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PATTERNS OF TROPICAL DEFORESTATION

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MURALI, K.S. & HEDGE, R. 1997. Patterns of tropical deforestation. In the recent past, there have been worldwide efforts to conserve tropical forests and forest resources for the future of mankind. Unfortunately, deforestation is taking place at an alarmingly faster rate all over the world than ever before. It is estimated that nearly 1.8 per cent of the forests are being degraded every year. The major threat to deforestation is considered to be the growing human population. An attempt is made here to provide a comprehensive analysis to show the relative contribution of several demographic and economic factors contributing to deforestation such as evaluating the role of population density, population growth rate, extent of forest area, total land area and foreign exchange earned through export of forest products in deforestation. Data on total geographical area, forest area, population density, export of forest products and population growth rate of 141 countries over different continents were obtained from the year book published by World Resources Institute and were analysed to understand the relation among these parameters on deforestation. Our analyses reveal that the deforestation was highest in South American countries followed by Asia. Surprisingly, although Europe had high population density, the deforestation rates were very low. This pattern is argued as the consequence of import of many forest goods from tropical countries rather than using their own resources or that they may be lacking in those resources. Further, our analyses reveal that the commonly held notion that population pressure causes greater levels of deforestation may not be true globally. Countries in Africa and Asia are showing density linked deforestation levels unlike South America and North and Central American continents. Interestingly, in Africa, small countries (having less total area and forest area) are having higher deforestation rates than larger countries. Owing to the poverty of developing countries and increasing resource intensive needs (largely due to shift in culture) of the developed countries, there was a shift in market to natural resources. Changing such attitudes and culture may play a more vital role in determining the deforestation levels rather than assuming population pressures as the major force behind the deforestation.

Key words: Tropical deforestation - population density - deforestation rate - industrialization - developing countries

MURALI, K.S. & HEDGE, R. 1997. Pola pembasmian hutan tropika. Kebelakangan ini, terdapat usaha di seluruh dunia untuk memulihara hutan tropika dan sumber hutan demi masa depan manusia. Malangnya, pembasmian hutan berlaku dengan begitu berleluasa di seluruh dunia berbanding sebelum ini. Dianggarkan hampir 1.8 peratus hutan dibasmi setiap tahun. Ancaman utama terhadap pembasmian hutan ialah pertumbuhan kependudukan manusia. Cubaan dilakukan untuk menyediakan satu analisis komprehensif bagi menunjukkan sumbangan beberapa faktor demografi dan faktor ekonomi yang menyebabkan pembasmian hutan seperti penilaian peranan ketumpatan penduduk, kadar pertumbuhan penduduk, keluasan kawasan hutan, jumlah kawasan tanah dan pertukaran mata wang yang diperoleh melalui eksport keluaran hutan dalam pembasmian. Data mengenai jumlah kawasan geografi, kawasan hutan, kepadatan penduduk, eksport keluaran hutan dan kadar pertumbuhan

penduduk 141 negara dari benua yang berbeza diperoleh daripada buku tahunan yang diterbit oleh Institut Sumber Dunia dan dianalisis untuk memahami kaitan di antara parameter tersebut dengan pembasmian hutan. Analisis kami menunjukkan pembasmian hutan paling tinggi di negeri-negeri Amerika Selatan, diikuti oleh Asia. Walaupun Eropah mempunyai kepadatan penduduk yang tinggi, kadar pembasmian hutan sangat rendah. Pola ini dipertikaikan sebagai akibat banyak hasil hutan diimport dari negara tropika daripada menggunakan sumbernya sendiri ataupun mereka mungkin kekurangan sumber-sumber tersebut. Tambahan pula, analisis kami menunjukkan anggapan umum bahawa tekanan kependudukan menyebabkan meningkatnya tahap pembasmian hutan mungkin tidak benar. Negeri di Afrika dan Asia menunjukkan tahap pembasmian hutan yang berhubung dengan kepadatan, tidak seperti di Amerika Selatan dan benua Amerika Utara dan benua Amerika Tengah. Menariknya, di Afrika, negeri kecil (mempunyai kurang jumlah kawasan dan kawasan hutan) mempunyai kadar pembasmian hutan yang lebih tinggi daripada negara yang lebih besar. Disebabkan kemiskinan di negara membangun serta keperluan intensif sumber (sebahagian besarnya disebabkan oleh perubahan dalam budaya) negara yang semakin bertambah, terdapat perubahan dalam pasaran kepada sumber semula jadi. Perubahan sikap dan budaya ini mungkin memainkan peranan yang lebih penting dalam menentukan tahap pembasmian hutan daripada menganggap tekanan kependudukan sebagai sebab utama berlakunya pembasmian hutan.

Introduction

Tropical forests offer a wide variety of cash and non-cash benefits to mankind. They act as sinks for carbon dioxide emissions thereby maintaining the earth's temperature, regulate the hydrological cycle and constitute the food synthesizing machinery which supports all heterotrophic organisms existing on our planet. Apart from their major role in the functioning of ecosystems and in maintaining complex food webs, tropical forests also fulfill a variety of human subsistence needs. They provide food and fibre, and meet sustenance and commercial needs of the people living in and around and even farther from the forests.

In the recent past, there have been worldwide efforts to conserve tropical forests and forest resources for the future of mankind. Increasing carbon dioxide (CO_2) emissions due to burning of fossil fuels and other human activities are turning the earth's atmosphere warmer leading to the "Green House Effect" and consequent rise in the sea level. The human activities which increase the "Green House Effect" may turn out to be catastrophes, as these effects may make the earth uninhabitable not only for human beings but for other terrestrial organisms as well. Therefore, several countries of the world are attempting to minimise their CO_2 emissions, conserve their biological diversity and maintain a stipulated green cover on their land.

Unfortunately, deforestation is taking place at an alarmingly faster rate all over the world than ever before. It is estimated that nearly 1.8 per cent of the forests are being degraded every year (Myers 1993). The major threat to deforestation is considered to be the growing human population (Myers 1993). However, others claim that human population is not a major factor which is responsible for deforestation (Hecht 1984, 1985, Dove 1993, Hyde & Seve 1993).

The causes of deforestation are varied and complex. In general, a comprehensive analysis of the relative contribution of each factor contributing to deforestation is lacking. Here, we evaluate several factors such as the role of population density, population growth rate, extent of forest area, total geographical area and foreign exchange earned through export of forest products in deforestation. We show, using multivariate statistics, how these factors influence deforestation.

Methods

Data on total geographical area, population density, per cent change in population, total forest area and per cent deforestation of 141 countries across the continents were obtained from the World Resources year book (1990) published by the World Resources Institute. Further, the data on the export of forest products (in US dollars) of each country were taken from the publications of Food and Agricultural Organization (FAO Year Book 1989). Spearman's rank correlation coefficients (r_s) were computed among the parameters for average values for continents to understand the impact of various parameters on deforestation rates at gross levels. Pairwise Pearson's correlations were computed to understand the relation between these parameters over the data on countries. These correlation values were then subjected to path coefficient analysis (hereinafter called path analysis) to understand the effect of each of these parameters studied in isolation on rates of deforestation globally. Path coefficients are standardised partial regression coefficients which indicate the direct effects of independent variables on the dependent variable. In addition, the path coefficients also give indirect effects of the independent variable through other independent variables (Wright 1921).

The data were also analysed for each continent separately to understand the differences among continents. The continents independently considered were Africa, Asia, South America, North and Central America for such analysis. Australia was not considered because it constitutes the very few countries which are not amenable for statistical tests. Overall, data on 141 countries were considered: 38 from Asia, 49 from Africa, 15 from North and Central America, 12 South America and 27 from Europe. Europe could not be subjected to path coefficient analysis because the data on deforestation for most of the countries were lacking or absent.

Results

Table 1 reveals that the highest deforestation rate was recorded in South America (1.3%), followed by Asia (0.9%). Europe and Oceania had almost no deforestation. Highest population density was recorded in Asia (116.05 km'^2) followed by Europe (105.23 km^2). The population density was much lower in Africa (21.85 km'^2), North and Central America (18.98 km^2) and South America (16.93 km'^2). Nearly 58% of the total world population is in Asia, followed by Africa (12%). Even though Europe had higher population density than to Africa, it contributed only 9.4% to the total world's population. Africa had the highest growth rate

(3%) followed by South America (2.07%). The lowest population growth rate was recorded in Europe (0.23%). South America had the highest proportion of forest cover to land area of 48.94% followed by North and Central America (37.53%). Europe had 33.4% of forest cover whereas Africa and Asia had 23.09 and 18.35% respectively.

Table 1. Total land area (TLA) in million km^{-2}, population density (PD) in number' km^{-2}, total population (TP) in 1000 million, percentage change in population (%PC), total forest area (TFA) in million km^2, percentage annual deforestation (% ADF) and percentage forest cover (% FC) of different continents of the world

	TLA	PD	TP	%PC	TFA	%ADF	%FC
Africa	29.64	21.85	647.5	3.00	6.84	0.6	23.09
North & Central America	21.38	19.98	427.2	1.28	8.02	0.1	37.53
South America	17.53	16.93	296.8	2.07	8.58	1.3	48.94
Asia	26.79	116.05	3108.5	1.85	4.92	0.9	18.35
Europe	4.73	105.23	497.7	0.23	1.59	0.0	33.40
Oceania	7.89	3.36	26.5	1.44	1.58	0.0	20.00
World	130.77	40.47	5292.2	1.73	40.82	0.1	31.21

Global patterns

Deforestation patterns of different continents differ. Across continents, it is clear from the Spearman's rank correlation values that there is a significant correlation between population growth rate and deforestation (r_s=0.73, n=6, $p<0.05$). Also the continents with higher forest areas are increasingly getting deforested (r_s=0.76, n=6, $p<0.05$). However, these correlation values were obtained using the average value for continents and therefore may not give the real picture of the continent.

At the global level, the total land area is highly correlated with total forest area (r=0.925, df=144, $p<0.01$) and the total population (r=0.484, df=144, $p<0.01$). The annual deforestation rates show significant positive correlation with population growth (Table 2a). However, the correlation value was poor (r=0.278, $p<0.01$). The path coefficients indicate that land area has negative influence on deforestation, i.e. that the countries which have greater land area have lower deforestation rate when compared to countries which have less total land area. The same result is reiterated by the fact that land area influences the rate of deforestation positively through the total forest area (Table 2b). In addition, it can also be seen that the population growth and the total forest area are influencing deforestation positively. However, the residual factor is high indicating the parameters considered presently are not sufficient to explain the relationship obtained.

Table 2a. Pairwise correlation between land area, population density, total population, percentage population change, total forest area and annual deforestation rate of the world (df= 144)

	Land area	Population density	Total population	Population growth	Total forest area	% annual defores-tation
Land area	1.000	- 0.089	0.484	-0.104	0.925	- 0.082
Population density	- 0.089	1.000	0.012	-0.170	-0.074	- 0.026
Total population	0.484	0.012	1.000	- 0.094	0.304	0.007
Population growth	-0.104	-0.170	- 0.094	1.000	-0.124	0.278
Total forest area	0.925	- 0.074	0.304	-0.124	1.000	-0.064
% annual deforestation	- 0.082	- 0.026	0.007	0.278	-0.064	1.000

Table 2b. Direct and indirect effects of land area, population density, total population, percentage change in the population and total forest area on deforestation rates of different countries in the world. Diagonal values (underlined) indicate the direct effect.

	Land area	Population density	Total population	Population growth	Total forest area
Land area	- 0.355	-0.001	0.061	- 0.030	0.242
Population density	0.032	0.009	0.002	- 0.049	-0.019
Total population	-0.172	0.000	0.126	- 0.027	0.080
Population growth	0.037	- 0.002	-0.012	0.287	- 0.032
Total forest area	- 0.328	-0.001	0.038	- 0.036	JL262

Residual factor = 0.6955.

Continental profile

- Countries in Africa show a significant correlation between population density and deforestation. Interestingly, the countries which have higher population growth rate have low population density as indicated by the negative but significant correlation between population growth rate and population density (Table 3a). The path analysis indicates that the highest contribution to deforestation rate is from population density indicating that the countries with higher population density are responsible for higher deforestation rates. The other interesting feature of Africa is that population growth is again contributing mostly to deforestation. Total land area is contributing negatively to deforestation through total forest area (Table 3b) implying that in the countries where the forest areas are higher there is less deforestation.

Table 3a. Pairwise correlation coefficients between land area, population density, total population, percentage population change, total forest area and annual deforestation rate of Africa (df=47)

	Land area	Population density	Total population	Population growth	Total forest area	% annual deforestation
Land area	1.000	- 0.349	0.396	0.088	0.504	-0.149
Population density	- 0.349	1.000	-0.023	- 0.304	- 0.200	0.443
Total population	0.396	- 0.023	1.000	0.080	0.228	0.029
Population growth	0.088	- 0.304	0.080	1.000	0.095	0.094
Total forest area	0.504	- 0.200	0.228	0.095	1.000	- 0.247
% annual deforestation	-0.149	0.443	0.029	0.094	-0.247	1.000

Table 3b. Direct and indirect effects of land area, population density, total population, percentage change in the forest and total forest area on deforestation rates in Africa. Diagonal values (underlined) indicate the direct effect.

	Land area	Population density	Total population	Population growth	Total forest area
Land area	0.144	-0.180	0.011	0.023	-0.117
Population density	- 0.040	0.516	-0.001	- 0.079	0.046
Total population	0.045	-0.012	0.028	0.021	- 0.053
Population growth	0.010	-0.157	0.002	0.261	- 0.022
Total forest	0.058	-0.103	0.006	0.025	- 0.233

Residual factor = 0.4574.

- Population density seems not to be an indicator of deforestation in Asian countries due to low correlation between deforestation and population density. Interestingly, the total population and population density are significantly but negatively related indicating that those countries which have a higher population density have declining population growth rate. None of the parameters has any significant correlation with deforestation rates (Table 4a). However, path analysis indicates that the highest contribution towards deforestation comes from total population followed by population density. Although the correlation between population growth and deforestation is negative the path effect is positive. Total land area influences deforestation negatively indicating that larger countries show lower rates of deforestation than smaller countries (Table 4b).
- There is high correlation between deforestation and population density in the South American countries. Interestingly, there is significant and high correlation between total population and total forest area and non-significant correlation between population density and total forest area (Table 5a). Surprisingly, the highest positive contribution towards deforestation is from total population followed by population density and population growth rate. The correlation is high and significant between population density and

deforestation. As in Asia, the countries with larger area have less deforestation than the smaller countries. The residual factor is very low (0.05) indicating the predictability of the values obtained is high and also the variables considered are sufficient to explain the deforestation patterns (Table 5b).

Table 4a. Pairwise correlation coefficients between land area, population density, total population, percentage population change, total forest area and annual deforestation rate of Asia (df=36)

	Land area	Population density	Total population	Population growth	Total forest area	% annual defores-tation
Land area	1.000	0.096	0.886	- 0.089	0.748	-0.078
Population density	0.096	1.000	-0.138	-0.318	- 0.033	0.144
Total population	0.886	-0.138	1.000	-0.232	0.759	0.076
Population growth	- 0.089	-0.318	-0.232	1.000	-0.351	-0.180
Total forest area	0.748	- 0.083	0.759	-0.351	1.000	0.078
% annual deforestation	- 0.078	-0.063	0.076	-0.180	0.078	1.000

Table 4b. Direct and indirect effects of land area, population density, total population, percentage change in the population and total forest area on deforestation rates in Asia. Diagonal values (underlined) indicate the direct effect.

	Land area	Population density	Total population	Population growth	Total forest area
Land area	-1.634	0.058	0.193	- 0.030	0.334
Population density	-0.157	0.609	-0.186	-0.107	-0.015
Total population	-1.448	-0.084	1.347	- 0.078	0.339
Population growth	0.145	-0.194	-0.312	0.338	-0.157
Total forest area	- 1.222	-0.051	1.022	-0.118	0.447

Residual factor = 0.4600.

Table 5a. Pairwise correlation coefficients between land area, population density, total population, percentage population change, total forest area and annual deforestation rate of South America (df = 10)

	Land area	Population density	Total population	Population growth	Total forest area	% annual defores-tation
Land area	1.000	0.024	0.983	-0.014	0.969	0.339
Population density	0.024	1.000	0.154	0.261	0.028	0.783
Total population	0.983	0.154	1.000	0.019	0.975	0.458
Population growth	-0.014	0.261	0.019	1.000	0.078	0.512
Total forest area	0.969	0.028	0.975	0.078	1.000	0.400
% annual deforestation	0.339	0.783	0.458	0.512	0.512	1.000

Table 5b. Direct and indirect effects of land area, population density, total population, percentage change in the population arid total forest area on deforestation rates in South America. Diagonal values (underlined) indicate the direct effect.

	Land area	Population density	Total population	Population growth	Total forest area
Land area	-LOLL	0.013	1.107	- 0.004	0.234
Population density	- 0.024	0.545	0.174	0.082	0.007
Total population	- 0.994	0.084	1.127	0.006	0.235
Population growth	0.014	0.142	0.021	0.315	0.019
Total forest area	-0.980	0.015	1.098	0.025	0.241

Residual factor = 0.0738.

- Population growth rates seem to be an overriding factor in determining the deforestation rates in countries of North and Central America. The correlation is high between deforestation rate and population growth and the contribution of population growth is highest towards deforestation. Population growth and population density are negatively correlated and land area and population growth are negatively correlated (Table 6a). The highest contribution towards deforestation comes from population growth followed by population density. Countries which have larger area also tend to have larger forest areas and also have lower deforestation rates (Table 6b).

Table 6a. Pairwise correlation coefficients between land area, population density, total population, percentage population change, total forest area and annual deforestation rate of North and Central America (df = 13)

	Land area	Population density	Total population	Population growth	Total forest area	% annual deforestation
Land area	1.000	0.365	0.725	-0.466	0.978	- 0.039
Population density	0.365	- 1.000	0.292	- 0.408	-0.354	-0.110
Total population	0.725	- 0.292	1.000	-0.321	0.567	-0.291
Population growth	0.466	-0.408	- 0.321	1.000	-0.451	0.556
Total forest area	0.978	- 0.354	0.567	-0.457	1.000	- 0.378
% annual deforestation	0.039	-0.110	-0.291	0.556	- 0.378	1.000

Table 6b. Direct and indirect effects of land area, population density, total population, percentage change in the population and total forest area on deforestation rates in North and Central America. Diagonal values (underlined) indicate the direct effect.

	Land area	Population density	Total population	Population growth	Total forest area
Land area	-0.256	0.176	0.067	- 0.388	0.363
Population density	- 0.094	0.481	- 0.027	- 0.339	-0.131
Total population	-0.186	-0.140	0.092	-0.267	0.210
Population growth	0.119	-0.196	-0.030	0.832	-0.170
Total forest area	-0.251	-0.170	0.052	- 0.380	0.371

Residual factor = 0.4974.

Overall, across four tropical continents (Africa, Asia, South America and Central America) it can be observed that a) the countries with larger areas have lower deforestation rates, except in Africa, as they influence deforestation negatively, b) population density seems not to be a major factor influencing deforestation, although it influences positively, except in Africa, and c) population growth seems to be a major factor for deforestation in North and Central America.

The correlation between export of forest products and forest area in the countries of Asia, South America and North and Central America (Table 7) is positive and significant indicating that the countries which have higher forest areas are exporting resources or forest products in large quantities. In Africa and Europe no such relation was found. In addition, on these two continents, the export of forest products is not related to any of the population and growth parameters, whereas in South and Central American countries, export is related to the forest and land areas.

Table 7. Correlation of various parameters which cause deforestation with export of the forest resources in various continents

Export with	Africa (df=47)	North & Central America (df= 13)	South America (df= 10)	Asia (df=36)	Europe (df=25)
Land area	0.13	0.94	0.79	0.26	0.17
Population density	-0.13	-0.32	0.03	0.06	-0.18
Total population	0.28	0.46	0.80	0.13	0.19
Population growth	-0.24	-0.46	-0.05	-0.21	-0.17
Forest area	-0.07	0.99	0.80	0.52	0.19
% deforestation	-0.26	-0.36	0.38	-0.11	0.00

Discussion

Many studies dealing with tropical deforestation assume that population growth and consequent increase in population density exert tremendous pressure on the forests (Lal 1990, Dayal & Shah 1993, Myers 1993, Sandier 1993, Southgate *et al* 1993). Myers (1993) identifies about 10 criteria responsible for tropical deforestation and considers population pressure as the most important factor particularly through the action of shifting cultivators and cattle ranchers. Although most authors do not agree with the estimated values of others on deforestation, most of them seem to accept population growth as a dominant factor influencing deforestation (Hecht 1984, 1985, Dove 1993).

Our analyses also highlight the importance of population pressure on deforestation levels. However, Europe differs in this respect to other continents. Although Europe is the second most densely populated continent next to Asia (the highest), it has very low deforestation rates. These low rates of deforestation probably do not arise out of lower forest areas in Europe as it has nearly 33% of the total area under forest. This contrast may be because the countries from Europe import many forest goods from other tropical countries rather than using their own resources or they may be lacking in those resources (Repetto & Gillis 1988). The situation is similar to that of exploitation of developing countries by developed countries for their resources (Dove 1993) as in the case of cattle ranching and fast food outlets (Myers 1984, Adams 1990). This suggestion is further strengthened by the fact that there is a weak relation between the total forest area and the export earnings through forest products in Europe. This is in contrast to Asia, South America and North American countries where there is a positive relation indicating these countries are earning foreign exchange through deforestation. The relative dependency on forests, directly or indirectly, is more by the developed countries and not by developing countries, in terms of timber and other forest products. Earning foreign exchange by way of exporting forest products (natural resources) may be an easier way by which developing countries alleviate foreign debts (Repetto & Gillis 1988, Hyde & Seve 1993). Unfortunately, these are the countries which have large manpower and also have large tropical forest wood resource bases. Therefore, it is difficult to delineate the confounding factors that influence deforestation as large population, large forest tracts and large forest exports. This is particularly true in South American and Asian countries.

Further, our analyses reveal that the commonly held notion that population pressure causes greater levels of deforestation may not be true globally. Countries in Africa and Asia reveal density linked deforestation levels unlike South America and North and Central American continents. Interestingly, in Africa, those countries having less land area and forest area are having higher deforestation rates than those having more land area and forest area which is similar to the global scenario. This could be due to lowered perimeter to area ratio which increases the accessibility of forests. The lower perimeter to area ratio may further lead to fragmentation and therefore increases the chances of accessibility and hence deforestation (Liu *et al* 1993). Fragmentation leads to loss of species and reduces the complex

webs among organisms in an ecosystem thereby reducing resilience to changes or catastrophes (Soule & Wilcox 1980). These relations indicate that the countries with rich natural resources rely on exploitation of such resources for income generation than through technology improvements which are capital intensive.

Most countries in the tropics were colonised in the past by several European countries. During this period of colonisation, the colonised countries developed extensive infrastructure (such as roads) to have an easy access to exploitation of forests and their products (Repetto & Gillis 1988, Liu *et al.* 1993). The development of roads increased the accessibility of forest to other local people which enhanced the area for exploitation leading to further deforestation. Further, the market which was created for forest goods during the colonial era continued even after independence as the new countries had to depend on the natural resources, at least initially, for their sustenance. Thus policies of the governments dwelt on the exploitation and export of forest goods (such as timber) for development causing deforestation. Owing to the poverty of developing countries and increasing resource intensive needs (largely due to shift in culture) of the developed countries, there was a shift in market to goods that are naturally grown. Changing such attitudes and culture may play a more vital role in determining the deforestation levels rather than assuming population pressures as the major force determining deforestation.

On the whole our attempt to make a robust analysis of the factors-influencing deforestation reveals that various factors considered to have 'priority' may not be so. Further our analysis indicates that the factors influencing deforestation are different in different continents. It may be difficult to generalise that one or several factors are the most important influencing deforestation.

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References

ADAMS, W. M. 1990. *Green Development: Environment and Sustainability in the Third World.* Routledge, New York: 122-130.

DAYAL, R.M. & SHAH, V. 1993. Dynamics of deforestation, the Indian scenario. *Journal of Tropical Forestry* 9:3-11.

DOVE, MR. 1993. A revisionistic view of tropical deforestation and development. *Environmental Conservation* 20 : 17 - 24.

FOOD AND AGRICULTURE ORGANIZATION. 1989. *FAO Year Book : Forest Products 1976-1987.* FAO, Rome, Italy.

HECHT, S.B. 1984. Cattle ranching in Amazonia, political and ecological constraints. Pp. 360 - 400 in Schumit & Wood, C.H. (Eds.) *Frontier Expansion of Amazonia.* University of Florida Press, Gainsville, USA.

HECHT, S.B. 1985. Environment, development and politics : capital accumulation and the livestock sector in Eastern Amazonia. *World Development* 13 : 663 - 84.

HYDE, W.F. & SEVE.J.E. 1993. The economic role of wood products in tropical deforestation: the severe example of Malawi. *Forest Ecology and Management* 57 : 283 - 300.

LAL.J.B. 1990. Deforestation : causes and control. *Indian Forester* 116 : 431 - 441.

Liu), D.S., IVERSON, I.R. & BROWN, S. 1993. Rates and patterns of deforestation in the Philippines: application of geographic information system analysis. *Forest Ecology and Management* 57 : 1-6.

MYERS, N. 1984. *The Primary Saurce: Tropical Forest and Our Future.* Norton, New York.

MYERS, N. 1993. Tropical forest: the main deforestation fronts. *Environmental Conservation* 20:9-16.

REPETTO, R. & GILILS, M. 1988. *Public Policies and the Misuse of Forest Resources.* Cambridge University Press: 15-18.

SANDLER, T. 1993. Tropical deforestation: markets and market failures. *American Journal of Agricultural Economics* 69 : 225 - 233.

SOULE, M.E. & WILCOX, B.A. (Eds.) 1980. *Conservation Biology.* Sineur, Sunderland, Massachusetts, United States of America.

SOUTHGATE, D., SANDERS, J. & EHUi, S. 1993. Resource degradation in Africa and Latin America: population pressure, policies and property arrangements. *American Journal of Agricultural Economics* 72 : 1259 -1263.

WORLD RESOURCES INSTITUTE. 1990. *World Resources 1990-91.* Oxford University Press, Oxford, United Kingdom.

WRIGHT, S. 1921 . Correlation and causation. *Journal of Agricultural Sciences* 20 : 551 - 581.