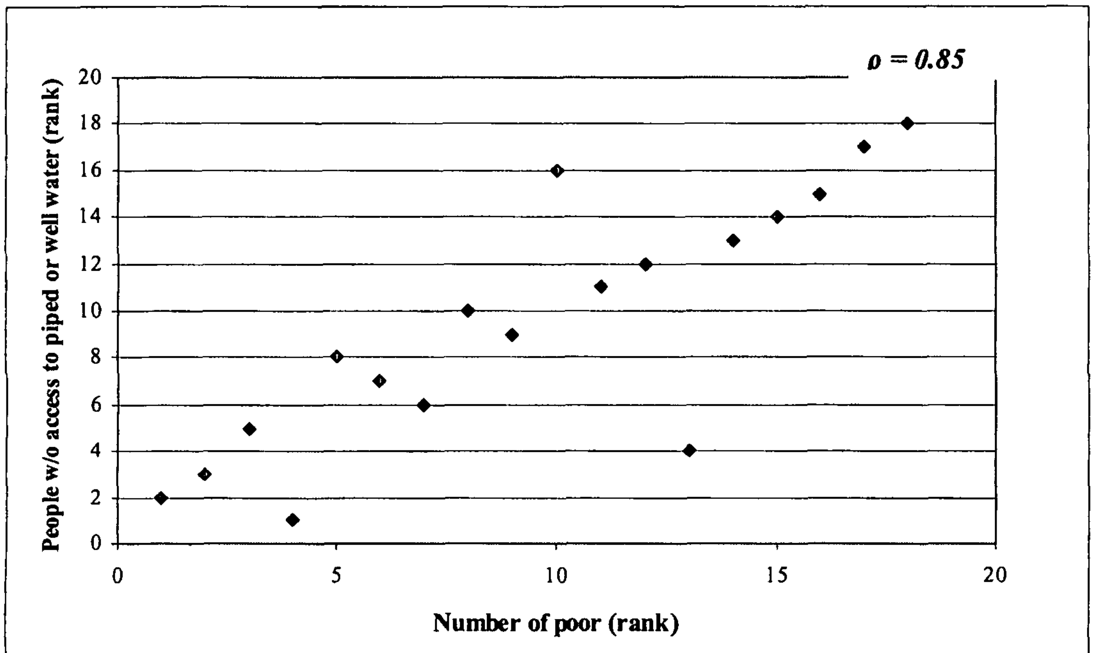


5.7 Lao PDR: Overlap of Population Without Access to Clean Water and Poverty Population, 1997/98

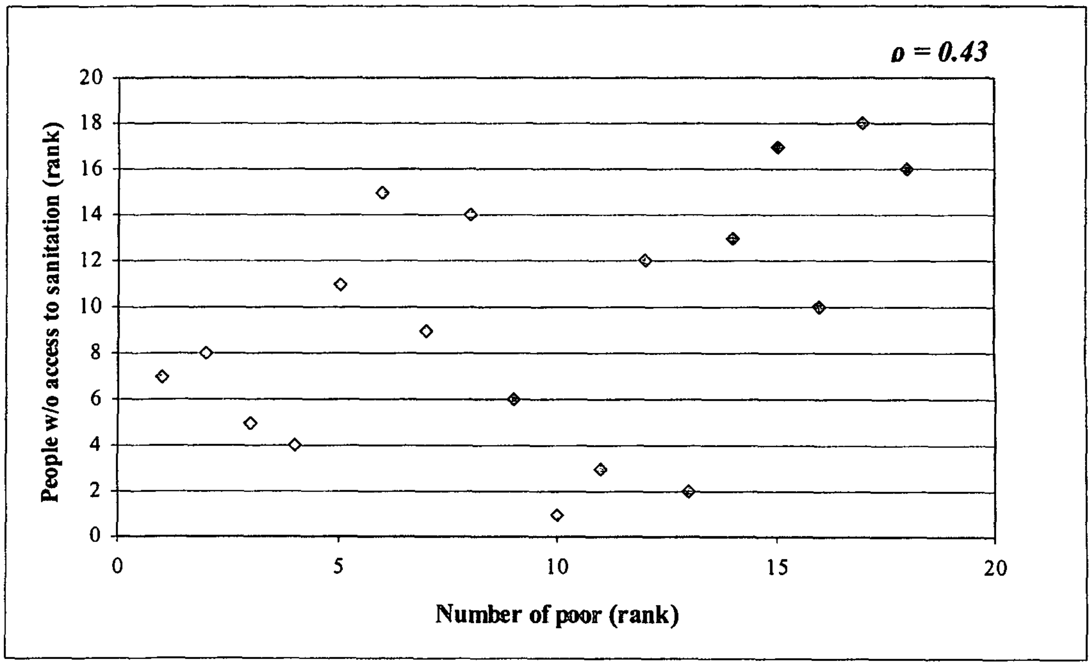


Source: Lao Expenditure and Consumption Survey (LECSII), 1997/98.

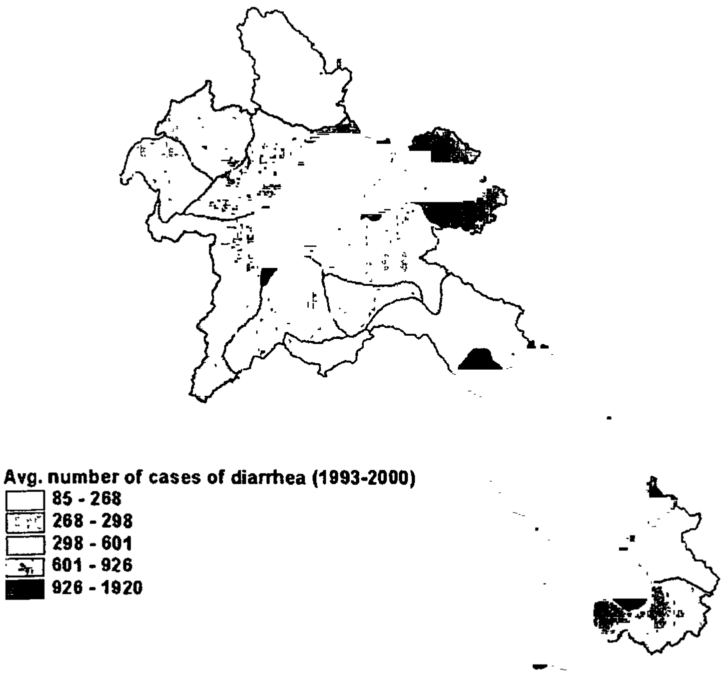
5.8 Lao PDR: Rank Scatter: Population Without Access to Clean Water vs. Poverty Population



5.9 Lao PDR: Rank Scatter: Population Without Toilets vs. Poverty Population

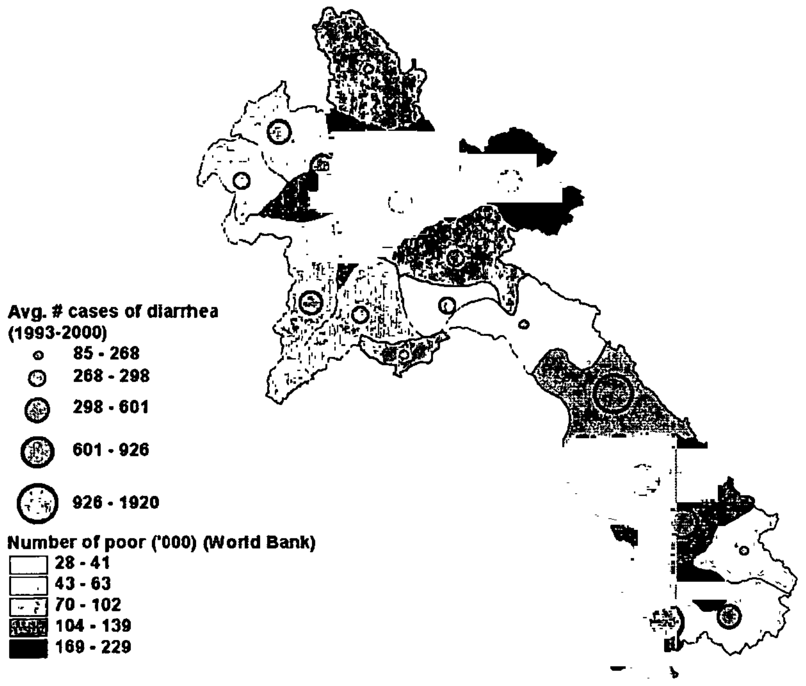


5.10 Lao PDR: Total Diarrhea Cases, 1993-2000

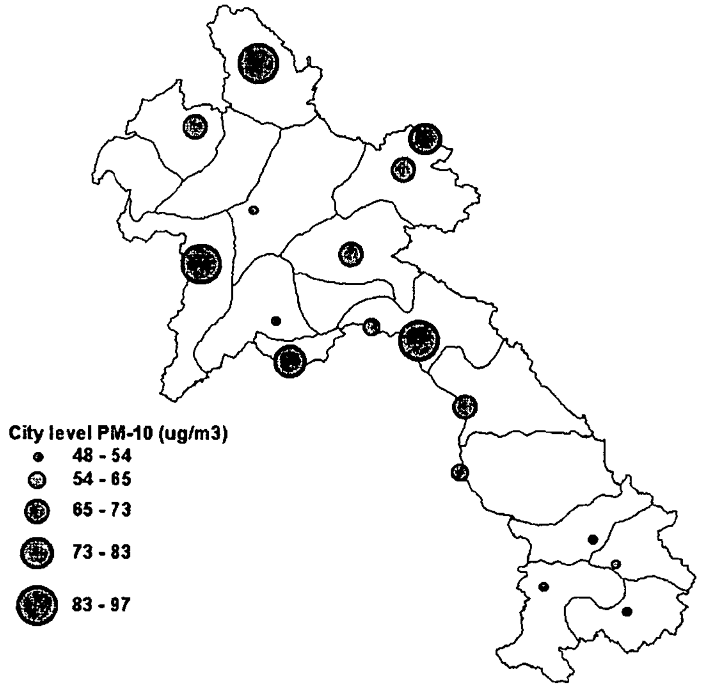


Source: Ministry of Health, 2001.

5.11 Lao PDR: Overlap of Diarrhea Cases and Poverty Population

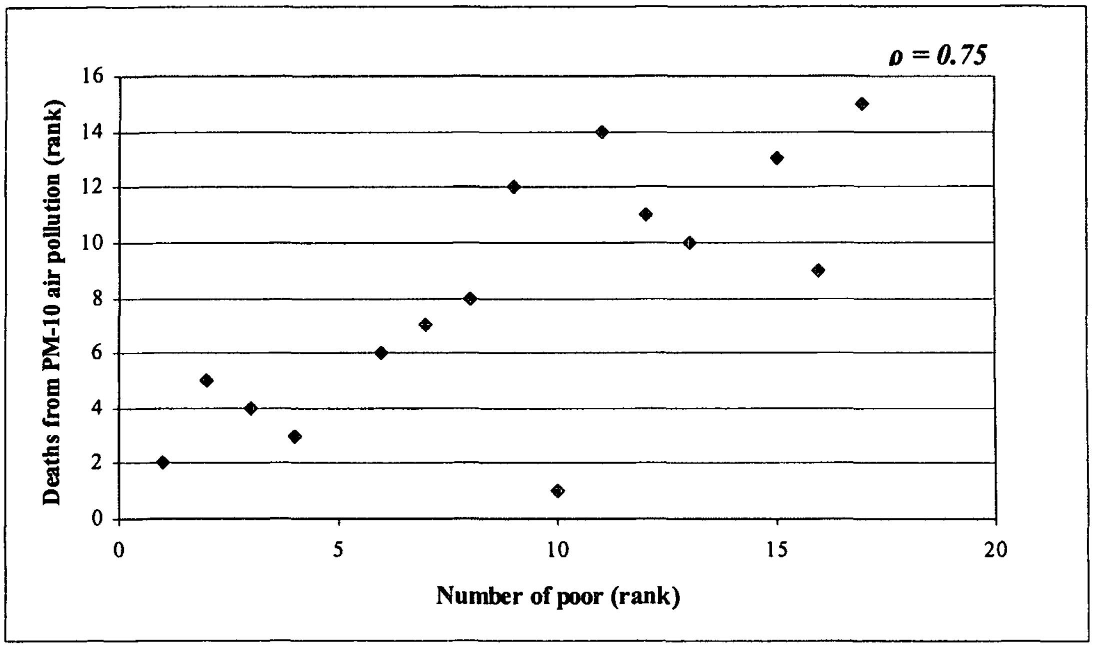


5.12 Lao PDR: Urban PM-10 Air Pollution



Source: World Bank Estimates, 2001.

5.13 Lao PDR: Rank Scatter: Deaths from PM-10 Pollution vs. Poverty Population



5.14 Lao PDR: Poverty Population and Environmental Problems

Province	Poor	Deforest	Slope	Wood/ Charcoal	No Water	No Toilet	Num Diarr	PM-10 Deaths
Savannakhet	1	4	4	1	1	2	1	1
Champasack	1	3	4	1	1	2	1	2
Huaphanh	1	2	1	2	1	1	1	1
Luangphrabang	1	1	1	1	1	1	1	1
Oudomxay	1	1	2	3	2	3	2	-
Saravane	2	3	3	2	2	4	2	2
Khammuane	2	4	3	2	2	2	1	2
Phongsaly	2	1	1	3	3	4	4	2
Xiengkhuang	2	2	1	3	2	2	3	3
Vientiane Municipality	3	1	4	1	4	1	4	1
Vientiane	3	2	2	2	3	1	3	4
Luangnamtha	3	1	2	4	3	3	3	3
Xayabouri	3	2	1	1	1	1	2	3
Bokeo	4	3	3	4	3	3	3	-
Attapeu	4	4	3	4	4	4	2	4
Borikhamxay	4	4	2	3	4	3	4	3
Sekong	4	3	4	4	4	4	4	4
Xaysomboon	4	4	4	4	4	4	4	-

Note: "-" denotes no data for that province.

5.15 Lao PDR: Poverty Population vs. Green and Brown Environmental Problems

Province	Poor	Green	Brown
Savannakhet	1	4	1
Champasack	1	3	1
Huaphanh	1	1	1
Luangphrabang	1	1	1
Oudomxay	1	1	2
Saravane	2	2	2
Khammuane	2	4	2
Phongsaly	2	1	3
Xiengkhuang	2	2	3
Vientiane Municipality	3	3	2
Vientiane	3	2	3
Luangnamtha	3	1	3
Xayabouri	3	2	1
Bokeo	4	3	4
Attapeu	4	4	4
Borikhamxay	4	3	4
Sekong	4	4	4
Xaysomboon	4	4	4

Note: Green indicator index (equal weighting): a) Deforestation rate, b) slope greater than 16%; (each equal weight)
Brown indicator index (equal weighting): a) Number using wood & charcoal, b) number of cases of diarrhea, c) number without access to water and toilets, and d) number of PM-10 air pollution deaths.

Table 4.1 Cambodia: Population, Poverty and Deforestation

Dependent variable: **Log (Forest cover 1997 / Forest cover 1993)**

Variable	Model 1	Model 2	Model 3
Log (Poor/forestcover97)	-0.007	-0.007	
Log (Population/forestcover97)	-0.010	-0.011	-0.018 **
Evergreen	0.052 *	0.018	0.020
Deciduous	0.036		
Mixed	0.062 **		
Constant	-0.014	0.030	0.039
N=	369	369	369
R^2=	0.065	0.056	0.052

* - significant at the 10% level; ** - significant at the 5% level
Evergreen, Deciduous, and Mixed forest dummy variables.

Table 4.2 Cambodia: Population, Poverty and Use of Wood fuel and Charcoal

Dependent variable: Model 1: **Population using wood & charcoal**
Model 2: **Log (Population using wood & charcoal)**

Variable	Model 1	Model 2
Total population	0.843 **	
Number of poor	0.292 **	
Log (Total population)		0.971 **
Log (Number of poor)		0.013 **
Constant	1101.698 **	0.141 **
N=	180	180
R^2=	0.979	0.994

* - significant at the 10% level; ** - significant at the 5% level

Table 4.3 Cambodia: Population, Poverty and Access to Safe Water

Dependent variable: Model 1: **Population without safe water**
Model 2: **Log (Population without safe water)**

Variable	Model 1	Model 2
Total population	0.241 **	
Number of poor	1.437 **	
Log (Total population)		0.587 **
Log (Number of poor)		0.186 **
Constant	3071.133 **	2.398 **
N=	180	180
R^2=	0.847	0.664

* - significant at the 10% level; ** - significant at the 5% level

Table 5.1 Lao PDR: Population, Poverty and Deforestation

Dependent variable: **Log (Forest cover 1997 / Forest cover 1993)**

Variable	Model 1	Model 2
Log (Population/forestcover97)	-0.0002	-0.0111 **
Log (Poor/forestcover97)	-0.0097	
Evergreen	0.0491 *	0.0392
Mixed	0.0178	
Constant	-0.0246	0.0009
N=	335	335
R^2=	0.014	0.017

* - significant at the 10% level; ** - significant at the 5% level
Evergreen and Mixed forest dummy variables.

Table 5.2 Lao PDR: Population, Poverty and Use of Wood fuel and Charcoal

Dependent variable: Model 1: **Population using wood & charcoal**
Model 2: **Log (Population using wood & charcoal)**

Variable	Model 1	Model 2
Total population	0.289 *	
Number of poor	1.948 **	
Log (Total population)		0.174
Log (Number of poor)		0.866 **
Constant	-6246.388	0.339
N=	18	18
R^2=	0.733	0.658

* - significant at the 10% level; ** - significant at the 5% level

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